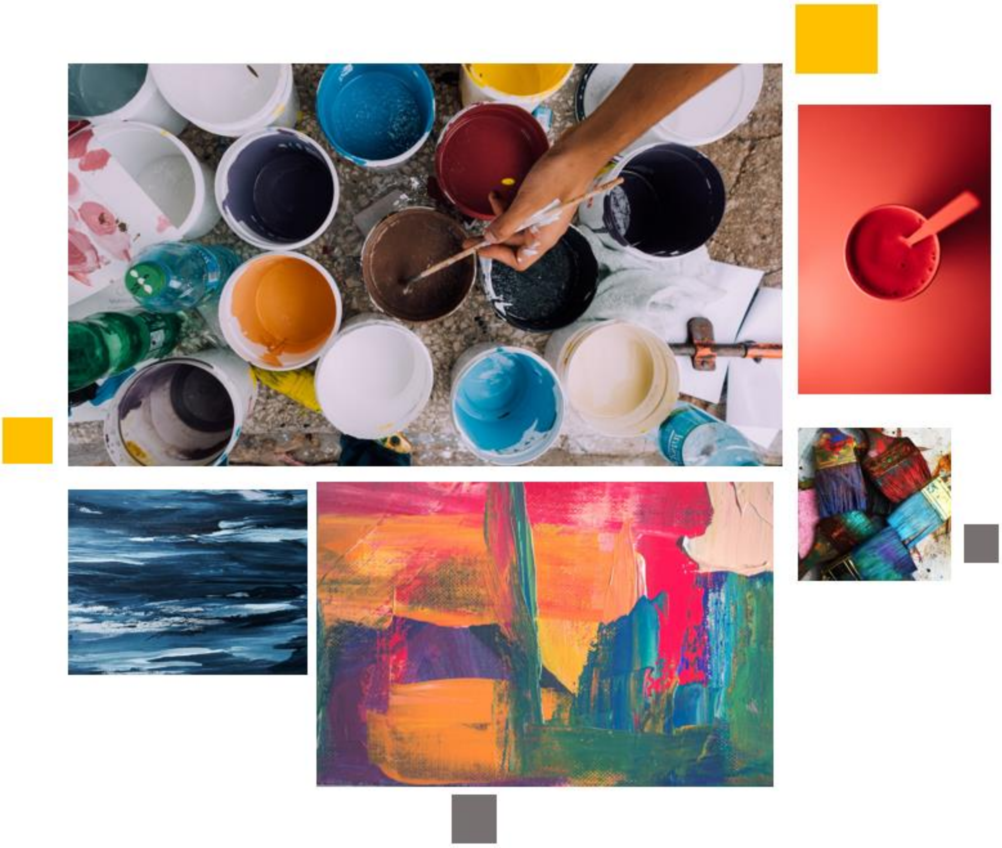
A SUSTAINABLE BUSINESS MODEL EVALUATION ABOUT THE END-OF-LIFE-MANAGEMENT OF LEFTOVER PAINT IN AMSTERDAM



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List of Abbreviations

AEB	Afval Energie Bedrijf / Waste Energy Company
BM	business model
BMC	Business Model Canvas
BMI	business model innovation
CE	circular economy
C2C	cradle-to-cradle
DGA	Depot Gevaarlijk Afval / Depot Hazardous Waste
EC	European Commission
EoL	end-of-life
EMF	Ellen MacArthur Foundation
GHG	greenhouse gas
KCA	Klein Chemisch Afval / Small Chemical Waste
KPI	key performance indicator
LCA	life cycle asssessment
MW	municipal waste
NC	Netherlands Circular!
SBM	sustainable business model
UNEP	United Nations Environment Programme

Executive Summary

This thesis researches the possibilities of changing end-of-life strategies for leftover paint chain in Amsterdam using a sustainable business model framework. It compares three scenarios by evaluating their economic, environmental and social impact.

The existing business models are mainly focused on the economic value. The purpose of this thesis is to develop a new practical sustainable business model that encompasses sustainable elements. These elements are: recycling level, social jobs, emissions prevented, waste prevented, raw materials reused and several other elements.

The main literature is focused on the sustainable business model framework by Bocken et al. (2015). This paper will form the fundament of the theory. There is a gap in the SBM literature that was identified by Boons and Lüdeke-Freund (2013). The sustainable business modelling does not include how companies combine the value proposition, organization of the value chain, and financial model in order to bring new sustainable practices to the market.

The research aims to exactly address these gaps by developing a new practical framework that can be used for comparing three end-of-life scenarios of the leftover paint stream. It concretizes concepts such as the sustainable business models, value chains and circular economy into one practical tool. The outcome is a quick overview of all the relevant criteria that are needed to assess each scenario on its feasibility. It will be further accompanied by theories from Guide and van Wassenhove (2012) about closed loop supply chain.

Then research gap is identified that helps to fabricate research questions. The research questions zoom in on the local context of leftover paint management in Amsterdam. The main research question will answer: *Which of the three U.K. closed-loop supply chain strategies for leftover paint is recommended for the city of Amsterdam?*

First, some global practices from around the world are discussed. It shows that there are different paint management schemes in the U.S. and U.K. In this case-study, the stakeholders have chosen to follow one of the three strategies from the U.K. The results of these three scenarios are compared holistically. Interesting is how solid the remanufacturing models performs economically overall. It scores exceptionally well in terms of economic value as well as environmental and social. The catch is that it requires significant amount of resources.

The limiting factors are discussed for each scenario. After which, the transferability of each model to other cities is discussed. The results show that is definitely possible to transfer the scheme to other cities once certain criteria are met.

The aim is to provide a guidance for waste management studies to quantify their research and make practical decisions regarding the best end-of-life strategies. It aims to integrate sustainability in the company business model as an essential part. Hopefully, this will lead to new sustainable business models in the future that can be applied.

Preface

The thesis is the final part of the master's degree Industrial Ecology at Leiden University and TU Delft. The study took place between February 2017 to September 2018. The author's background is in environmental sciences, and is specialized in entrepreneurship, innovation, and business development.

There are several people that I would like to thank. Their continuous support kept me focused, motivated and get inspired.

First of all, I want to thank my first supervisor Jaco Quist, an assistant professor in Sustainable Innovation and Transitions at the Energy & Industry Section of the Technology, Policy & Management Faculty, Delft University of Technology. His interest domain includes: Sustainable Production and Consumption (SPC), Industrial Ecology, Circular Economy, Renewable Energy, Climate Adaptation, and Urban Agriculture and Food. His sharp feedback really helped me to better structure my thesis and include interesting data that was left out. He was also always available for me.

The second supervisor I would like to thank is Benjamin Sprecher, an assistant professor at Leiden, Delft and Erasmus Centre for Sustainability. His interest domain includes: material flows in resilient cities, circular economy, life cycle thinking and materials supply chain. Benjamin works for the resilient hub initiative in Rotterdam and is interested to include the findings of this thesis in his work. His expertise in waste management helped me to further deepen my work about this sector.

My supervisor from AEB is Evert Lichtenbelt; he is responsible for strategy, international relationships and business development of AEB. He oversees the water-based paint project and will evaluate the pilot project after four months. I have every week a meeting with him to ask questions and discuss the progress of my thesis and project.

A second supervisor is Rik Pothuizen; he is the manager raw materials at AEB. The paint recycling activities will fall under his department once it is established.

I also want to thank all the people I have met during my research at AEB, AkzoNobel, the Municipality of Amsterdam, and the local thrift stores (Rataplan and De Lokatie). Without their support it would have been much tougher to do this research. All important stakeholders are mentioned in annex 7.

Last but not least. I want to thank my friends and family who supported me continuously. Especially, in the last few months when I was finishing the thesis.

Unubold Altanchimeg

Amsterdam, 10th of September 2018

1. Introduction

The age of linear consumption is coming to an end. Business-as-usual is becoming a risk for companies if they do not change their business model due to factors like resource insecurity, climate change and pollution. An example of resource insecurity concerns water scarcity, a major issue in key mining areas across the world (CETF, 2013). The current pattern of extracting materials, using manufactured products, selling the product to the end consumers and discarding it after usage has enormous effects on the environment. In 2010 65 billion tons of new raw materials entered the economic system and this volume will increase to 82 billion tons in 2020 (EMF, 2013).

Smart companies see these challenges as an opportunity for business. There is a growing amount of evidence supporting the idea that sustainability is beneficial to companies in several ways: increased efficiency, new products and services, lower costs, increased public trust and a future-proofed business. Understanding sustainability can offer a huge competitive advantage for firms. It helps companies to see the world from a different view so that new innovative business activities are created (FF, 2010).

The need for fresh materials is linked to the destruction of value in the current state of production. Once a product reaches its end-of-life stage, the value it generated during the manufacturing process is mostly lost. In the EU, where most countries are developed, the recycling rate of waste is around 36% now. The ambition of the European Commission is 85% recycled waste in twenty years. However, in some countries of the world, less than 5% is recycled. The common disposal methods there are landfills and incineration (EC, 2014).

Important to consider is that recycling only offers a limited form of preserving value. The value is lowered to the material level, while in many cases value can be retained at a component or the product level. Hence, recycling is not enough to tackle all environmental risks of extracting natural resources. To address the whole range of environmental problems that come with the linear economy. It is necessary that not only the material value is recovered but also the invested labour, energy and other types of input (NC, 2015).

Re-using and re-manufacturing products requires much less energy and water than recycling. These resource loops are tighter and provide the greatest mitigation of energy and water usage risks. Research has shown that companies already tend to choose the tightest loop possible if that is in their favour. They can preserve the original value, avoid risks like price volatility for materials and secure resources for production.

An outstanding example is the Apple iPhone. A reused iPhone contains 48% of its original value, while a recycled iPhone only captures 0.24% of its initial value (CETF, 2013).

Essentially, the traditional business model boils down to bringing value to the customers, persuading them to pay for value, and, finally, converting this into profit for the company (Teece in Bocken et al., 2013). The main driver of the BM is economic value.

A sustainable business model goes beyond the economic value. It brings additional customer value by contributing to the sustainable development of the company and society (Lüdeke-Freund, 2010). Thus, the objective in sustainable business models is to identify solutions that create economic value but also generate environmental and social value (Bocken et al., 2013).

The sustainable business model approach is based upon the principle of shared value creation. It acknowledges the importance of balancing short-term trade-offs on the one hand and environmental or social goals on the other. More specifically, the model invests in opportunities to create social value for different stakeholders and integrate this into the corporate strategy. Multinationals like Philips, Unilever, and AkzoNobel have extensive Corporate Social Responsibility programs and help marginalized communities everywhere in the world. Shared value creation can help innovation and growth of those companies by using solutions to social and environmental challenges as core business strategies (Bocken & van Bogaert, 2016).

The transition from a linear business model towards a circular business model, including sustainable production and consumption, requires a new way of thinking. The implementation of new processes such as closing material loops often affects the BM on all levels. When a product is re-used, it means that the consumer does not have to buy a new product.
The customer relationship dynamics change since this customer might buy a re-used product instead of a new one. Other effects might be: different products or services, different production processes, different revenue models and creating different value for various stakeholders (Mentik, 2014).

1.1. Circular Economy

The idea of transitioning into a circular economy (CE) emerged in the 1970s. In the debate on CE, the cradle to cradle concept is commonly mentioned by academics and researchers. Walter Stahel wrote the report Product-Life Factor in 1982. It is one of the first works that focused on closing the resource loop. The cradle to cradle model is shown in figure 1.1. The report clearly explained the advantages of a loop economy versus a linear economy. It could create more jobs, save resources and reduce waste while being economically profitable (Product-Life Institute, 2013).

In poverty-ridden societies, such as developing countries, CE principles are already widely used for certain goods because of the economic value of the materials. Plastic bottles are collected, clothes are repaired, and expired food is used for animal feed (Ellen MacArthur Foundation, 2013).

Compared to a linear economy, a CE is more labour-intensive because of industry processes like repairing, reusing and recycling. This increases the development of social jobs for people with a distance to the labour market. A linear economy has less of these benefits because extracting virgin materials and manufacturing are often highly automatized and robotized processes (Wijkman & Skanberg, 2015).

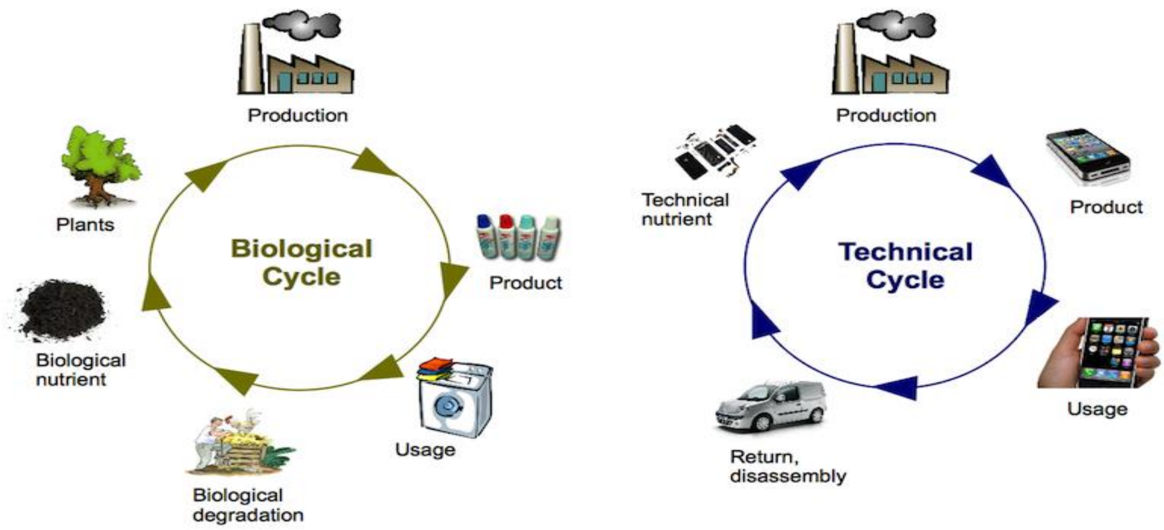

Figure 1-1:The Cradle to Cradle Model (Source: Innochem, 2006).

There are several methods to define the circular economy. One broadly-used definition is from The Ellen MacArthur Foundation: "A circular economy is an industrial system that is restorative or regenerative by intention and design. It replaces the end-of-life concept with restoration, shifts towards the use of renewable energy, eliminates the use of toxic chemicals, which impair reuse and return to the biosphere, and aims for the elimination of waste through the superior design of materials, products, systems and business models" (EMF, 2014, p.15).

The circular economy definition of EMF bases on three principles as is shown in the butterfly model in figure 1.2. The model incorporates the biological as well as the technical life cycle.

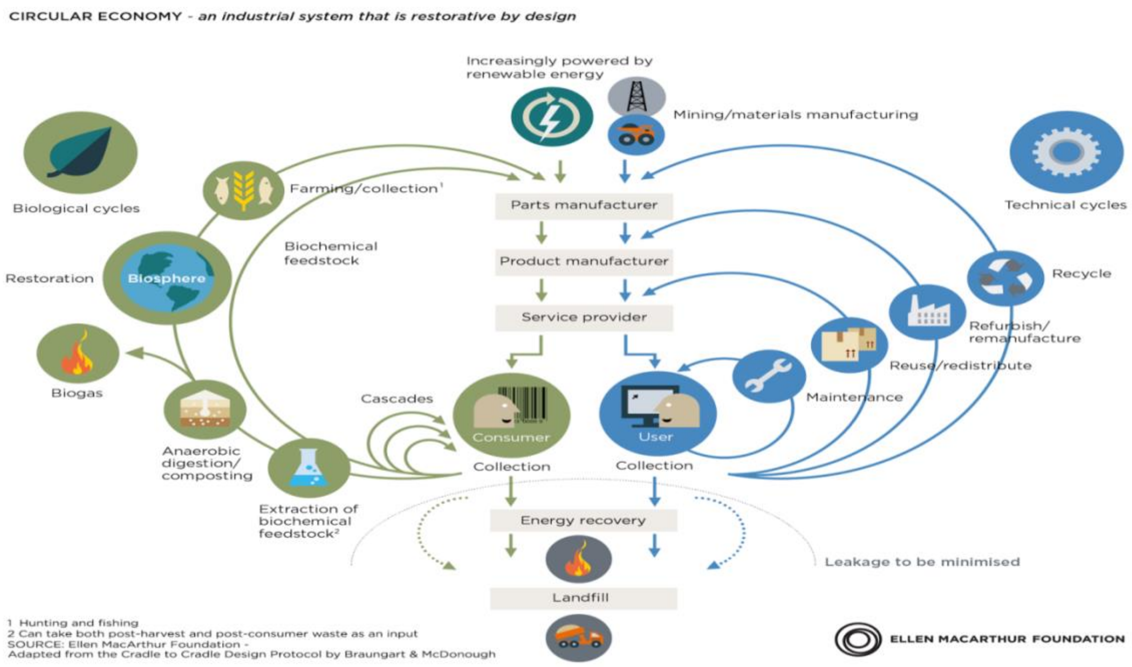

Figure 1-2: The The Butterfly Diagram (Source: Ellen Mac Arthur Foundation).

Principle 1: Preserve and enhance natural capital by controlling finite stocks and balancing renewable resource flows (EMF, 2015). The key message is that natural resources should be used optimally in a circular system. Technologies and processes ensure that the value of the products stay in the loop and minimize the need for new materials.

Principle 2: Optimize resource yields by circulating products, components, and materials at the highest utility always in both technical and biological cycles (EMF, 2015). The design is essential for further remanufacturing, refurbishing and recycling of functional components and materials. In this way, it can contribute to the circular economy by picking the most efficient loophole. For instance, maintaining a product in a technical cycle requires less energy and materials than recycling a product. This same principal applies to biological cycles. In the natural cycles, resources are broken down in the most efficient way so that they can be used for new biological cycles (EMF, 2015).

Principle 3: Foster system effectiveness by revealing and designing out negative externalities. It is important that the impact of existing systems for food, mobility, health, and entertainment is minimized. Meanwhile, external effects like land use, air, water and noise and toxic pollution need to be adequately managed (EMF, 2015). The three principles are complemented by a few more characteristics.

- Diversity is necessary to be more resilient. A diversified circular economy is better equipped against negative influences. Biodiversity in nature shows that ecosystems are more resilient against environmental influences. This model can be applied to small and large firms in the economy. Both are needed to make the economy versatile (EMF, 2015).

- Renewable energy sources are crucial for the transition towards a circular economy. The linear economy of today is still largely reliant on fossil fuels. A next step is to make use of renewable energy sources that can be harvested everywhere across the world instead of coal, oil, and gas (EMF, 2015).

- Thinking in systems can ensure that factors like resources, energy and capital flows can be optimized. It is important that industries, persons, and plants are not viewed as one system isolated from the other systems. Instead, it is part of the surrounding systems, and it can significantly influence each other. The linkages and consequences between different actors should always be taken into consideration for a smooth transition towards a new circular economy (Graedel and Allenby, 1995).

- Prices should reflect real costs. In the current system, the environmental damage from industrial processes is often not considered because it makes the process less competitive regarding cost. For instance, the cost of air pollution on the human health and environment created by a fossil fuel power plant is not expressed in the economic equation of costs (EMF, 2015). Therefore, the total cost of negative externalities should be considered.

1.2. Producer responsibility

In their report on the circular economy, The Ellen MacArthur Foundation emphasizes that the linear consumption pattern is clashing more and more with the availability of resources. For specific waste streams in the Netherlands, regulations apply. Manufacturers in certain industries are held responsible for the end-of-life strategy of their product. This law in the Netherlands is called producer responsibility, which holds original manufacturers accountable for the end-of-life process. For instance, the manufacturers of batteries and plastics need to pay extra for the waste management of their product (Rijksoverheid), 2016).

Accountability comes mostly in the form of taxes on produced products, and firms must anticipate changes in legislation. Last year, China suddenly levied the consumption tax on paint with too many organic compounds, AkzoNobel's products were largely exempted from this tax due to their long-term strategy (SCPRC, 2015). They anticipated that China's legislation regarding sustainability would become stricter. Therefore, they focused on the sales of the more environmentally-friendly, water-based latex paint in China.

AkzoNobel is the biggest paint manufacturer of the Netherlands and has set a clear strategy for the future. It anticipated a shift in the existing landscape of the linear economy. Producer responsibility is becoming increasingly more important in the Netherlands. AkzoNobel anticipate that such a legislation can be introduced soon. They prefer an own accountability scheme to deal with old paint, which has a positive social and environmental impact. Since recycling requires an integrated supply chain approach, AEB is involved as well.

1.3. Waterbased paints

The waste stream that will be researched and tested is paint. Paint is used for the protection and beautification of all kinds of materials such as wood, metals or plastics. Paint is a complex blend of different components. The main paint ingredients include extenders and additives, pigments, binders, solvents, antimicrobials and water. There is quite some difference in the composition of latex based paints and oil-based paints (Henneman, 1998).

Latex paint is also often named water-based paint. Oil-based paints in most cases have more solvents that are harmful to the human health and the environment. Paint can generally be classified into these two categories. Recently, a trend has been noted that latex paint production is increasing while oil-based paints are decreasing (Houshamand et al.,2013).

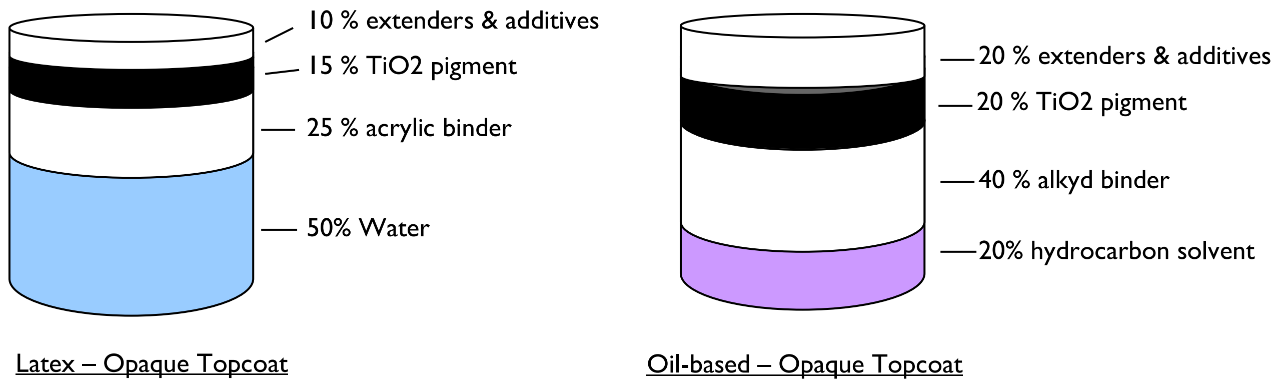

Figure 1-3: Typical Paint Formulation (percent by volume) (Source: PPP, 2004)

As is shown in figure 1.3, paint consists of several components. The type of binder used is essential for the characteristics of the paint such as shine, elasticity, strength and stitch to the foundation. For this reason, paint is frequently classified on the type of binder used.
The additives such as filler are needed to polish the paint, reduce the costs and in order to give the paint a better filling. In addition, additives can give the paint other functions like a different drying process, make the paint more stable, mould-resistant and UV-resistant.

Pigments give a colour to the paint but also provide the covering capacity and corrosion protection. Solvents are needed to make the paint easier to process and improve the flowing. Latex paints do not only have water as a solvent but also have small amounts of organic solvents to get good paint characteristics. Solvent-based paints do not have water as the main solvent. That is the difference between water-based paints like latex and oil-based paints. The main advantages of water-based are:

- A limited amount of emission of volatile organic substances
- Incombustibility
- Shorter drying time
- No yellowing

The main disadvantage is that the latex paints are less flexible for the type of foundations it can be used for. The long-term effects of solvent-based paints on human health are more serious. Turpentine is often used as a solvent and it its effect can cause:

- Narcotic effects
- Irritation of mucous membranes, eyes and skin
- Neurotoxic effects
- Damage to organs

In general, this can be avoided by adequate ventilation and no skin contact with the paint. The European Union set up a first guideline for volatile organic substances in 1993. In 2004, the current EU guideline came for volatile organic substances (solvents) in paint. The first phase started on the 01-01-2017 with a maximum of solvents allowed in grams per liter. The second phase started on 01-01-2010 and continued minimizing the amount of solvents that can be used (EUR-Lex, 2004).

In terms of effects on the environment, organic solvents can indirectly cause smog and acid rain due to its chemical reaction with the air. Water-based paints have the disadvantage that they require a lot of water to produce. Therefore, the wastewater stream is larger and requires more cleaning after production by water treatment plants (Henneman, 1998).

The manufacturers of paint have a responsibility to pursue sustainable growth. There are three concrete objectives that most paint manufacturers can improve to make their production process more sustainable and increase resource efficiency (Alkaya & Demirer, 2014):

1. Reduce chemical consumption and associated pollutant load of wastewater
2. Reduce paint consumption and related VOC emissions
3. Introduce energy efficiency measures and reduce direct /indirect carbon dioxide (CO_2) emissions

AkzoNobel has an eco-efficiency footprint measurement that focuses on: toxicity, energy efficiency, use of raw materials, emissions and waste, land use and risk / accidents. The relative footprint improvement between 2009 and 2016 was 28% (AkzoNobel, 2017).

1.4. Waste Paint in the Netherlands

Paint in the Netherlands from households is classified as "Klein chemisch afval" or Small Chemical Waste [SCW] due to its negative impact on human health and the environment (Milieucentraal, 2017). The products in this category can be anything from batteries to needles, but they all contains hazardous particles.

Waste paint has a considerable volume in this stream; sometimes it is the largest part of this category (Housahamand et al., 2013). The waste paint in this project is water-based paint. It is a solvent-free, water-based paint that has almost no organic solvents with limited health and safety hazards.

According to AkzoNobel, the deco paint market in the Netherlands is around 75 million litres. This includes DIY and professional use. They estimate that the market of waste paint is around 10 million litres or 13% of the total market.

From this paint, about 50% is reusable for new or recycled paint. The other 50 % is unusable (e.g. solvent-based, dried in container, contaminated) (AkzoNobel, 2017). In comparison to the previous years, the total volume of commercial paint decreased significantly. This is mainly caused by the increased prices for raw materials and a new method for calculating the volumes (VVVF, 2017).

1.5. Case-study context Amsterdam

In February 2017, a paint recycling pilot started in the cities of Amsterdam, Den Bosch, Den Haag and Rotterdam. It was organized by AkzoNobel, one of the largest paint manufacturers in the world. AkzoNobel approached the federation of paint manufacturers, municipalities, thrift stores and waste management companies to setup a new recovering model based on the model in the U.K.

Recycling through direct redistribution does not require a lot of investment and the results are easily measurable. The second step is to give extra value to the paint by adding additives and doing basic paint processing. This way, a new recycled end product is made (AkzoNobel, 2017).

The approach of this project is not commercial so that competitors can support the implementation of this project in Amsterdam and possibly the Netherlands (AkzoNobel, 2017). AEB joined this project because it fits in its strategy to become more efficient with natural resources.

Important to consider is the involvement of various stakeholders from the paint value chain. AkzoNobel is involved as an original paint manufacturer. AEB is involved as a waste handler that deals with the leftover paint. The Municipality of Amsterdam is involved as supporting stakeholder and is also 100% shareholder of AEB. The thrift stores functions as an outlet for the recycled paint for the secondary market.

AEB has six permanent waste collection points in the city of Amsterdam. The six collection points are shown in figure 1.4. The waste is brought once a week to the central waste facility in the port of Amsterdam. The drop-off points in the city ensure that households can give off away almost all their waste in a free, safe and environmentally-cautious way to the waste collection company (Gemeente Amsterdam, 2016).

Another type of waste paint comes from companies with rejected batches. This kind of waste stream is much smaller because in most cases, it is sold to other commercial parties like Decotrading and the Verfboer (Tauw, 2015). AEB does not receive rejected batches.

At AEB, around 300 ton of waste paint is collected from the Greater Amsterdam Metropolitan Region (AEB, 2017). The paint is collected and sent to the incinerator, where a small percentage of the total invested energy is recovered. The paint quantity collected from each waste collection point can be found in annex 1. This practice does not align with the vision of the Afval-Energie Bedrijf (AEB). Their vision is to shift from a waste management company towards an energy and resources company.

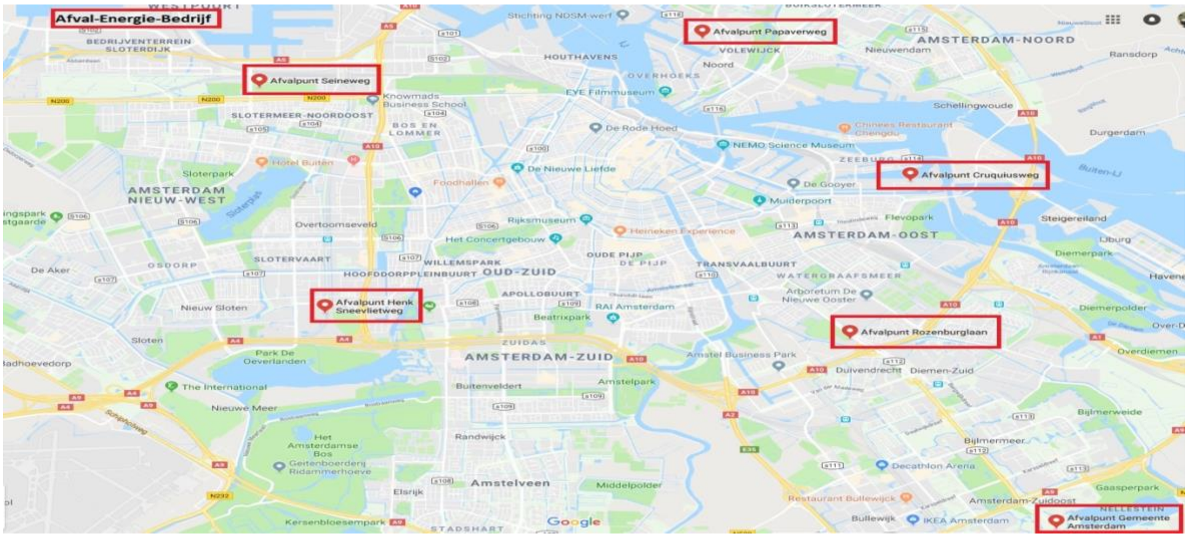

Figure 1-4:Waste collection points in Amsterdam (AEB, 2017.

The basic assumption is that introducing such a model is seen as beneficial for everyone, because it reduces harmful leftover paint and also contributes to the circular economy. A major driving factor for AkzoNobel was that a large volume of leftover paint could still be re-used but instead was destroyed in the Netherlands.

1.6. Changing the End-of-Life strategy for waste paint

For the rollout of this program in Amsterdam, several issues need to be solved. One of the biggest hurdles is that, in the waste management sector, there are very strict regulations that need to be followed. The external regulations coming from local and national government (environmental) agencies limit room for manoeuvre. Another important issue are the economic costs associated with a closed-loop supply chain. The business case needs innovative solutions to make it viable in a real-life scenario.

Internally, there is an issue that the program cuts through several departments. This means that there are a lot of stakeholders that need to be satisfied. The hazardous waste department facilitates the storage location for the paint, while the collection and recycling department will provide workers for sorting. Business development and communication are also involved in the project. The last permission is given by the health and safety department that must give the final clear to start the project.

Another issue might be the amount and types of stakeholders involved. It is a public-private partnership with a large multinational, the municipality, privatized government company, retailers and social initiatives. It is unclear which partners will continue to take responsibility and ownership after the pilot has ended.

The last issue is the quality of the paint. It is uncertain how much paint can be recovered. The estimates are between 15 - 30%. Although there are cases where only 5% is reused. The start of the pilot is in a critical phase right after the winter. The biggest risk for latex paints is freezing temperatures. It is expected that the paint is of better quality during summer.

Abovementioned challenges notwithstanding, latex paint has been identified as one of the most promising sectors with a high opportunity for circular economy potential. The existing system primarily focuses on energy recovery, which does not support the reuse potential of discarded paint. The existing waste management system seeks to reduce collection and disposal costs. In a CE waste management system, the focus will be on creating value from EoL products.

To support this CE system, better communication is needed with the product user. It should be easier to dispose latex paint in Amsterdam. Also, more information is needed on what to do with leftover paint. A specific guideline on how to deliver latex paint at the waste collection points should be made to avoid quality and quantity issues (Parajuly & Wenzel, 2017).

1.7. Research gap

Boons and Lüdeke-Freund (2013) identified that much of the research literature about sustainable business modelling does not include how companies combine the value proposition, organization of the value chain, and financial model in order to bring new sustainable practices to the market.

Their finding was correct, but my aim is to quantify these terms by using a real-life case-study. The developed framework will aim to execute a practical sustainable business model that can be used by stakeholders to make decisions. Through this research, the gap is filled for developing a new quantitative SBM framework that acknowledges both the environmental and social impact. It is a rather simplistic model that can be easily used for a wide variety of waste streams. It encompasses the most important criteria for decision making in the industry.

The outcome is a quick overview of all the relevant criteria that are needed to assess each scenario on its feasibility. It complements these criteria with limiting factors that need to be tackled. Finally, it develops new transferability criteria that are important for the success of the model.

1.8. Research questions

This study assesses the pathway towards reusing water-based paint in the Netherlands. It will analyse how current disposal methods are and what kind of impact they have economically, environmentally and socially. Through the concept of the CE, it will identify the main challenges and opportunities that need to be overcome to implement a new CE water-based paint value chain in Amsterdam.

The main question is: *What is the best option for CLOSC strategies for leftover paint and how can this be implemented in Amsterdam?*

The sub-questions that are answered are:

1. What can we learn from paint recycling internationally?
2. What are the three sustainable business scenarios for the case study in Amsterdam?
3. What are the limiting factors for recycling leftover paint?
4. Is the paint model that is developed in Amsterdam also transferable to other cities in the Netherlands?

The research objectives of this thesis are:

- To develop a framework that helps to select the best option for closing the loop of leftover paint in Amsterdam. The specific objectives of this framework were developed through a combination of literature review as well as input from the case study.

The specific objectives are:

- Integrate sustainability (economic, environmental and social dimension) in the business case and supply chain.
- Identify the limiting factors of a closed loop supply chain
- Understand the circular value chain potential of each model and assess its transferability to other cities in the Netherlands
- Compare the three end-of-life options with a SBM
- Integrate the specific case-study context of Amsterdam, AEB and AkzoNobel into each model.

1.9. Relevance for Industrial Ecology

This study is part of the master program industrial ecology. A simple definition is that IE is focused on reducing the environmental impact of industrial activities (Garner and Keoleian, 1995). Industrial ecology has a system-wide view, that considers local environmental constraints, while looking at their global impact. It attempts to be a replication of a living system in terms of waste. It does not only focus on natural capital restoration but also on the social wellbeing of humans (EMF, 2017).

Closing the loop of leftover paint fits into IE because leftover paint is part of the industrial ecology and it affects nature. The outcome is that industrial processes are redesigned to solve sustainability problems. In IE, a multidisciplinary approach from social, economic and natural sciences is crucial to understand complex situations. In footnote [1], a short introduction is given on the role of the author at AEB.

[1] The author of this research was responsible for the implementation of the paint reuse and remanufacturing model in Amsterdam. He worked and did research for eighteen months at the waste company of Amsterdam. Through his research, the author tried to bridge the gap between the abstract concept and practical reality of implementing new sustainable solutions. He gained valuable inside knowledge through his observations and his

The majority of returned leftover paint is incinerated while around 40% of the paint can be recycled. There is the possibility of closing this loop and promote the circular economy. In this case, a sustainable business model can help to compare the best options for end-of-life strategies for paint (BCF, 2015).

2. Literature review

Topics	Why
Business Model	Business Model Canvas
Sustainable Business Model	Framework

access to data. As the project manager, he was responsible on all levels (operational, tactical and strategical) of the project. His tasks consisted of: stakeholder management, project management, and business development.

Closed Loop Supply Chains	CLOSC Strategies
Global waste paint management practices	EoL strategies for paint

Table 2-1: Overview of literature review topics.

2.1 Business model

The business model is a young concept that emerged around two decades ago. It has gained substantial attention since it was defined. A few of the definitions are given below:

Teece (2010) defines a business model as: 'the design of the value creation, delivery and capture mechanism employed'. The BM addresses the basis customer needs and its willingness to pay, the way by which firms respond to and delivers value to consumers, persuade customers to pay for value, and translate those payments to profit by properly designing the various elements of the value chain (Teece, 2010, p.179).

Osterwalder & Pigneur (2005) define a BM as a conceptual tool that helps businesses to analyze, compare and assess performance, manage, communicate, and innovate their way of conducting business. In their framework, they divide the business model into three elements namely: value proposition, value creation & delivery and value capture.

Osterwalder & Pigneur developed the Business Model Canvas (BMC), a well-known conceptual map in poster format that functions as a visual language. As shown in the figure 2.1. It helps to insert pieces of information in the model and let others see the bigger picture of the BM. In addition, it shows the interdependencies between various elements of the BM. These elements combined let the viewer truly understand the essence of the business (Osterwalder & Pigneur (2010).

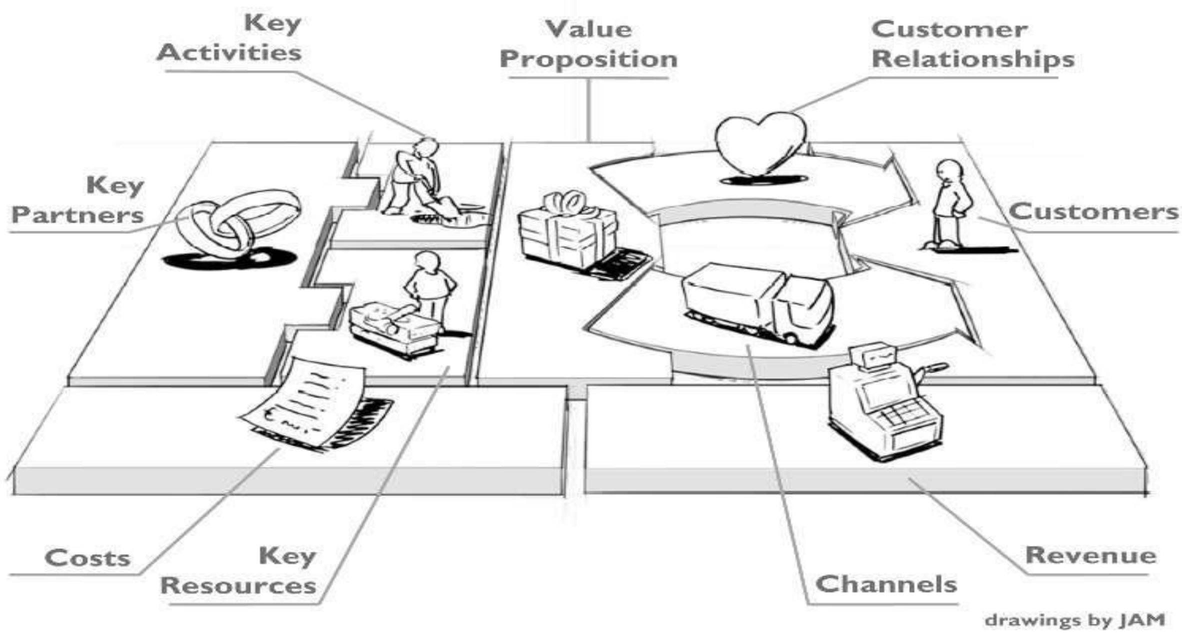

Figure 2-1: The Business Model Canvas (Source: Osterwalder & Pigneur, 2010).

The BM concept or framework also has a mediating function. It bridges the gap between nearly all domains of the business from technology, to strategy and economics. It excels as a mediator between technical inputs and economic outputs. A BM approach helps companies to adapt faster to changing market circumstances.

Moreover, the business model concept helps companies to align strategy, business organization and technology (Osterwalder, 2004, p.21).

Mainstream companies try to optimize the ratio between technical input and economic output, while sustainable companies often also should deal with other variables such as limited input variability. For example, a new production process may require a different supply chain (Hansen & Schaltegger, 2013). These problems add upon the general challenges that are associated with sustainable business models.

The most efficient method to reduce the environmental impact of human activities is to decrease resource consumption. The pressure on raw materials is increasing due to the growing world population and increasing middle class (Royal Society, 2012).

Companies that can adapt to the global situation can turn this challenge into a new business opportunity. Essential fact is that consumption patterns differentiate depending on the social, cultural and institutional context.

Companies are the driver for unsustainable consumptions patterns, while they can also be the driver for sustainable consumption patterns (Young and Tilley in Bocken, 2017). The challenge for businesses is not only to stay competitive but also to create new roles for business in society. Instead of producing more, they should opt for creating more value. In this way, a company can grow without using more resources.

Each step of the BMC will be further explained in the methodology section because it will form the basis for the framework.

2.2 Sustainable Business Models

The framework in this thesis will be based upon the Sustainable Business Model framework by Bocken et al. (2015). This section will discuss some of the existing theories about SBM.

Whelan and Fink (2016) gave the definition of a sustainable practice for companies when a company does not harm people or the planet and at best create value for stakeholders. Also, it focuses on improving environmental, social and governance performance in areas where a company has environmental or social impact such as their operations, value chain or customers.

One of relatively new definitions of Sustainable Business Models (SBM) by (Boons and Lüdeke-Freund, 2013) is: “aimed to balance the environmental, economic and social needs according to sustainable norms and values”.

To encourage sustainable patterns of consumption and production, more radical and sustainability-driven innovations are necessary. These types of innovations start mostly in niche markets and find it difficult to reach mainstream market (Tukker et al., 2008).

To reach the mainstream market, the business model needs to be designed in such a way that value proposition, value creation and other elements of the business are still environmentally, socially and economically sustainable (Charter et al., 2008). Recent literature on the transformation to more sustainable business models suggest improving efficiency, have cleaner production, and integrate corporate social responsibility (Porter and Kramer 2011; Schaltegger et al. 2012; Bocken et al. 2013, 2014; Boons and Lüdeke-Freund 2013).

To facilitate this change, a fundamental shift is needed to repurpose the function of the business. Rethinking value creation is necessary to redesign the business model. With careful planning it is possible for mainstream businesses to integrate sustainability into their business.

Schaltegger et al. (2012) proposes that companies make sustainability an integral part of their business of value proposition and value creation. The current corporate social responsibility programs split the financial performance from the ecological and social performance. In most cases, it means that the ecological and social performance has to benefit the financial performance (Salzmann et al., 2005).

It is important that companies continue to innovate their business models in order to develop new business cases for sustainability. Stubbs and Cocklin (2008) argue that sustainability concepts should be the driving force of the company and decision-making processes. Hogevoldet al. (2014) disagrees and mentions how companies often state environmental reasons as their first driving force for SBMs. In reality, however, economic reasons tend to be companies' main motivation for considering more sustainable options.

The main challenge is to design the business model in such a way that it helps the firm to achieve economic value by delivering social and environmental value. Hence, there is a high need for business model innovation (BMI) in order to develop a sustainable business model (Schaltegger et al., 2012).

Business Model Innovation (BMI) is defined by Bocken et al. (2014, pp. 44) as: "Innovations that create significant positive and/or significantly reduced negative impacts for the environment and/or society, through changes in the way the organisation and its value-network create, deliver value and capture value (i.e. create economic value) or change their value propositions".

The added benefits of an SBM model by Bocken et al. (2015) is that captured, missed, destroyed and new opportunities for value are mapped. This SBM tool can provide a simple and visual representation of the business value for companies, society and the environment.

The SBM model will be further explained in the methodology section. In this section, the SBM will be conceptualised and operationalised.

2.3 Closed-Loop Supply Chains

Closed-loop supply chains focus on the return of products. These product returns can have a variety of reasons such as: return after purchase, warranty, repair, end-of-use, and end-of-life. Depending on the product, the return can happen in days, months, years and sometimes even decades. Each type of return requires a reversed supply chain to maximize value recovery (Guide and van Wassenhove, 2006).

Guide and van Wassenhove (2009) define closed-loop supply chain management as the design, control, and operation of a system to maximize value creation over the entire life cycle of a product. That includes the dynamic recovery of value from different types and volumes of returns over time.

A key factor is that Guide and Wassenhove (2006) focus on the business aspect, rather than focusing on the environmental aspects of the supply chain. There are three reasons to backup this approach. First, most companies see the reverse logistics as a hurdle that costs extra resources while missing out on the opportunity to generate extra value from recovery. Second, remanufactured goods can help to increase the market share instead of cannibalizing the new product sales. Third, remanufactured goods are often cheaper than new products.

Figure 2.2 shows how a closed-loop supply chain (CLOSC) Is organized. The traditional forward supply chain and the additional reverse supply chain activities together form the CLOSC (Guide et al., 2003).

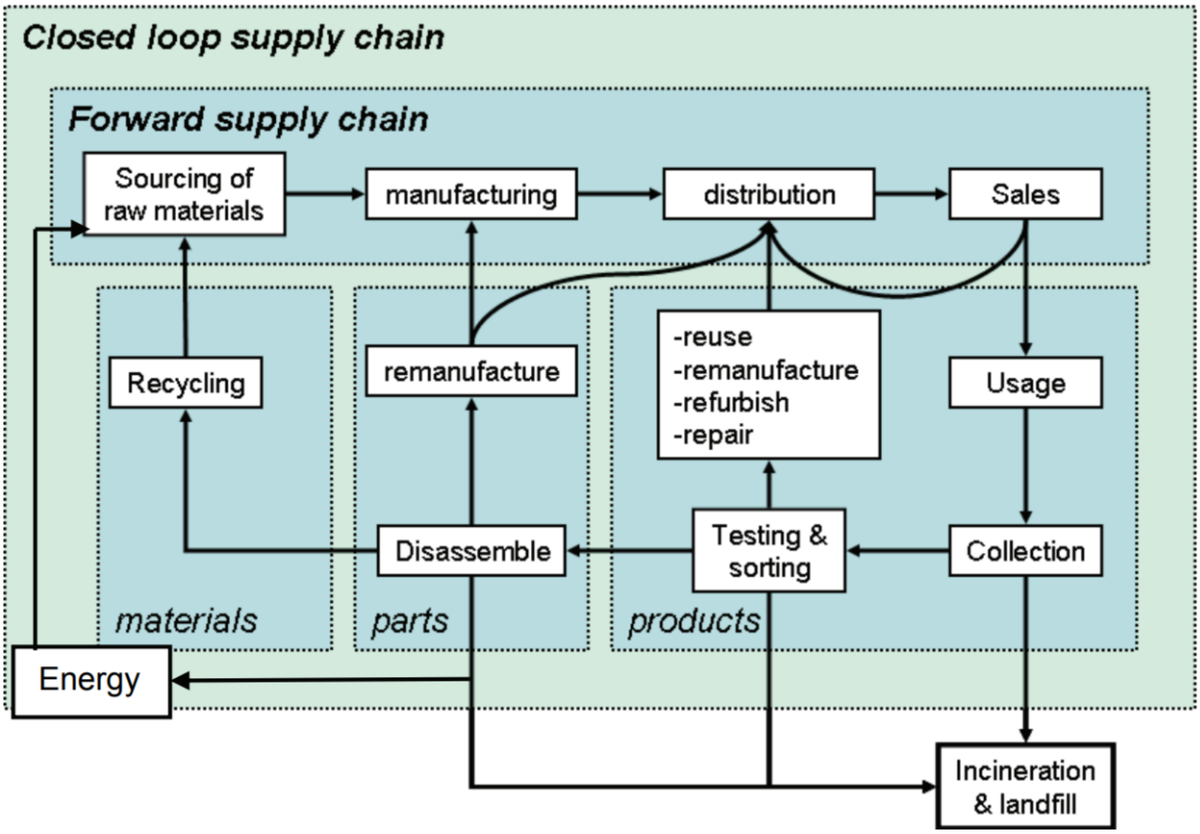

Figure 2-2: The process of a closed loop supply chain (Bloemhof et al., 2012).

The business perspective by Guide and van Wassenhove (2006) showcase that generating extra value from product returns can be an opportunity.

The growing interest in reverse logistics has two reasons:

1. Producer responsibility: European regulations require disposal tariffs, disposal bans, restriction on waste transportation, waste prevention and emission control (Hogg, 2002). Some CLOSCs will never be profitable. Legislation can be a measure to overcome this problem. A legislation like producer responsibility can help to overcome this hurdle. It can help businesses to organize systems and solutions themselves (Guide et al., 2013).

2. Consumer awareness: Consumers demand that products are recycled and produced eco-friendlier. Otherwise the consumer might go to a competitor (Krikke et al, 2003).

The CLOSC can be separated into several processes that Geyer and Jackson (2004) have identified:

- Acquisition processes are necessary to ensure the right volume of products returns with the right quality
- Recovery processes ensures that products return is reused in a meaningful way
- Integration processes find a useful outlet for the recovered products and material.

The processes are shown in figure 2.3.

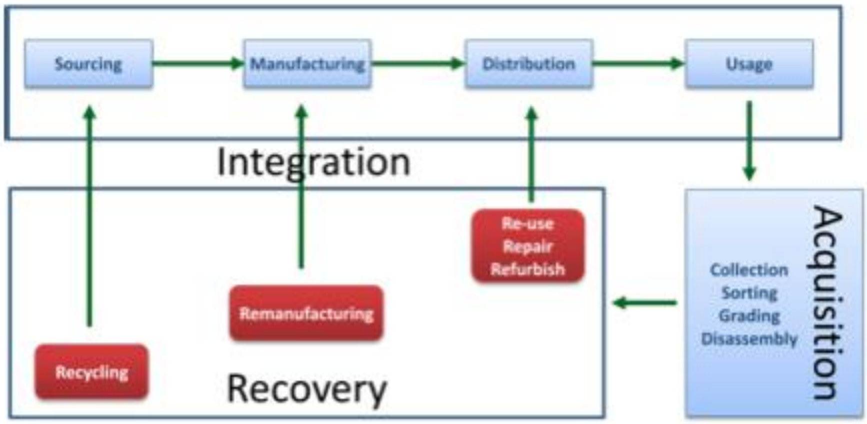

Figure 2-3: Key processes of closed loop supply chains (Koppius et al., 2011).

Acquisition includes collection from end users, sorting and sometimes disassembly operations (Quariguasi et al., 2010). Recovery options can vary and depend on the type of product returned. For paint, all three recovery steps are possible. In the current program paint is re-used directly, although it is also possible that paint is remanufactured or recycled. The type of recovery process then will be integrated in a specific stage of the forward supply chain. Another option is that the re-used paint is sold on the secondary market, like in thrift stores. This is the case in the U.K. paint scheme and in Amsterdam (communityrepaint, 2017).

The product remanufacturing matrix in figure 2.4 helps decision makers to consider action. It was developed by a remanufacturing business manager called Don Olsen from Alcatel-Lucent. The matrix does not include two important elements, namely price points and competition. Yet, it can help to classify products into different categories of opportunities for remanufacturing (Atasu et al., 2010).
If there is no product availability and the market demand is low, then no action is required. The product is not ready for remanufacturing now. The monitor category has enough market demand but not enough product availability.

The monitor category is an interesting market that can become a profitable market over time. Increasing the product availability could be a step for companies to pursue. When a product belongs in the act category, it means there is a high market demand and high availability of products. It means that remanufacturing is a viable option that should be pursued.

For example, Apple does this with their refurbished Iphones. The final category is recycling, including a high product availability but low market demand. The best choice in this category is to generate revenue through materials recycling (Atasu et al., 2010). Based on this matrix, a decision can be made for further exploration of the possible value chain pathways.

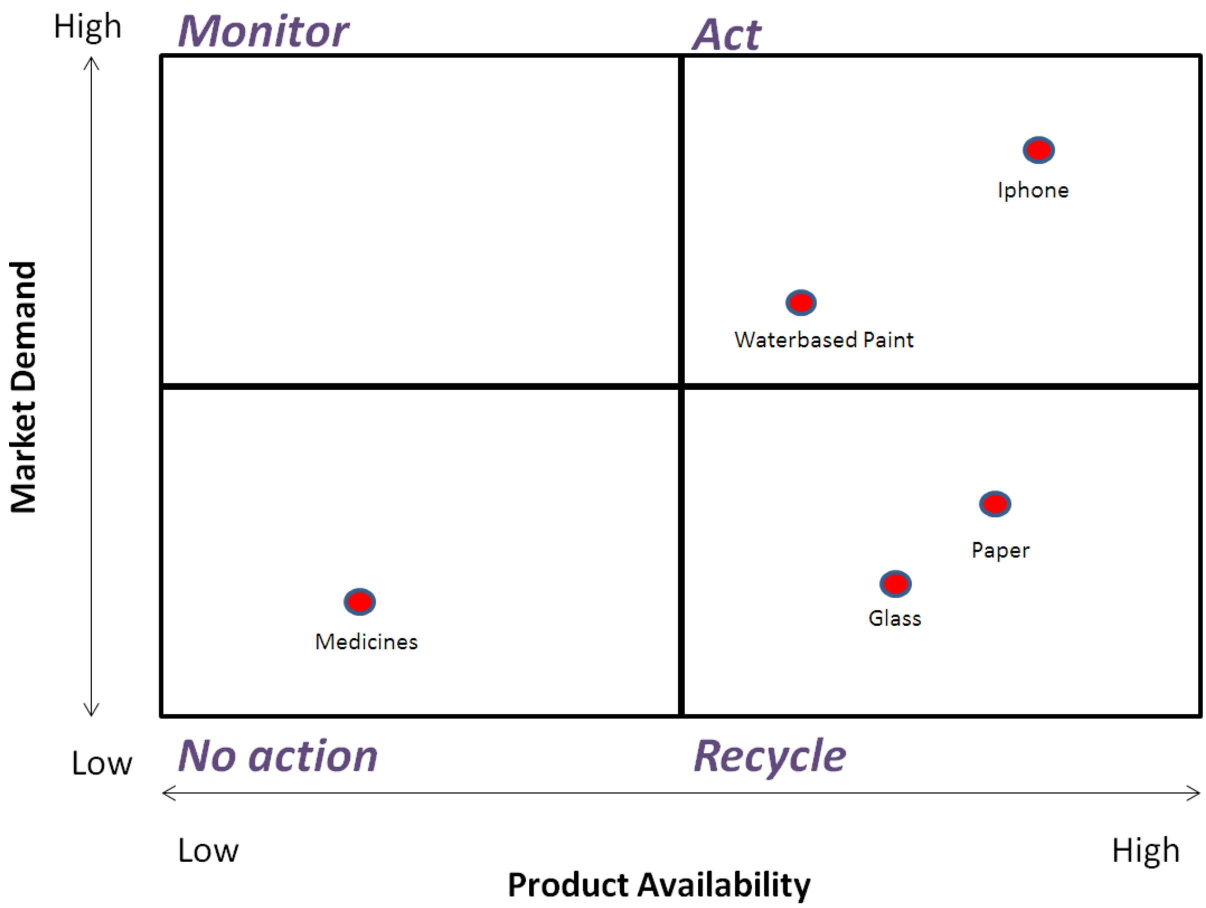

Figure 2-4: Product remanufacturing matrix (Source: Atasu et al., 2010).

2.4 Global practices in waste paint management

The coatings industry has focused on optimizing production processes in order to save raw materials and become more energy efficient. The main area where material savings and resource optimization have not been fully explored is the handling and recycling of leftover paint (BCF, 2015).

The total amount of paint sold in the world is over 25 million tons (PPP, 2004). According to AkzoNobel, around 10% of the paint in the world is unused and is considered leftover paint (AkzoNobel, 2017). One can thus imagine that the total potential amount of leftover paint in the world is huge.

Examples from the U.S. show that there are huge quantities of leftover paint in the world. The state of California and Washington together produce an estimated 50 million litres of leftover paint from households alone every year (PPP, 2004).

A considerable amount of the paint remains waste paint after usage. Paint is an important concern for the government based on the high volume in the chemical waste streams of households. The paint is problematic because of the negative environmental impacts of improper disposal. The current end-of-life management of waste paint in the Netherlands is energy recovery through incineration.

However, there are alternative options for a more sustainable end-of-life management of paint due to its high volume, expensive disposal process, and the chemical constituents with a high recycling potential. Potentially, it could lead to conserving energy, reducing costs of disposal and a reduction of greenhouse gas emissions. Several studies have been conducted to research the different recycling options of paint.

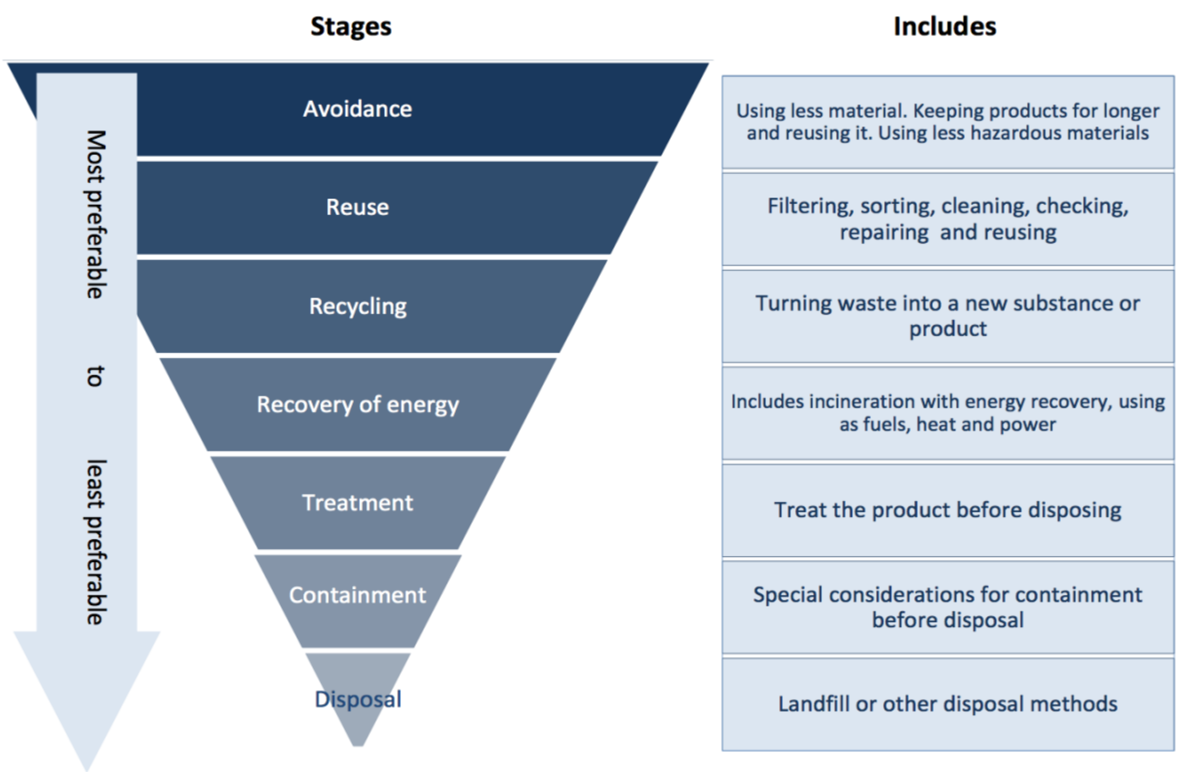

Figure 2-5: Waste Hierarchy (EPA Victoria, 2013).

The pyramid in figure 2.5 illustrates the preferred order to reduce waste. This type of hierarchy can also be applied to paint more specifically in order to select the best potential value chain for waste paint management. Avoidance is the most preferred option in the waste hierarchy. There are still several things that need to be accomplished according to Ogilvie (2016):

1. Raising awareness of sustainability with professional decorators
2. Raising awareness of sustainability in the DIY paint market
3. Raising awareness of sustainability with apprentices
4. Demonstrating good practices to members from the coating federation
5. Continued collaboration with other stakeholders

Now more specifically for paint: Eco-Paints (2017) did a SWOT analysis for paint recycling in the Netherlands that is shown in figure 2.6. In the analysis, it becomes clear that the factors for a company to recycle paint are highly diverse. It concerns sustainability but also customer experience. Since paint recycling is a new experience, it is also good for the social responsibility and reputation of the company. Together with the product remanufacturing matrix in the CLOSC literature review section, these two tools can help to make a quick decision on whether to pursue paint recycling or not. After which, a more thorough analysis can be conducted with the SBM analysis.

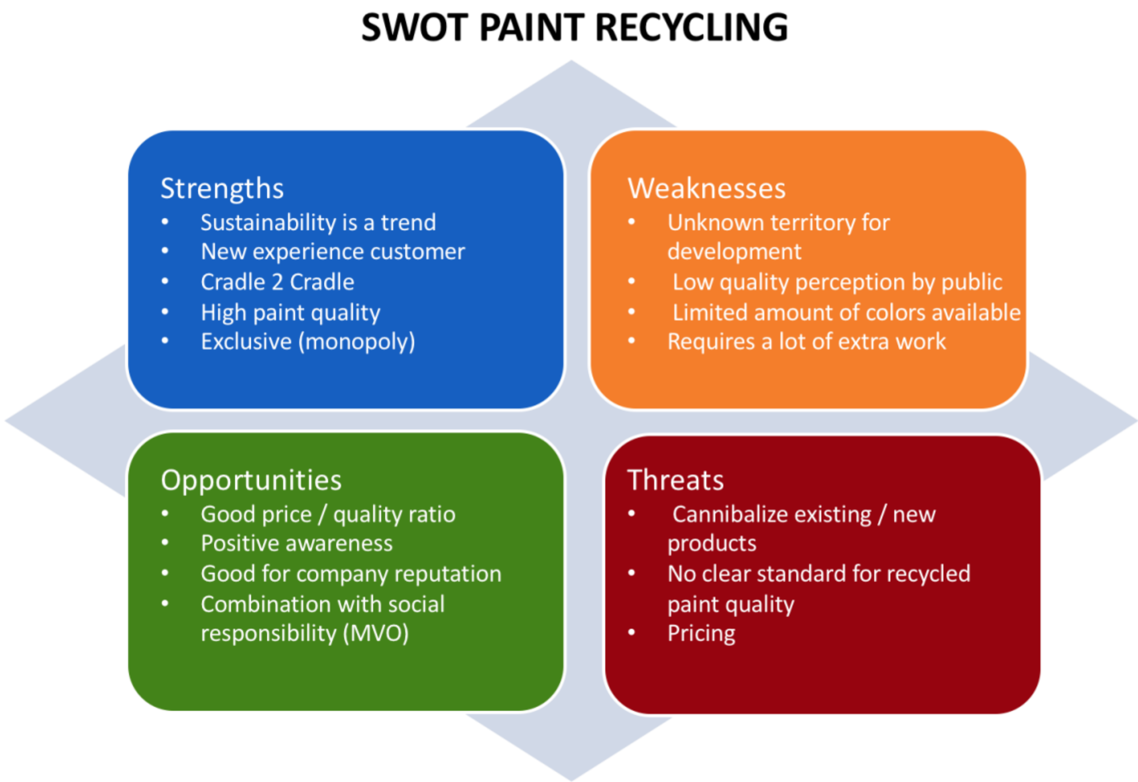

Figure 2-6: SWOT analysis paint recycling (Eco-Paints, 2017).

Figure 2.7 shows the waste hierarchy for waste paint globally. This figure is not related to figure 2.5 and not all options are mentioned. It focuses on the waste hierarchy options for paint recycling specifically. Compared to figure 2.5, it has less steps. An option that could be added to the waste paint pyramid is avoidance of paint usage. Waste avoidance is in general the most preferable option.

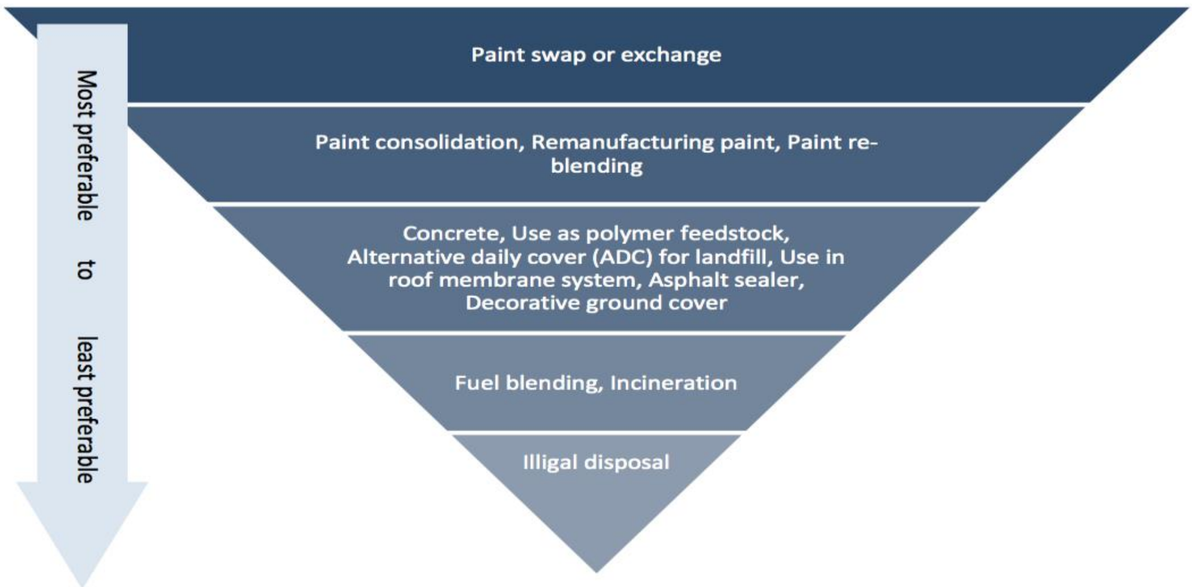

Figure 2-5: End-of-Life options waste paint (Houshamand et al., 2013).

Paint swap

The most environmentally friendly option for latex paint is to re-use it for its original purpose. The easiest way is to transfer the excess paint from households to local communities also called paint swap or paint exchange. The collected paint is checked and redistributed again to locals without processing the paint. Often, a sticker with the verification of quality is put on top of the packaging.

Although each step in the process of collection, transport, sorting to distribution can form a barrier. This type of scheme exists all over the world. Community Repaint in the U.K., Paint Recyclers in Australia and the current introduction of the Community Repaint project in the Netherlands and Belgium have shown that this model is viable (Community Repaint, 2016).

The benefit of this model is that the collected paint is used in the local area and does not need reprocessing. For quality assurances, the paint needs to be checked in the manual sorting process. Nonetheless, the efficiency of this loop is high because it saves a lot of materials and energy.

Media is important to raise public awareness around collection programs. Local governments like municipalities are a key driver for such schemes.

Paint consolidation

This method mixes paint types with the same characteristics, such as colour and chemical type. After this, the paint is mixed in a container manually. For the reprocessing, no extra machinery or transport is required. It is one of the most cost-effective methods for reprocessing paint. There are, however, a few downsides to this approach: It is labour intensive, there are health and safety risks for the volunteers who do the labour, and there is a risk of low-quality paint (Housahamand, 2013).

Remanufacturing paint

The first method where extra resources are needed is remanufacturing paint. The process gets more complicated because a higher quality and performance is required, resulting in more professional staff and machinery being necessary for the reprocessing.

The extra steps in the supply chain will put pressure on the paint price, especially if it has to compete with the conventional paints in the stores. The advantages are that new additives, pigments, and virgin paint can be added to meet specific customer needs. Government regulations can play a major role to stimulate this process.

Dulux, a paint brand produced by AkzoNobel, did a pilot project in Australia in 2003. The initial price per kg paint was 8.67 Australian dollar and eventually dropped to 0.74 Australian dollars at the end of the pilot. Dulux Walpamur substituted 60% of virgin paint with recycled paint, while reducing their carbon emissions with 1 kilogram per litre of paint produced. The project ended due to bacterial contamination, financial constraints, technical risks, lack of warranties and the quality of collected paint (Sustainability Victoria, 2007).

Paint Re-Blending

This method is very similar to the previous method and only differs in terms of the recycled paint being used. Approximately 20% of recycled paint or less is used to produce new paint. The inflow can be consolidated paint and is often already pre-sorted. The main advantage compared to the remanufacturing of paint is that the quality level can be the same level as virgin paint. All the other risks for the remanufacturing of paint are largely redundant. A con is that only a small part of the paint is reused, and a large part is made from virgin materials.

Energy recovery

The end-of-life options for paint is limited at the moment. The most common form of end-of-life is energy recovery, which is slightly better than throwing it away in a landfill. It is crucial to assess new recovery methods because waste paint forms a large part of the small chemical waste, is expensive to dispose of, and has good recycling opportunities (Housahamand et al., 2013).

Illegal disposal

Illegal disposal is the worst option. All the other options for waste management are setup to avoid this. However, it occurs that households throw away their leftover paint in landfills. Unfortunately, this is not unavoidable. Therefore, it is encouraged to have as many waste collection points close to every household.

2.5 Summary

The literature review is the first detailed chapter about the thesis research. It has provided an overview of important topics that will be further discussed, analysed and implemented. The BM theory is the fundamental theory for the framework that will be discussed in chapter 3. Osterwalder & Pigneur (2005) define a BM as a conceptual tool that helps businesses to analyse, compare and assess performance, manage, communicate, and innovate their way of conducting business.

The SBM model theory is based on the BM theory with the addition of sustainable elements. However, including sustainability into a business models does not mean that it is an SBM. To achieve real sustainability, Schaltegger et al. (2012) argues that sustainability should become an integral part of the company. Now, sustainability is often used for the financial performance rather than environmental and social performance. Stubbs and Cocklin (2008) agree and are in favour of making sustainability the driving force of a company and is included in the decision-making process. Hogevolder et al. (2014) disagrees with this argument. His research concluded that many companies promote sustainability as a first driver to change, while they are in fact economically driven.

The conceptual framework in the next section will operationalize the conceptual SBM framework by Bocken et al. (2015). It will be used for the case study in Amsterdam. Not only are the results of the case study interesting to compare. It can also help to see if sustainability is integrated into the BM or that it is an SBM. Meaning that environmental and social performance are also important decision-making criteria.

The CLOSC theories discuss how the forward and reverse supply chain can be integrated. Together they form the CLOSC. There are many opportunities to create extra value over the entire life-cycle of a product. However, most companies think that it is a waste of resources. Guide and van Wassenhove (2006) are opposed to this idea and see reverse logistics as a business opportunity. They identify drivers that convince companies to manage the end-of-life of their products. The last section uses a SWOT analysis by Eco-Paints to present important factors for companies that help Eco-Paints make decisions regarding paint recycling.

The final part of the literature review will look into the global waste management options for paint. The most common options for waste management of paint have been discussed, in which two working models in the U.S. and Canada are briefly explained. Interestingly, both countries have a levy system for the management of waste paint. Three of the waste management options will be used for the case study. The three options are energy recovery, reuse / consolidation and remanufacturing.

3. Framework, methodology and tools

This chapter provides the methodology of the research and introduces the conceptual framework. The conceptual framework will be based upon the SBM framework provided by Bocken et al. (2015). Then, the scope of the research is defined. This will include the main advantages and disadvantages of the framework. Finally, the system boundaries and data collection methods are discussed.

3.1 Conceptual framework

The fundamentals of the SBM framework is that system-level challenges such as climate change and natural resource use need to be tackled. Most companies do not internalize the costs of their externalities. These externalities such as emissions and pollution have a negative impact. The costs of are carried by planet earth and societies.

It is essential that these systemic challenges are tackled by a collaboration of stakeholders instead of individuals. Companies need to have greater trust, better customers and a long-term vision in order to become sustainable.

The business model framework can help businesses to develop a structured way of exploring the opportunities for value creation across the supply chain and value capturing.

Bocken's framework is rather conceptual and the used data is qualitative. The framework for this research paper will be practical and quantitative-oriented. It will incorporate the business model, closed-loop supply chain and SBM frameworks.

Through these eleven steps, a comparison can be made between the models.
It will provide guidance in the decision-making process of selecting the best closed-loop supply chain model for leftover paint Amsterdam.

Sustainability can be integrated, specific characteristics of each model can be identified, costs and benefits can be calculated, and the value chain of each business model is understood. Figure 3.1 shows the conceptual SBM framework by Bocken et al. (2015). The concept of each step will be explained using largely the BM theory by Osterwalder & Pigneur (2010). The role of sustainability in each step is given as an example. Finally, the concept will be operationalized for the results.

Figure 3-1: Conceptual sustainable business model framework (Bocken et al., 2015).

1. **Concept of product / service:** The product and service create value to the customers in a systematic and sustainable way. Value can be generated from a variety of resources, such as: innovation, lower cost, or higher quality. To customers, the value proposition of the company is a crucial factor in choosing one company over another (Osterwalder and Pigneur, 2010).

   Operationalization of the product / service: In terms of the delivered product, there is a focus on the main outputs of leftover paint. These outputs can be divided into: electricity by incineration, residual waste heat by incineration and amount of recycled paint in cans.

2. **Concept of customer segments:** A company has to make important decisions regarding which customer segments they want to serve. This is the most important part of the business model since the customer need and behaviour have to be identified. The type of customer segments can be classified into: mass market, niche market, segmented, diversified and multi-sided platforms (Osterwalder & Pigneur, 2010).

   Operationalization of customer segments: The number of customers is counted, and their role is explained, including their type of customer segment.

3. **Concept of value for customer, society and environment:** The value proposition should not only benefit the customer and the company but also the society & environment. All the negative externalities such as emissions and pollution are carried by society and the environment.

   Operationalization of value for customer, society and environment in terms of CO2 emitted
   The extra value created for society and the environment can be measured by the amount of CO2 emissions prevented from getting into the atmosphere and the amount of waste prevented.

Value creation & delivery

4. **Concept of Activities:** Key activities for paint recycling are: collection, (re)processing, marketing, distribution, and incineration. These are the most important activities that a company must do in order to make the business model work. The focus is on creating and delivering the value proposition, reach new markets, customer relationship and revenue. (Osterwalder & Pigneur, 2010.

   Operationalization: Activities (amount of extra work created in FTE)
   The activities include all the essential operations that a company has to do in order to make the business model work. Since the research is quantified, the key activities are shown as the amount of extra Full-Time Equivalent of work created in addition to classification of the activity.

5. **Concept of Resources:** All businesses require resources to conduct activities. These resources can be production facilities, human resources and other types of resources. Most resources are physical, financial, intellectual, or human (Osterwalder & Pigneur, 2010).

   Operationalization of resources:
   The assets will be operationalized in terms of how many different types of the key resources are needed (physical, financial, intellectual or human).

6. **Concept of distribution channel:** This step is about how the company can deliver the value proposition to the customer. The value is delivered through physical or online stores (Osterwalder & Pigneur, 2010).

   Operationalization of distribution channels:
   The distribution channels are physical places where the product is sold. Electricity is sold through the grid. Heat is sold through pipelines that go into the city of Amsterdam. The paint is sold through thrift stores.

7. **Concept of key partners:** This is the network of partners and suppliers of the company. Partnerships are crucial for the survivability of a company. Osterwalder & Pigneur (2010) identified three factors to form partnerships: risk reduction, scalability and uncertainty about acquisition of resources and activities.

   Operationalization of key partners
   Building partnerships is important for a lot of reasons. For instance, if the costs of a project are too high for one company. The risks can be split in a joint venture. It is difficult for one company to own the entire supply chain (Osterwalder and Pigneur, 2010). In the results, the amount of extra new partners is compared to Business-As-Usual.

8. **Concept of technology level:** There is no clear definition given by Bocken et al. (2015), but the assumption is that they refer to the main technology that is needed to make the BM work. It aligns with the resources needed. The technology needed are for: incineration, paint reuse and paint remanufacturing.

   Operationalization of technology and product features (product level in waste hierarchy)
   The type of technology that is needed to facilitate the BM.

Value capture

9. **Concept of cost structure:** This step describes the associated costs of operating the business model. The costs can be calculated after the activities, resources and partnerships are defined (Osterwalder & Pigneur, 2010). The capital expenditure (CAPEX) and operational expenditure (OPEX) will be included as well.

   Operationalization of cost structure & revenue streams
   This section focuses on the regular business case and the associated costs.

10. **Concept of value capture for key actors including environment & society:** This concept relates to what kind of value proposition is delivered to the customer, environment & society that can be captured (Bocken et al., 2015).

    Operationalization of value capture for key actors including environment & society
    The value captured for the environment is expressed in percentage of raw materials recovered and on what waste level. The value captured for society is expressed in the amount of social jobs created and

amount of social initiatives (thrift stores) involved. The re-use of raw materials and creation of new jobs for society are seen as very important factors that can contribute to the environment & society.

11. **Concept of potential growth strategy / ethos:** The growth strategy is linked to the growth potential and scalability of the BM.

    Operationalization of growth strategy / ethos:
    The growth strategy projects the potential of growth in the future of the business model. A new innovative business model might be more attractive for investments because it has more potential to grow than the already existing business model. The growth strategy will be quantified in terms of extra waste handling of leftover paint generated in tons.

Summary

Table 3.1 shows all the steps that are needed to make an SBM work. The right section focuses on the operationalization of all the steps. The SBM framework will provide a holistic overview of all the three scenarios.

The limitations of the framework will be discussed in the discussion chapter.

Concept	Indicator of element
1. Value proposition / product / service	- Electricity in MWh - Heat in GJ - Amount of 5L recycled paint buckets
2. Customer segment and relationships	- Amount of customers - Customer segment
3. Value for customer, society, and environment	- CO_2 emitted / prevented - Amount of waste prevented
4. Key Activities	- Amount of FTE created - Type of activities
5. Key Resources	- Amount of key resources needed
6. Distribution channels	- Number of stores
7. Key partnerships	- Amount of new extra partners
8. Technology and product features	- Type of technology used
9. Cost structure and revenue streams	- Revenue and costs - CAPEX and OPEX
10. Value capture for key actors inc. environment & society	- Raw materials percentage used - Social jobs created in FTE - Amount of thrift stores involved
11. Potential growth strategy / ethos	- Potential of leftover paint that can be collected

Table 3-1: Operationalization units matrix

3.2 System boundaries and assumptions

The system starts once the paint enters its end-of-life stage.

The main geographical research area of this study is the city of Amsterdam and the industrial facility of AEB in Amsterdam. This is the main plant where the paint is collected from all the waste collection points. The field study for the re-use model was done at this facility.

The second important geographical area was the field study visit to the U.K. The main purpose of this visit was to gather data about the remanufacturing process. The remanufacturing facility was called Recipro and was located in Liverpool.

The third geographical area is the city of The Hague. One research question will look into the possibility of transferability of a paint recycling model from Amsterdam to other cities (The Hague). There was one visit to the municipality of The Hague to talk about recycling paint.

All three scenarios only take into account the important revenue streams. An example is the BAU model where only the following revenue streams are taken into account: paint processing revenue for client, paint processing cost internal, revenue electricity production and revenue heat production. All the other costs are not included.

The system scope for environmental impact is focused on the amount of raw materials recycled, and on how much CO2 is saved during that process.

For social impact, the scope is the amount of social jobs created and thrift stores involved.

The system boundaries end where the streams become much more intertwined with other waste streams. Residual ash is not taken into account.

Furthermore, transport is not taken into account for the environmental impact part because the paint is transported with existing lines (AEB, 2018b). This means that no extra transport is needed. Once the process is scaled up, transport will of course become more important

The system does also not take into account recycled paint that becomes leftover paint again. It is unavoidable that it happens and will lower the environmental benefits of recycled paint. However, this is left outside the scope.

3.3 Introduction SBM Scenarios

The three scenarios are based on real life data. The data gathering methods and analysis are given in the next paragraph. The Netherlands has around 10 million litres of leftover paint. This is around 13% of the total market and approximately 50% is reusable according to AkzoNobel (2017c).

The paint reuse pilot started in February 2017 in four cities. The remanufacturing model will only start in Amsterdam. The aim of the pilot was not commercial. The scenarios that are developed will be commercial and is based on the total capacity of leftover paint that is processed at AEB. Annually, around 300 tons of paint is collected from the Greater Metropolitan Region.

More information on the case-study can be found in the previous sections 1.4, 1.5 and 1.6 of this research. The end-of-life options that are used in these scenarios are described in section 2.4.

Business-as-usual

Each scenario is based upon the current amount of leftover paint that AEB collects. Scenario 1 is the business-as-usual model, meaning that the paint is incinerated to recover its energy. The produced electricity is used for the city of Amsterdam. A part of the residual heat is used in a heat network for houses in Amsterdam.

At the moment, energy recovery is the main strategy for leftover paint waste management in the Netherlands (communityrepaint, 2018).

Re-use

Scenario 2 is the re-use model. The re-use model is based on the field study pilot that was conducted from March 2017 – June 2017. Like the business-as-usual scenario, the assumption in the re-use model is that 300 tons of paint are collected and processed annually for reuse.

'Re-use' here means that the collected paint is checked, sorted and brought back to the market. Through the re-use process, approximately 15% of all the leftover paint can be re-used. The majority (85%) is still incinerated for energy recovery.

The re-use model is often the first step into leftover paint recycling because it requires low investments (AkzoNobel, 2017b).

Remanufacturing

Scenario 3 is the remanufacturing model. The pilot is setup to start in September 2018. To compare all three models, scenario 3 also predicts to process 300 tons of leftover paint annually for remanufacturing.

Remanufacturing means that the collected paint is checked and further processed in a larger batch. New additives are added, and the remanufactured paint is put into new cans. Through the remanufacturing process, around 35% of all the leftover paint can be recycled. It is also possible to get a higher price for the paint since its quality is improved (AEB, 2018b).

The remanufacturing model requires larger investments because more machinery and time is needed to setup this project. It is seen as the last step in the Community Repaint pilot (AkzoNobel, 2017a).

3.4 Data gathering

The data for this thesis is gathered through several sources. First of all, an extensive amount of literature was used. The literature also consisted of internal reports that were delivered by AEB, AkzoNobel and Newlife Paints. This was mainly used for the introduction chapter and in the results section about the current status of leftover paint waste management.

Secondly, data was gathered in the field and the use of internal reports of the companies. However, it was difficult to structure all the data correctly because it was impossible to process the enormous amount of available data. The cost calculations are based on many different metrics such as electricity costs, material costs, machinery cost, labour cost and so on. These can be specially found in the annex 9 - 11 about business cases.

The data for the first scenario was gathered through the use of internal data from AEB combined with LCA data about leftover paint.

The data for the second scenario was gathered through the field study that was conducted in March 2017 – June 2017. In this period, the paint was sorted and reused every week by employees of AEB. The costs and production of the reuse model were monitored.

The evaluation report of the field study was used to form the basis for second scenario. The calculations for the 300t scenario were based on the field study data, LCA data about leftover paint and internal reports from AkzoNobel.

The data for the third scenario was based on field study data from the U.K. where remanufacturing already took place. Other important data came from Newlife Paints and AkzoNobel.

The data for limiting factors was collected during the course of the research and during the field study. Many of the barriers were identified during the project management phase of the two projects. The data consisted mainly of documents from various stakeholders such as the local environmental agency, expert opinions and internal policies.

Documentation

Documentation is one of the most important ways to collect data. Yin (2009) argues that for almost every case study documentation is needed. In this research, the use of documentation is very crucial. It consists of e-mails and collected reports with experts. Important documents are shown in the table below.

Title	Topic	Source
Project proposal latex reuse Amsterdam	Implementation plan reuse	AEB, AkzoNobel, Municipality of Amstedam, Thrift Stores
Project proposal latex remanufacturing Amsterdam	Implementation plan remanufacturing	AEB, AkzoNobel, Municipality of Amstedam, Thrift Stores
A Resource Efficiency Action Plan for Decorative Paint	Creating a circular economy for leftover decorative paint in the U.K.	David Cornish – AkzoNobel
California Waste Paint Programme	Waste paint in California	David Cornish – AkzoNobel
Post-Consumer Paint Waste Management	Waste paint in Canada	David Cornish – Akzo Nobel
PaintCare Paint Stewardship Program (USA)	Non-profit organization that runs paint recycling operations in the U.S.	David Cornish – AkzoNobel
Environmental Footprint Report	LCA about paint	AkzoNobel and Newlife Paints
Factsheet pilot recycling verf-restanten Amsterdam	Initial project plan for the Netherlands	AkzoNobel
Permit for reuse paint	Legislation about end-of-waste	Omgevingsdienst – Local environmental agency

Table 3-2: Documents overview

3.5 Data analysis

The analysis for the data consisted of four steps. First, the gathered data was structured, proofread and corrected from the three scenarios. The BAU scenario already existed for years and there was a lot of data available. The reuse scenario was conducted as a case-study and data was collected. The remanufacturing scenario is purely based on assumptions that was provided through documentation.

For each specific question, the relevant data was selected. Sometimes the data was ready to use but, in many cases, calculations needed to be made in order to match criteria of the developed scenarios. Meaning that the production will run on full capacity.

The data was then put into the framework for comparison. This helped to analyse the data in an orderly and quantitative way.

4. Results

4.1 Waste paint management practices globally

In this first part, three paint recycling models in the world will be discussed. Although all three countries are Western because other countries do not have such a scheme yet.

One of the most promising schemes is the PaintCare program that was established by the American Coatings Association and the paint manufacturers. Current studies estimate that there are more than 200 million litres of leftover paint available annually.

The first program started as a three-year pilot in Oregon. In 2013, it became a permanent program. The program has expanded further into California, Colorado, Connecticut, District of Columbia, Maine, Minnesota, Rhode Island, and Vermont (Paintcare, 2018). Additional information can be seen in figure 4.1.

PaintCare is funded by a state fee that is levied on the amount of paint sold. The fee is around $0.35 under 3.7 litres. The fee is around $1.60 above 3.7 litres (Paintcare, 2018).

The water-based paints are separated from the solvent based paints. The oil-based paint is used as fuel for energy recovery. The water-based paints are directly reused (1-2%), sent to a landfill (5-6%), or send to other paint recycling companies. The paint that is directly reused consists mainly of unopened cans of paint. The paint that is sent to a landfill was rejected. The remaining 94% of the paint goes to paint processors. It goes into the same process as at AEB. A part will be rejected and incinerated or sent to a landfill. Another part will be reused or remanufactured (Paintcare, 2018).

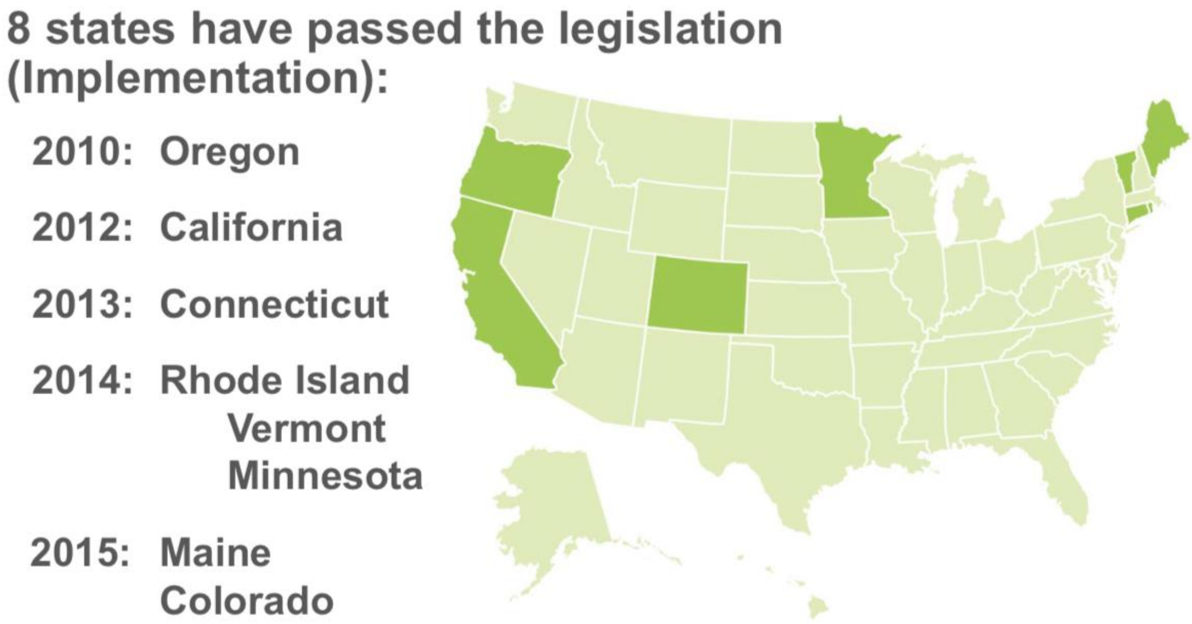

Figure 4-1: Paint scheme U.S. (PaintCare, 2018).

Another paint scheme exists in Canada. The drivers for recycling were the same as in the U.S. The majority of paint ends up in landfills and costs a lot of money for local governments. Due to tightening budgets of local government agencies, the agencies lobbied on a provincial level that the Producer should pay. The province set up a legislative framework to tackle the issue. Resulting in a levy between $0.25 - $0.45 Canadian dollars for every can bought. In Ontario there was a proposal to go above $1. Paint manufacturers heavily objected this raise (Cornish and Cook, 2011).

There are two different paint schemes in Canada. The paint scheme Stewardship Ontario (SO) is set up by the government and is run through a non-profit organization. Product Care (PC) is another non-profit organization setup by paint manufacturers. The government only defines the outcome, not how the solution is organized.

The SO sends their paint to Boomerang Paints, a non-profit business that reprocesses collected paint. The retail price of the reprocessed paint is half of the commercial paint price. Their approach to collecting the paint is through the retail stores such as Home Depot. The SO is also cash-neutral due to the government involvement (PaintCare, 2018)

The PC initiative is different because anyone can apply to run a paint recycling scheme. Their scheme is audited by the provincial government. Most of the paint is collected through the waste collection points (60%) and retail stores (15%). The PC initiative has low involvement of the government and can keep cash reserves. This is mostly used to keep the existing levies for paint low for the future (PaintCare, 2018).

Waste paint management practices in the U.K.

Every year there is fifty million litres of leftover paint in the U.K. AkzoNobel estimates that around 20 million litres is reusable. As is shown in the figure 4.2.

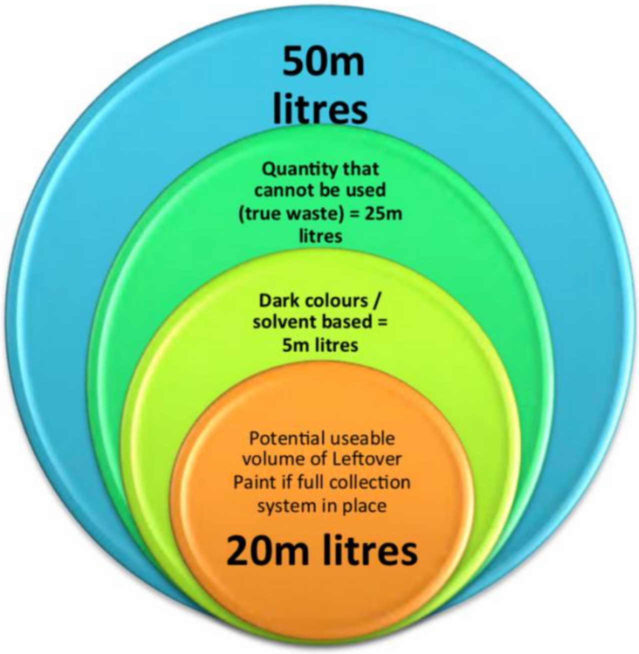

Figure 4-2: Leftover paint in the U.K. (BCF, 2015).

More than 95% of the paint is being incinerated at the moment (BCF, 2015).
The paint pilot that is introduced in the Netherlands is based upon practices in the U.K.
AkzoNobel started the Community Repaint program in 1993 together with the Leeds City Council. By 2003, there were 49 schemes in the U.K. In 2015, the first paint remanufacturing scheme started with the help of AkzoNobel (CommunityRepaint, 2018).

This section will describe the U.K. program and compare it to the program in Amsterdam.
Why did the pilot select the U.K. model? In the U.K. paint is already being recycled for more than 20 years. Every year around 500.000 litres of paint is recycled. The potential is that every year approximately 20 million litres of paint can be reused or remanufactured in the U.K. The lessons that are learned in the U.K. can be of value for the program in the Netherlands. Currently, it is the only large-scale paint decentralized recycling program in Europe (BCF, 2015).

Figure 4-3: Remanufacturing facility Recipro.

A field visit was conducted in November 2017 to see the U.K. model. Figure 4.3 shows a remanufacturing facility. An important finding during the field visit was that most of the programs in the U.K. are run by volunteers. The volunteers have a deal with local waste companies to pick up the leftover paint and retrieve the good paint. Everything that is declined will go back to the waste company. The waste company in return has to process less leftover paint which makes it financially attractive for them.

In the Netherlands, there are more rigorous rules concerning waste streams. Volunteer organizations are not allowed to work with leftover paint in facilities.

Still there are similarities between the Netherlands and the U.K. in terms of the paint content, collection system, involved stakeholders and production process. Yet, there are differences in culture, legislation, handling of waste and the ownership of leftover paint. The differences and the similarities will be further discussed in the results chapter. Figure 4.4 shows how the remanufactured paint looks like in new cans and how it sold in the stores.

Figure 4-4: Retail store for remanufactured paint.

Lessons learned

It is interesting to look at the models in the Anglo-Saxon countries and learn from the experiences there. The North-American models are centralized and large. The model is paid for by the consumer that buys new paint. While the U.K. model is decentralized, and the model is paid for by the revenue from the sales of reused paint.

The models in the U.S. and Canada are either controlled by the government or are backed by paint manufacturers. The U.K. model has less help from either the government or paint manufactures.

The enforcement of legislation about leftover paint is less strict in the U.K. then in the Netherlands. It allows non-profit organizations to become an intermediary between the waste collection points and waste handlers. In the Netherlands, a license is required to handle waste, but this is not required in the U.K.

The Dutch model will be in between the U.K. model and the North-American model. It is more organized than the U.K. model but less organized than the North-American model.

4.2 Sustainable Business Modelling for Amsterdam scenarios.

The literature review discussed the most common global paint recycling strategies. The next step was to zoom in on a national level and look into the paint schemes of the U.S. and Canada. They provided some insight in how these schemes operated and differed.

The previous section was about the waste management practices in the U.K. The U.K. model is different paint scheme then the ones in North-America because they are organized decentralized. This setup was chosen by AkzoNobel as the best possible scenario for the Netherlands. Therefore, the current setup was introduced in Amsterdam.

The value chain for paint recycling in figure 4.5 shows that collecting paint for energy recovery is the main activity in the Netherlands. Another activity is to export it to other waste processors if the party cannot handle it themselves. The other activity that is now being tested in the Netherlands, is to reuse the paint directly after the sorting process. This is easiest and quickest option to recycle paint.

The final studied method is upcycling paint to enhance the quality or recycling percentage of the paint. This method requires extra investments like machines, facilities and technical training.

The activities that will be studied are: energy-recovery, paint consolidation (reuse) and full remanufacturing.

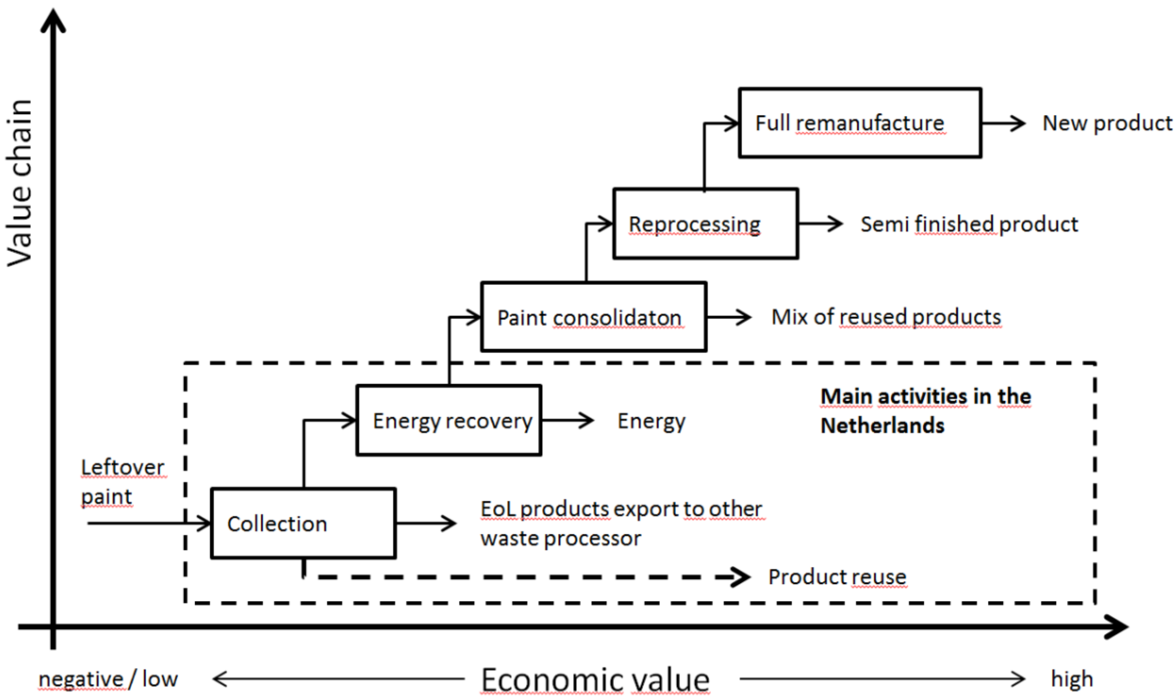

Figure 4-5: Value chain leftover paint waste management.

The market for leftover paint is still under-developed. Markets barriers for recycled paint include a perception among consumers that the paint quality is quite low, lack of available colours and quantity. Furthermore, the paint may contain unknown hazardous materials.

Interesting issue about the product return of leftover paint is that it is stored too long. Each household has twelve to thirteen buckets in their house. Households store the leftover paint in their house until the quality is so bad that it loses much of its recycling value (communityrepaint, 2017). To retain the value of the product, the importance of speed and acquiring returns is of utmost importance for a successful reverse supply chain.

The opportunities that derive from a circular value chain can be: low-cost source of raw materials for new products, good marketing for customers of reblended and recycled paint, incorporating paint into other products such as cement additives and opportunity to further identify the viability of recycled paint sales in the market (PSI, 2014).

For more information about the case-study and the scenarios. Please go to section 1.4, 1.5, 1.6, 2.4 and 3.3.

4.2.1. Business-as-usual / Waste-to-Energy

In general terms, the material flow of leftover paint starts with the consumer bringing the leftover paint to a waste collection point. From there, it is transported to the main processing facility. A simple overview is shown in figure 4.6. The figure shows how the leftover paint moves from one location to another. In the end, all the paint is brought directly to the bunker for energy recovery.

The excess stock of paint manufacturers is brought to other parties such as social initiatives and / or sold to commercial parties. The excess stock of paint manufacturers is not part of the 300 tons of leftover paint. It is a separate stream.

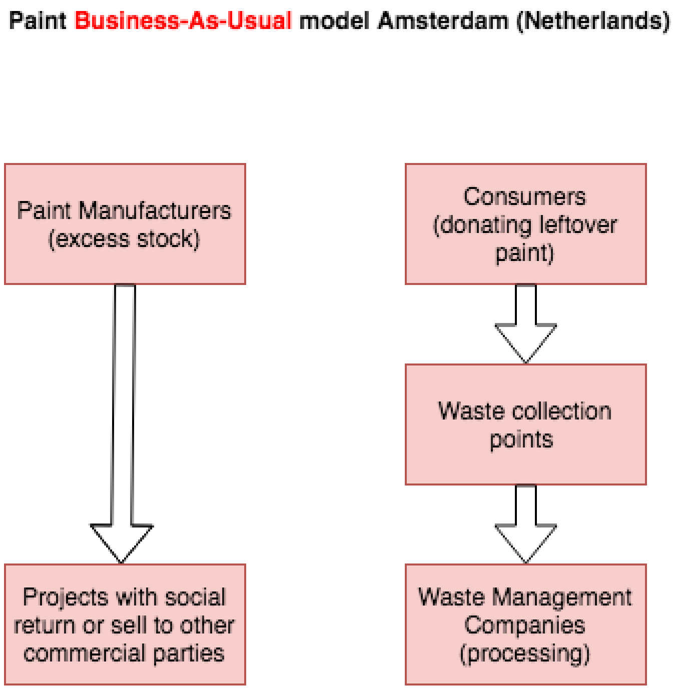

Figure 4-6: BAU Model Amsterdam for leftover paint.

To understand the value chain of the leftover paint, figure 4.7 shows the whole process of leftover paint at AEB from collection to disposal including the different business departments that handle the paint. It also does not include other streams or processes if they do not mix with the paint stream.

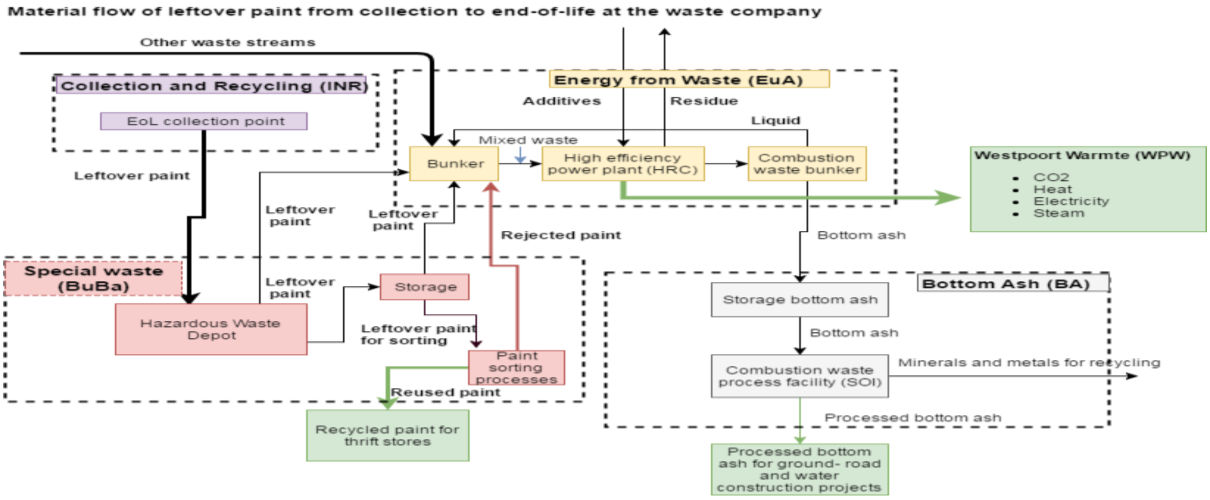

Figure 4-7: Material flow diagram of leftover paint from collection point to end-of-life disposal in Amsterdam.

The paint in the bunker is mixed with other waste streams to have the right calorific value. After which, it is incinerated in a special oven with a flue gas cleaning system and the energy is recovered. The main output is heat, electricity and steam for the city of Amsterdam. Although, this process also produces CO_2.

The residual is mainly bottom ash. This is polluted ash from the combustion process in the oven. It is processed in the combustion waste process facility after which the streams are separated. The main materials retrieved are ferro, non-ferro and processed bottom ash. The ferro and non-ferro are further processed in another installation. However, this is out of scope.

A typical latex paint has around 15% of titanium dioxide pigment (PSI, 2014). Titanium dioxide is the oxidized version of titanium, but it is not retrieved as a metal from the bottom ash because the temperatures during incineration are too high for the metal. The remaining processed bottom ash can function as a substitute for sand and gravel in ground-, road-, and water construction projects (VA, 2017). However, it is a waste stream and not as a resource stream. Therefore, a fee is required to dispose the processed bottom ash by third party contractors.

4.2.2. Reuse

The second waste management strategy for leftover paint is reuse. This is the most environmentally friendly option for reusing paint. The paint is collected, quickly checked and redistributed again without any difficult processes. The paint content and packaging stay the same. In most cases, some sort of sticker or label is put on the packaging to verify that it is checked. Annex 2 shows the training day and the reuse instructions from AkzoNobel.

This was the starting strategy for the Community Repaint pilot in Amsterdam. The reuse model is the only one that was tested in the field. The test lasted for four months in 2017. The gathered data was used to develop the new scenario for reuse. This data was further calculated to develop a scenario where 300 ton is processed. In comparison to the remanufacturing model, this was real data and not based on assumptions.

The principles of this strategy are: to reduce the environmental impact by paint residue and to contribute to the circular and social economy. Although each step in the process of collection, transport, sorting to distribution can form a barrier. In figure 4.8 there is an overview of the reuse model in Amsterdam. A difference to the BAU model is that the excess stock of paint manufacturers also mixes with the streams from the waste company. It is caused by the social goals that both stakeholders want to achieve. There is a new integrated connection between the actors in the supply chain. From this connection, new cooperation's can develop.

These types of schemes exist all over the world. Community Repaint in the U.K. and Paint Recyclers in Australia have shown that this model works. Currently is the time for the current introduction of the Community Repaint project in the Netherlands and Belgium (Community Repaint, 2016)

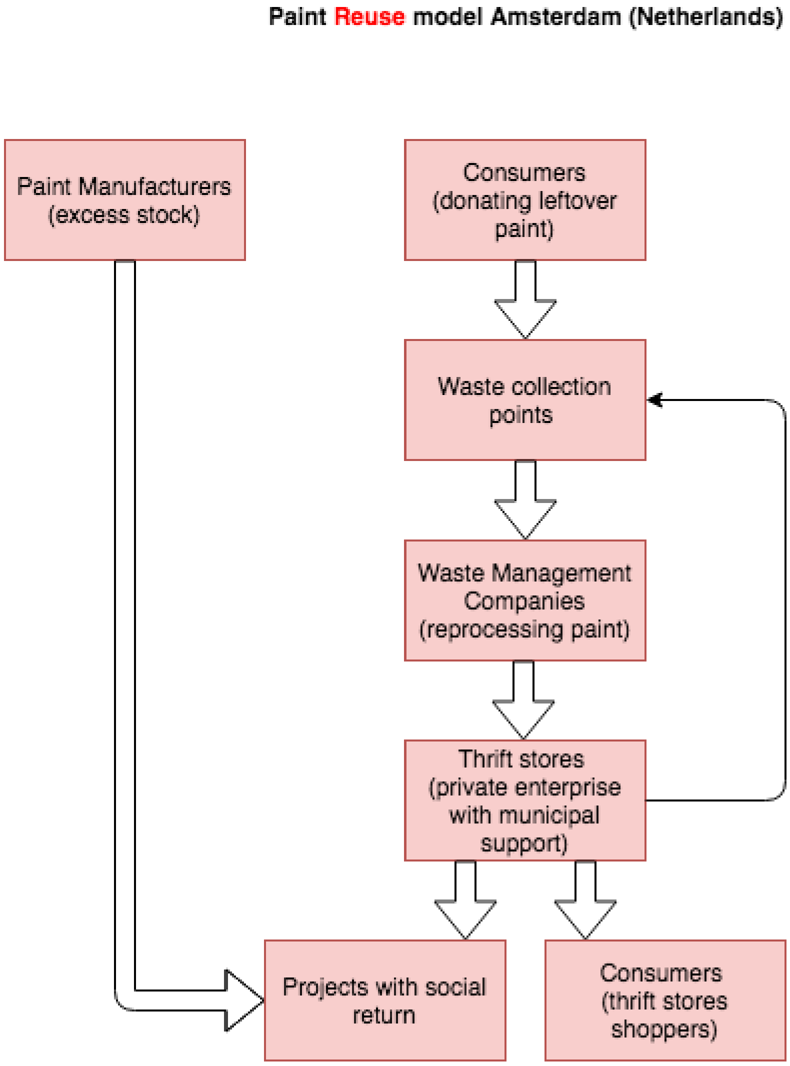

Figure 4-8: Reuse Model Amsterdam for leftover paint.

The paint is collected at the waste collection points and is transported to the Hazardous Waste Department of AEB where the reuse checking takes place. The paint cans are examined for the following criteria (AkzoNobel, 2017):

1. Damage of the packaging
2. Weight of the paint content
3. Danger symbols
4. Type of paint should specifically be water-based paint for interior spaces made for the EU.
5. Labelling is readable and contains product information
6. Shake test to test fluidity of paint
7. Paint smells normal
8. Paint can contain >40% paint
9. Steerability of paint

The benefit of this model is that the collected paint is used in the local area and does not need reprocessing. For quality assurances, the paint needs to be checked in the manual sorting process. Still, the efficiency of this loop is high because it saves a lot of materials and energy. Although some paint is not recycled if the content is less than 40%. This is partially because the customer does not want to buy cans that are filled less than half of the packaging. The average recycle percentage using this process is between 10 – 20% (AkzoNobel, 2017).

Month 2017	Paint Collected in kg	Paint Reused in kg	Recycling percentage	Working hours
March	9045	1225	13,5%	24
April	4779	1032	21,6%	10
May	6386	1083	17%	15.25
June	7736	1459	18,9%	21
July	6946	1022	14,7%	22
Total	34892	5821	16,7%	92.25

The reuse of paint started from March till July 2017. Only the waste six collection points in Amsterdam participated in the pilot. The results of the total weight, percentage and amount of work hours of paint reused are shown in table 4.1 (AEB, 2017). Important fact is that the reuse model is in the pilot phase and did not run at full capacity. Annex 3 shows the kick-off opening in the thrift store while annex 4 shows the marketing materials that were used. Annex 5 shows all the results from the case study. The amount of paint reused, and the percentage of paint reused.

Table 4-1: Reuse Model Amsterdam for leftover paint.

Figure 4.9 shows a simplified overview of the supply chain of the paint after its selection process. Paint that is approved will go to the thrift stores and social initiatives while the declined paint is incinerated for energy.

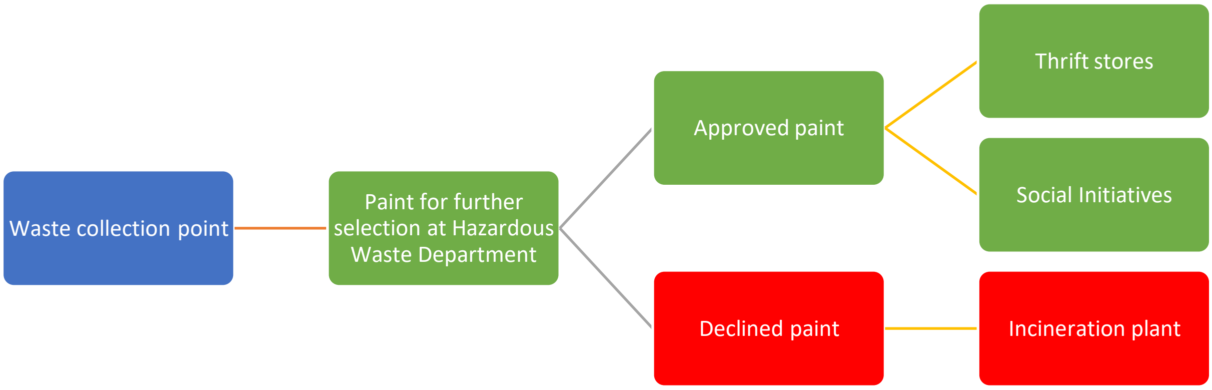

Figure 4-9: Simplified overview of supply chain paint after selection (AEB, 2017).

Sales of reused paint

The reused paint was sold in six stores in the period between week 13 and 23 in 2017. The first weeks there was a really high amount of sales. This was partially because of the kick-off event as well as a good stock of paint. The stores were several times completely sold out, which partially caused some of low sales in a few weeks. This is shown in table 4.2

Week	De Lokatie (3 stores)	Rataplan (3 stores)
April 13	1147,5	423,1
14	379,5	814,8
15	282,5	143,7
16	226	154,2
17	247	250,9
May 18	231	200,5
19	179,5	189,6
20	282	63,9
21	94,5	44,6
June	172	39,6
23	159,5	50,3
Total	3401	2375,1
Total sold in kg		5776,1

Table 4-2: Sales of reused paint in six stores (AEB, 2017).

4.2.3. Remanufacturing

Paint remanufacturing is the third possibility and requires more processing equipment, more skilled workers, and a larger volume of leftover paint to be economically feasible. These requirements also limit the choice for remanufacturing locations. While the paint reuse model can be done at a waste collection point, this is not likely for the remanufacturing model. The model is shown in figure 4.10. Compared to the previous two models, more actors partake in the new scheme. For example: new waste collection points at retailers, Newlife Paints as a paint remanufacturing partner and possibly also new municipalities. There starts to form a new cluster around paint recycling.

For reprocessed paint, there are several additional steps necessary. One of the most important ones is that new additives are added and mixed. This requires extra machines such as mixers, filters and a pump. The paint is made per batch of around 200 litres. This is around 280 kg. It is possible to produce around four batches per week and one day is used for cleaning.

In the first year, it is expected to produce around 40.000 litres. Annex 6 shows the expected quantity and the percentage of remanufactured paint. In addition, more paint can be recycled because all smaller cans with less than 40% of paint can also be used in this model. The recycle percentage can be between 30 – 50%. The benefits of remanufactured paint include a wider variety of colours, better quality paint and new packaging.

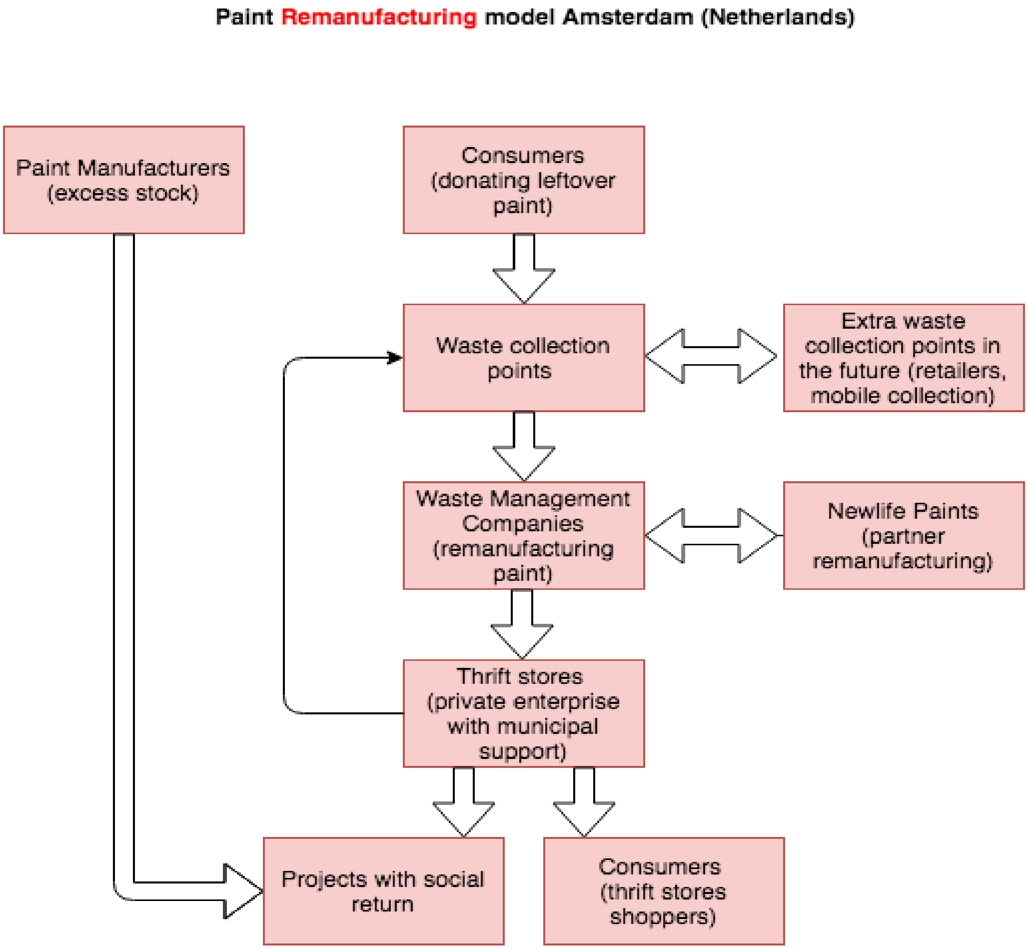

Figure 4-10: Remanufacturing Model Amsterdam for leftover paint.

Remanufactured paint can be used for a wide range of activities and can sometimes replace virgin paint with additional cost savings. The cons are: a limited number of colours, a lack of specific product features, and limited availability (PSI, 2004).
The pre-selection for paint remanufacturing are very similar to paint reuse. Although there are some minor differences. The main benefits are:

1. Paint cans with <40% can also be used in the remanufacturing process
2. It does not matter if the packaging is damaged as long as the content is good.

It is estimated that in the first year around 40.000 litres of paint can be produced. This is 56.000 kg per years because 1 litre of paint weighs approximately 1.4 kg. The expected production per year and month are shown in table 4.3.

Month	Paint collected in kg	Paint remanufactured	Recycling percentage
Expected production per year	160.000	56.000	35%
Expected production per month	13333	4666	35%

Table 4-3: Expected paint collection and remanufacturing in Amsterdam (AEB, 2018).

Costs

In a standard business case, the costs are the main component. These costs can be divided into direct and indirect costs. Direct costs are costs that are directly related to the project. New costs that are made because certain resources are needed, processes are adjusted, and extra employment is needed. Indirect costs can be costs that can sometimes can be integrated in direct costs. AEB might have a large warehouse where there is enough storage space. Therefore, maybe it is not necessary to fully charge for storage space.

The SBM in the next section will provide a detailed overview of the costs that are needed to process the paint and the fee that is charged to the customer. Looking at table 4.4, it shows directly that the costs compared to the prices show a different range. The costs are much higher in the reuse and remanufacturing model. The profit margin in a 300-ton scenario is 76% for the BAU model, 56% for the reuse model and 49% for the remanufacturing. The differences in profit between the BAU model and the two other models is quite significant. The cost calculations can be found in annex 9, 10 and 11.

Cost comparison of end-of-life options leftover paint 300 tons				
Model	Costs per 300 tons	Revenue	Profit	Profit margin
Business-as-usual (Gate fee for leftover paint)	21000	89.000	68.000	76%
Reuse	58727	132.800	74.073	56%
Remanufacturing (expected)	146.583	345.800	169.817	49%

Table 4-4: Cost comparison end-of-life options leftover paint.

Quality and quantity

Each model delivers a service and / or product. The value proposition for business-as-usual consists of waste management, electricity and waste heat. The reuse of paint has a slightly different business case with extra services and products. Yet, around 10-20% of the leftover paint is reused. Therefore, 80-90% of the paint is still processed the same as the business-as-usual model. This has considerable effect on the overall impact of the reuse model which can be considered marginal.

For remanufacturing, a much larger percentage of the paint is used. Leaving 50-60% of leftover paint for incineration.

Production processing of leftover paint	Business-as-usual	Reuse	Remanufacturing

Incinerated for electricity and waste heat	100%	80-90%	50-60%
Reused or remanufactured	0%	10-20%	40-50%

Table 4-5: Percentage of volume that is incinerated, reused and / or remanufactured. (AkzoNobel, 2017).

In terms of percentage of raw materials recovered, the remanufacturing model has much more impact. This is an important criterion when thinking about the quality and quantity of the paint.

4.2.4. SBM analysis

The learnings from the previous chapters have resulted in the development of a framework and three scenarios. The business model of each model is evaluated through the new SBM framework, together they incorporate all important dimensions (economic, environmental and social) for sustainability.

The core of each business model layer consists of the value proposition, value creation & delivery and value capturing element (Bocken et al., 2015 Some of the concepts are simplified in order to quantify the results. Through this framework, all three scenarios can be compared equally, and it helps to select the best performing sustainable leftover paint waste model for Amsterdam or to stay with the BAU model. The SBM framework with data is shown in table 4.6.

Comparing SBM	Business-as-usual	Reuse paint	Remanufacturing paint
Product service	• 0.2 MWh of electricity produced (100% incinerated) • 0.16 GJ of heat is produced	• 9000 buckets of 5L paint (15% reused) • 0.17 MWh of electricity produced (85% incinerated) • 0.14 GJ of heat is produced	• 24000 buckets of 5L paint (40% remanufactured) • 0.12 MWh of electricity produced (60% incinerated) • 0.1 GJ of heat is produced
Customers	3 customers (municipality, electricity companies and heat distribution) Customer segments: Mass market (the segments fulfils the need of a large part of the population)	4 customers and 1 end-user (municipality, electricity companies, heat distribution company, thrift stores, and thrift store customers) Customer segments: Mass market and niche market (the segment is focused on the particular needs of the	4 customers and 1 end-user (municipality, electricity companies, heat distribution company, thrift stores, and thrift store customers) Customer segments: Mass market and niche market (the segment is focused on the particular needs of the customer, which is low cost in this case).

		customer, which is low cost in this case).	
Value for customer, society and environment in terms of CO2 emitted	Total amount of emitted CO2: 409 tons Total amount of waste prevented: 300 tons of paint is incinerated for energy	Total amount of emitted CO2: 348 tons Total amount of CO2 saved compared to BAU model = 15% Total amount of waste prevented: 255 tons of paint is incinerated, and 45 tons of paint is reused	Total amount of emitted CO2: 254 tons of CO2 Total amount of CO2 saved compared to BAU model = 38% Total amount of waste prevented: 180 tons of paint is incinerated, and 120 tons of paint is remanufactured
Amount of extra work created in FTE and key activities	• 0 FTE Key activities: Collection, incineration	• 0.2 Full Time Equivalent for project management • 0.2 FTE for sorting Key activities: collection, reprocessing, incineration, marketing	• 0.2 FTE for project management • 2 FTE for remanufacturing Key activities: collection, reprocessing, incineration, marketing
Resources	Physical and human resources	Physical, financial and human resources	Physical, financial, intellectual and human resources
Distribution channels (number of stores delivered)	• Electricity through the grid • Heat through the pipelines • 0 stores	• Electricity through the grid • Heat through the pipelines • 6 stores	• Electricity through the grid • Heat through the pipelines • 6 stores with possible upgrade to 23 stores in total
New partners in supply chain and suppliers	0 extra partners	3 extra partners (AkzoNobel, 2 thrift stores (de Lokatie and Rataplan))	4 new partners (Newlife Paints, AkzoNobel, 2 thrift stores (de Lokatie and Rataplan))
Technology level	Recovery of energy is already available inhouse; includes incineration with energy recovery, using as fuels, heat and power (EPA Victora, 2013).	Reuse requires special training by AkzoNobel (EPA Victora, 2013).	Remanufacturing requires special technology by Newlife Paints (EPA Victora, 2013).
Cost structure & revenue streams	Profit: 68.000 euros CAPEX: 0 euros OPEX: 21.000 euros	Profit: 74.073 euros CAPEX: 0 euros OPEX: 58.727 euros	Profit: 169.817 euros CAPEX: 147.000 euros OEX: 146.583 euros

	See annex 9 as mentioned in note	See annex 10 as mentioned in note	See annex 11 as mentioned in note
Value capture for key actors including environment & society in raw materials recovered	• Environment: - 100% of raw materials is recovered for energy Society: - none	• Environment: - 85 % of raw materials is recovered for energy - 15% of raw materials is reused for primary function (paint) Society: - 0.2 FTE social jobs created - 6 local thrift stores involved	• Environment: - 60% of raw materials is recovered for energy - 40% of raw materials is reused for primary function (paint) Society: - 2 FTE social jobs created - 6 local thrift stores involved and potentially 17 thrift stores more
Growth strategy / ethos	No foreseeable growth strategy	No foreseeable growth strategy	Interest from municipalities of Groningen (40 ton), Meerlanden (70 ton), Utrecht (70 ton). Together
Note: See Annex 8, 9, 10 and 11 for all the calculations and assumptions.			

Table 4-6: Comparing SBM for leftover paint.

Further analysis

Value proposition

1. Product service

Comparing the three models in the SBM framework showed us the following results. The Business-As-Usual (BAU) generates approximately 0.2 MWh of electricity and 0.16 GJ of heat.

The reuse option reuses 15% of the materials. The other 85% of materials is incinerated like the BAU model. It delivers a slightly lower 0.17 MWh of electricity and 0.14 GJ of heat. The 15% of reused materials will be around 9000 buckets of 5L paint. The used packaging stays the same.

The remanufacturing option produces even a bit less electricity with 0.12 MWh and 0.1 GJ of heat. It produces also 24.000 new buckets with high quality paint.

2. Customer segments and relationship

Each SBM has a different customer. The BAU model gets most of its waste from municipalities and sells its electricity to energy companies. The residual heat network is a joint-venture with AEB and Nuon (energy company). In total there are two customers. The main difference between the BAU model and the second two models is that they have additional customers.

The additional customers are the thrift stores to which the paint is sold to and the end-customer who buys the paint (AEB, 2018). Although AEB deals only with the thrift stores, they are responsible for the production process of the paint. The customer segment for the BAU model is mass market. The product / service that is sold is meant for the majority of the population.

The customer segment of the reuse and remanufacturing models are meant for the niche market. The recycled paint is sold in thrift stores to the end-customer.

The end-customer is needed to create demand for the reused and remanufactured paint. The most important customer in all three scenarios is the municipality. They require that AEB improves its sustainability performance every year. Since they are 100% shareholder of AEB, they can use their influence to follow this model. In total, the reuse and remanufacturing options have four customers.

3. Value for customer, society and environment in terms of CO2 emitted

The difference in value created for the customer, society and environment in CO2 are evident.

The BAU model emits 409 tons of CO2.

The reused paint emits 348 tons and the remanufactured option 254 tons.

The reused paint model saves 15% of CO2 compared to the BAU model. The remanufacturing saves 38% of CO2 compared to the BAU model.

The second measurement is the waste prevention.

The BAU models recovers the energy of 300 tons of paint.

For reuse, the amount of waste prevented is 255 tons for energy recovery and 45 tons for reuse.

For remanufacturing, the amount of waste prevented is 180 tons for energy recovery and 120 tons for remanufacturing.

Value creation & delivery

4. Activities (amount of extra work created in FTE)

The amount of activities increased significantly with the reuse and remanufacturing model. To facilitate extra FTE is required.

In the normal BAU model, everything is already arranged, and no extra FTE is needed. In the reuse model, 0.2 FTE of project management and 0.2 FTE for the sorting is needed. The remanufacturing model requires significantly more FTE. At least two extra employees are needed to run the operations. Also, 0.2 FTE is needed for the project management.

The key activities for the BAU model are mainly collection and incineration for energy recovery.

The key activities for reuse and remanufacturing also add reprocessing, distribution and marketing activities to the BM.

5. Resources

The BAU model requires the existing physical and human resources.

The reuse model requires also the physical and human resources but also an extra financial resource.

The remanufacturing model requires all available resources. The physical, human, financial and intellectual resources in order to run the remanufacturing process.

6. Distribution channels
The BAU model has no stores and sells its products to the energy company. The reuse option has six stores that can meet the production. Remanufacturing has a much higher production and therefore more stores are maybe needed. There is an option to expand to seventeen other stores.

7. Partners and suppliers
All three waste management options have important partners and suppliers. In the BAU model, the municipality and electricity companies are important partners. In the reuse model, there are three additional partnerships with AkzoNobel and the two thrift stores. It also generates more activities with other potential partners that are interested such as other municipalities.

The remanufacturing model has on top of the reuse partners one extra technology partner. Newlife Paints has the IP on the technology and is required to remanufacture paint (Newlife Paints, 2018).

8. Product level in waste hierarchy
The BAU model has the available technology for incineration already inhouse.

The reuse model gained the reuse technology from AkzoNobel by training.

The remanufacturing model required the IP from Newlife Paints for the detailed remanufacturing process.

Value capture

9. Cost structure & revenue streams
The cost structure and revenue streams figures are shown in the annexes 9 -11. Looking at the profits, it shows that the BAU model and reuse model are quite close to each other.

The BAU model has the normal cost and revenue stream that is shown in annex 9.

The reuse model has extra costs and revenue streams. The main differences come from the processing of paint for reuse and the sales of reused paint.
The remanufacturing model has extra costs above the reuse model due to the license fee, investment for machinery and extra labour. The extra revenue is mainly created by a higher selling price (AEB, 2018).

There are more resources available for the reuse and remanufacturing model because it is a public-private partnership with several partners. The reuse scheme has no CAPEX investment costs since no large investments are needed. The only costs are smaller items such as stickers and marketing, but this can be placed under OPEX.

Interesting is the high investment needed for the remanufacturing scheme. An investment of 147.000 euros is needed to finance the necessary equipment, licenses and other costs. This investment is significantly higher than the other two options. In the decision-making process, it will be a crucial criterion.

The OPEX are the operational expenditures or the costs. The BAU model has the lowest OPEX of 21.000 euros, the reuse has 58.727 euros and the remanufacturing has the highest OPEX.

10. Value capture for key actors including environment & society
The main differences between the BAU model and the other two models are: raw materials recovery, creation of social jobs, improved image company and better regulations.

11. Growth strategy / ethos
The BAU model will remain stable in terms of growth because there is no incentive for municipalities to bring their paint to AEB. Municipalities could move their waste towards AEB because the waste management options are better there than at the competitor. For the remanufacturing option, there is interest from several municipalities.

Remanufacturing has the highest level of growth potential compared to the two other models due to the value it captures for key actors.

4.3 Limiting factors

Important factors that limited each of the scenarios will be discussed in this section.

Regulations

The regulatory can be divided into two main categories: (a) European and local regulation of handling and transporting of hazardous waste where leftover paint is classified under, and (b) European regulation for chemicals that fall under REACH.

The national regulation is based on the EU directive 2008/98/EC on waste. Leftover paint is classified as "Klein Chemisch Afval" also known as Small Hazardous Waste. It falls under the national waste policy framework LAP3. The policy describes the traditional waste management activities such as collecting, recycling, incinerating, and dumping. Other important topics are: relation to the circular economy, make a judgement about the waste status of a material and permits. The LAP3 policy framework is divided into 85 categories of waste of which KCA is number 18 (LenW, 2018). This experiment aims to overcome the barriers setup by the LAP3 policy framework by giving a demonstration of the opportunities of recycling leftover paint.

The first barrier is that there is a legal framework for treating waste in the EU. Its aim is to protect the environment and the human health. Requiring proper end-of-life management of waste streams. That is why products are classified into the waste status once it is collected by waste management companies. It falls under the waste directive 2008/98 article 3, paragraph 1. The definition of waste is: *"any substance or object which the holder discards or intends or is required to discard"* (EU, 2008).

To get a product or stream out of the waste status, it has to comply to article 6 of the EU 2008/98 directive which is about the end-of-waste status. Article 6 says: "*Certain specified waste shall cease to be waste within the meaning of point (1) of Article 3 when it has undergone a recovery, including recycling, operation and complies with specific criteria that are developed*" (EU, 2008). Moreover, the Omgevingsdienst mentioned that article 1 should also always be taken into account. Article 1 lays down measures to protect the environment and human health. In addition, it wants to reduce the overall impact of resource usage and improve resource efficiency (EU, 2008).

Waste status
In the circular economy, there is an argument that waste for one can be a resource for another. However, this is more complicated in reality due to the waste status regulation. A product that is recycled and leaves the production facility, can still be classified as waste. To turn the waste stream into a resource streams that can be brought back to the market requires that the process is approved by the local or national environmental agency. This is applicable to all waste streams. The current legislation is lacking behind because it has a linear economy perspective where products are not recycled (lenW, 2017).

Limitations business-as-usual

The current legislation is designed for this type of model. The waste products do not re-enter the market anymore. Therefore, there are no issues with the waste status.

Limitations reuse

The waste status is applicable to this model because the product re-enters the market again. Therefore, it needs to get out of the waste status. The control process needs approval from the local environmental agency. It includes documents about health, safety and the environment. The risks need to be identified and control measures are taken. After the approval of the Omgevingsdienst, AEB can control a product and turn a product from the waste status back into a product that can re-enter the market.

Limitation remanufacturing

The waste status is applicable to this model because the product re-enters the market again. Therefore, it needs to get out of the waste status. The control process needs approval from the local environmental agency. Since new additives are added, this control process is checked more thoroughly.

REACH

REACH EC 1907/2006 is a European directive that was implemented to protect humans and the environment from chemical substances by identifying their properties.

It started on June 1st, 2007 and stands for: Registration, Evaluation, Authorisation, and Restriction of Chemicals. The aim of the law is to identify risks of chemical substances, how to handle them safely and how to mitigate risks. If the risks are uncontainable, authorities can limit the use of that particular substance. In the future, the dangerous substances are replaced by less dangerous substitutes (ECHA, 2018).

Limitations business-as-usual

This regulation is not applicable to this model.

Limitations reuse

This regulation is not applicable to this model because the paint content does not change, and the reused paint was designed for the European market. If the product is made for the European market, it means that it is REACH compliant.

Limitation remanufacturing

This regulation forms a significant limiting factor for the remanufacturing model. The process needs to be recorded and materials used catalogued in order to be REACH compliant.

Summary

The business-as-usual model scores best because it does not require changes in the waste status or REACH legislation. The reuse model is a bit more complicated and a permission is needed from the local environmental agency. It is exempt from the REACH status because the content of the paint stays the same. For that it gets a green. Remanufacturing is the most difficult model since new additives are added and the content of the paint changes. That is why permission is needed for the waste status as well as REACH.

The initial aim of regulation is to ensure that waste materials do not enter the market again due to environmental and health reasons. It typically reflects the linear economy. In a circular economy, these waste materials are seen as an important resource.

The goal of the experiment is also to improve regulations, so they can better facilitate the circular economy. In this case, the goal is to take water-based paints out of the waste status just like steel. If there is a positive evaluation of the pilot, in the future hopefully paint can be recycled everywhere in the Netherlands without any regulatory barriers.

Health and Safety

The industrial processes at AEB increase the exposure to certain safety risks. Therefore, there is a strict health & safety culture and AEB. The safety of the employees, visitors and the surrounding area are all important. AEB has to follow strict procedures set-up by the European Union. AEB falls under the Seveso III- directive also known in Dutch as "Besluit Risico's Zware Ongevallen" (BRZO). In the Netherlands, around 400 companies are considered BRZO companies (Seveso, 2017).

Within AEB there are strict health and safety procedures. These can be classified into environmental and working related factors (AEB, 2016).
The environmental issues are focused on four points:

1) Limit the output of substances that can harm the environment through the air and water
2) Make efficient use of water
3) Protect the soil underneath the terrain
4) Optimize the use of additives and reduce the amount of substances use

Limitations Business-as-usual
The environmental and labour conditions are not a concern.

Limitations Reuse
The environmental and labour conditions have some concerns. The environmental factors are related to paint spillage that can end up in the ecosystem. The labour conditions were related to the paint itself. The employees work with hazardous materials and this comes with risks that need to be identified (omgevingsdienst, 2017). These limitations are fairly easy to solve.

Limitations Remanufacturing
The addition of new raw materials that are highly toxic were a significant limitation. The biocides that are used to kill all bacteria in the paint, are essential for this process. Resulting in that the potential impact to the environment and employees is also bigger. Therefore, more measures need to be taken to ensure the health and safety of the environment and employees. The omgevingsdienst were largely concerned with the labour conditions of working with these substances. The process steps were redesigned in order to make them failproof (omgevingsdienst, 2018).

Supply chain

Limitations Business-as-usual
There are no limitations for business-as-usual in terms of logistical activities and storage facilities. Nothing is stored, and no extra transport is needed. The leftover paint that is collected will be send off to the incineration plant directly.

Limitations Reuse
It is clear to see that an attempt to enlarge the process of reuse would increase logistical activities. The incoming paint arrives Wednesday and is stored until Thursday. The paint is processed on Thursdays. The reused paint leaves every Thursday and Friday to the stores. During this time storage capacity is needed (AEB, 2017).

Limitations Remanufacturing
It is evident an attempt to enlarge the process of remanufacturing would increase the logistical activities. Remanufacturing requires there is always a stock of pre-selected and remanufactured paint. The model requires a lot more storage capacity than the other two models. H=
Summary

The objective was to identify the limiting factors for a closed loop supply chain for leftover paint. The five main limiting factors are identified. Costs, Regulations, Health & Safety, Acceptance Rate and the supply chain itself greatly affect the possibilities for the reuse and remanufacturing model. Each limiting factor can be overcome but requires extra paperwork, resources and adds extra risks to the project. In fact, identifying the limiting factors can result in creating new opportunities.

4.4 Transferability

The aim of AkzoNobel, a paint manufacturer, is to roll this project out in the Netherlands and Belgium. The first phase of the pilot started in four Dutch cities (Amsterdam, Den Bosch, The Hague, Rotterdam) and in four Belgium cities. However, due to several reasons each city had its own pace in setting up the model. For instance, in Belgium the pilot started six months later with the first phase of the pilot then in the Netherlands due do legislative constraints (AkzoNobel, 2018). The cities were selected based on their experience in reusing paint, the involvement of stakeholders as well as their size and population.

Amsterdam is the only city that moved on to the second phase of the pilot, which is remanufacturing. The other cities are waiting for the results from Amsterdam before they continue to the second phase. In this sense, the pilot in Amsterdam is pioneering. Yet, are specific local circumstances that have a positive or negative effect on the transferability of this model. During the first pilot and during setting up the second pilot; several important criteria were identified that must be met to make this model work in a city. Then the critical conditions for making the model work in a city are identified. This is based on the lessons learned from the U.S. and U.K., limiting factors and parts of the SBM results.

Criteria for transferability

The transferability of a specific sustainability project to another city is dependent on several criteria. The criteria will be individually explained.

The analysis provides a chance to learn from the previous experiences. Thereby, avoiding earlier made mistakes from the case-study in Amsterdam and identifying important opportunities. The transferability analysis table is developed through desktop study, interviews, field visits and databases (AEB, 2017; AkzoNobel, 2017; Denhaag, 2018).
The analysis has six criteria that can assess the transferability of the model to another city.

Support from the municipality for the project: Support can be given in different ways such as communication, financial and project management. Without the support of municipality, it will become very difficult to overcome some of the barriers.
Practical interpretation of cooperation: Each stakeholder should take concrete actions to make the cooperation successful.
Connection with the municipal circular economy agenda: The circular innovation agenda of a city is aimed at developing the circular economy and provide them with support.

Connection with the municipal social agenda: The social agenda is focused on important topics such as care, youth and employment but also education, health care and diversity. Implementing this model can create new social jobs. Therefore, the social agenda of a city is an important condition.

Enough resources for setting up project: There should be enough resources available to manage this project properly. A dedicated team of employees is necessary to do the work of managing the project and the reprocessing process.

Connection with retailers: In order to ensure the sales of the recycled paint, there needs to be a adequate distribution channel.

Network and involvement local stakeholders: Involvement of local parties such as thrift stores are necessary for parts of the extra work created through this model. The citizens and local organizations are necessary to increase the awareness concerning the reusability of leftover paint.

The Hague, The Netherlands

The Hague, the capital of the province South-Holland, is one of Netherland's largest cities with around 1 million inhabitations in the metropolitan area and over 500.000 in the municipality (Den Haag, 2018). The focus will be on the municipality. The average household in the Netherlands separates around 50% of its household waste. In the Hague, this is approximately 30% (van Gansenwinkel, 2017).

Although the Hague scores on several aspects of the six dimensions. Three or half of the dimensions are sufficient instead of good. The results are derived form an interview with a public servant of the Municipality of The Hague. Together with the evaluation that was given by AkzoNobel.

Support municipal administration and staff Amsterdam: In Amsterdam, there is a commited projectteam that actively supports the project. The development is bi-weekly discussed in the muncipal meetings. The Hague: In the Hague, the municipality is not actively involved in the development of the project anymore. The whole project is carried out by the waste company.
Practical interpretation of cooperation Amsterdam: The practical cooperation requires that AEB and the thrift stores run the operations. The municipality gives background support. The Hague: The practical cooperation is that the municipality requires that one party takes the lead in progressing the project. This is not the case now. The leading party should be operational. In the Hague, this is Renewi (Den Haag, 2018).
Connection with the municipal circular economy agenda Amsterdam: Amsterdam is the first city that researched the possibility of the circular economy. The market approved this and together with the municipality they started with the transition towards circularity. This project falls perfectly in line with the Amsterdam circular agenda (Amsterdam, 2016). The Hague: The Hague has a plan called Circulair Den Haag. It is a comphrensive report about circularity. Their main focus is households, trade, construction and government services. For households, they want to improve waste seperation on a product level. This aligns exactly with the paint model (Den Haag, 2018).

Connection with municipal social agenda Amsterdam: The social agenda of Amsterdam is about inclusiveness. Unemployement is one of the key aspects. The paint model tackles this problem by creating decentralized jobs in the social domain. The municipality is not actively involved. Therefore, it fits well in the municipal social agenda (Amsterdam, 2015). The Hague: The social agenda of The Hague emphasizes the importance of social impact. Helping people getting a job is one of their top priorities. This aligns with the reuse and even more with the remanufacturing model, where several social jobs are created. Moreover, a part of the paint goes to social initiatives and people in need. This is strongly encouraged by the municipality (Den Haag, 2008).
Enough resources for setting up project Amsterdam: An essential resource is that AEB and the thrift stores run the operational activities. In addition, there is a projectteam to further enhance the project. There is a dedicated person who is responsible for the project. The Hague: Compared to Amsterdam, there is little control over the operational activities. The public servants do not have contact with the local waste handler. There is also not a dedicated person who is active on this project yet (Den Haag, 2018).
Connection with social enterprises Amsterdam: From the beginning there was a lot of interaction with social enterprises. Over eight social initiatives got support with recycled paint. The role of thrift stores was important in Amsterdam. They functioned as a ‘social’ hub to attract new social enterprises (AEB, 2017). The Hague: The Hague has a broad network of social enterprises that are willing to cooperate. A part of the contacts are run through the thrift store ‘Kringloop Den Haag’ (Den Haag, 2018).
Network and involvement of thrift stores Amsterdam: There are six thrift stores involved in Amsterdam. They are very active in terms of organizing social events and attracting new social enterprises. In addition, they promote the paint actively in the stores (AEB, 2018). The Hague: In the Hague there are three thrift stores involved. They are not actively involved in organizing social events. Compared to Amsterdam, there is not a real coalition of partners (Den Haag, 2018).

Table 4-7: Transferability criteria leftover paint.

Interesting to observe was how local conditions can change during the study. An example was that there were several fires at AEB in 2018. The result was that AEB came under strict supervision of the local environmental agency. All health and safety procedures became more severe. Demonstrating a new pilot with hazardous materials is then seen as something risky. This affected the planning of the remanufacturing pilot. It got delayed with more than ten months. The message of this observation is that local conditions can change quite dramatically in a short amount of time. The transferability and success of a model can be jeopardized by such events.

5. Discussion

From the results of the research, several points arise for discussion. The choices that have been made regarding the chosen literature, methodology and framework have limitations. Identifying these limitations will result in new questions for a new research.

What makes this research unique is that there is deep inside knowledge of the three projects. Still, due to time constraints some of the data is based upon estimates and assumptions. This affects the overall outcome a bit. Although, it provides a solid overview of the characteristics, opportunities, limitations and impact of all the three models.

5.1 Limitations of the methodology

One of the limitations was that there is a lot of unstructured data that has not been integrated. The researcher could have prevented this by clearly structuring his work with logical reasoning. This data came from mails, small talk with experts, own observations, serious discussions with experts. If this data was included in a structured way, it would give a much more holistic overview of each model.

Adding data from other companies and cities could have widened the size and scope of the research. There is more data to be found in the U.K. about remanufacturing and reuse. The models are managed on a voluntarily basis by small enterprises. This could give a different perspective on the sustainable business model. The small enterprises might be more or less sustainable. There was no time to look into this could be the basis for a new research in the future.

To develop each scenario, several assumptions have been made. For instance, the recycling percentage for remanufacturing is based on the experiences from the U.K. The quality of the paint very much depends on the local conditions such as weather, urban density and other factors. There is not much data available about the previous owners of the leftover paint and / or the end-user.

Gathering and summarizing all the data was also a difficult task. Some data was out of the scope or hard to retrieve. For instance, the price of residual heating is unknown, but this can be estimated. Unfortunately, due to time constraints this was not done.

In a further research, it is advised to first develop the framework tool before gathering the data. This way, the data collection would be more structured and time-efficient. In this research, there was a strict planning. The project started before the framework could be finished and resulted in delays.

It would also help other cities to assess the potential of this paint recycling model. Since there were three end-of-life models for paint, it was sometimes difficult to align data from the three scenarios.

During the case-study and the implementation of the project I also learned a lot about changing standardized work routines. I believe that theories about change-management could be very useful in this research. Theories like Lewin's Change Management Model, McKinsey 7-S Model and Kotter's 8 Change Model challenge these barriers for change with their own methods (Quickbase, 2012).

For instance, the LCM model assumes that the majority of people prefer to operate in their safe zone and resist change. The author argues that the first phase is unfreezing the people by motivating them. The second phase is the transition. During this transition period, adequate leadership and encouragement is needed to make the process successful. The third phase is the refreeze where the company becomes stable again once the change has been accepted and implemented (Quickbase, 2012).

The operationalization of the framework is a limitation because it could be more holistic. Some building steps are more useful than others. Only one case-study is used while more case-studies could be good to have different perspectives and to see if the framework works in another context.

5.2 Limitations of the framework

The original SBM framework by Bocken et al. (2015) is qualitative. The new application of the framework for paint recycling turns this around by making it more quantitative. The results can be more easily compared once they are quantitative.
Also, the framework does not fully take into account the human factor of each model. The success of a model also depends on the project team, stakeholders and internal organization involved.

Project management is needed to the further roll out. Therefore, it is recommended that a short version of the thesis is made with a summary, conclusion and recommendations for AEB.

5.3 Linking research to literature and future research

Throughout this thesis there were a lot of studies reviewed about recycling waste streams. These studies are all rather conceptual and do not take into the account the local organization that is involved. There is a lack of literature about waste paint and the recycling of waste paint. The research used the literature about sustainable business models, closed loop supply chain and combined this with paint recycling.

It showcased how global paint waste management practices are operating. The ambition of the case-study pilot is to proof that paint recycling can work. Amsterdam is the first city in continental Europe where paint is remanufactured. The remanufacturing method was developed in collaboration with the association of paint manufactures. The drivers for paint recycling were identified through the product remanufacturing matrix and the SWOT analysis. Several closed loop supply chain strategies and the global waste management practices were discussed as well. The SBM comparison further complemented these options with real data from the case-study.

In the previous chapter, the transferability to the city of The Hague was analysed in the transferability table. The lessons learned from this case study were mostly related to the transferability criteria. In order to implement a program, all six criteria should be there. To see a more practical result, the SBM comparison showcases each of the criteria in a quantitative and simple method.

Although, the cases in the U.S. and U.K. have shown that different paint schemes are also possible but they all checked the six criteria that were mentioned. The assumption is that support from the local government agency, cooperation, sustainability ambitions, available resources, social networks and involved partners are all very important for the viability of the program.

Other important findings are that highly urbanized areas are preferred because they generate more leftover paint and reduce the amount of logistics involved. There has not been an increase of collected leftover paint during the reuse pilot. It will take more time and effort to persuade people to bring their paint to waste collection points.

The reuse model is fairly easy to start with because there are no high investments needed. The remanufacturing model requires extra resources and is better for a second phase. Annex 7 provides a list of all the experts that were involved in the project.

A future research could look into the transferability and development of sustainable closed loop supply chain scenarios. Other types of waste streams and regions can be investigated. The literature review of this research can be used but put into a different perspective. It could also be from the perspective of a small local organization instead of a large company.

The funding of the paint recycling models could be further researched. Especially the U.S. and Canada based levy system that finances the models. Is it more effective than the model in the U.K. and the Netherlands that is financed by the sales of recycled paint?

A structured and finished framework from the beginning could further enhance the potential of data gathering and analysis. New lessons can be learned that help to make the framework more robust.

The involvement of citizens and how they perceive these scenarios would also valuable to study. Encouraging and educating them about recycling waste streams will have significant impact. Avoidance is always the preferred end-of-life strategy in the waste hierarchy.
In the end, AEB has the final decision power in implementing this project. Choosing between a short-term strategy without any significant improvements in the nearby future or choosing a riskier long-term strategy for recycled paint. This research hopes to provide a conclusive overview of the dilemmas at stake in making the right decision for the best possible circular value chain outcome for leftover paint.

6. Conclusion

The transition to the circular economy is a hot topic but large-scale transitions are not yet implemented. The national resource plan that AEB signed is aimed at becoming a neutral consumer of natural resources by 2050. The development of secondary resource markets such as the thrift stores and further integration of the whole paint supply chain, including societal acceptance, are all equally important.

The results provide a solid background to answer the main question of "*Which of the three closed-loop supply chain strategies for leftover paint is recommended for the city of Amsterdam??*" There are three feasible options in Amsterdam for handling leftover paint.

The sub-questions that are answered are:

1. What can we learn from paint recycling internationally?
2. What are the three sustainable business scenarios for the case study in Amsterdam?
3. What are the limiting factors for recycling leftover paint?
4. Is the paint model that is developed in Amsterdam also transferable to other cities in the Netherlands?

1. There are several lessons that can be learned from the Canada, U.S. and the U.K. In Canada, there are two different type of paint models that both work. The first model is a non-profit organization that is controlled by the government. The second model is a non-profit controlled by the paint manufacturers. The paint manufacturers organization has better cash reserves because they are allowed to make profit. The U.S. model is also a non-profit that is controlled by the states.

   The U.S. and Canada model are similar because they charge a levy when new paint is sold. This levy is enough to setup a whole paint recycling scheme with extra new waste collection points.

   The U.K. model is much more decentralized. There is one civil society led organization that provides the know-how for setting up a scheme but besides that everything is locally arranged. The majority of the work is voluntary. This greatly reduces the labour costs for recycling paint. The legislation in the U.K. is less regulated.

   An example is that local community organizations are allowed to pick-up the hazardous waste from waste collection point and process it before it goes to the waste company. The benefits are: the waste company has to process less waste and the Community Repaint organization can claim the leftover paint resources. The risks are: health & safety concerns for employees and environmental problems such as spillage.

2. The three scenarios that are used in the SBM researched are energy recovery, reuse and remanufacturing. The investment costs are similar for energy recovery and reuse. They require no large investments to run the model. The remanufacturing does require a large investment of over 100.000 euros.

   However, the results show that the percentage of recycled materials with the reused model is quite low. The majority of the stream is incinerated. This jeopardizes the impact of the second model. Remanufacturing has overall the largest sustainability impact and is economically more attractive than the reuse model.

   In terms of risk, the BAU model has the lowest financial risk since it is the existing model. It does not create extra value like the two other models. In terms of growth potential, it loses from the remanufacturing model. Most municipalities demand and prefer a sustainable solution for their waste streams.

3. The limiting factors are categorized into three parts. Regulations is a limiting factor but can potentially become an opportunity. In this case, the goal is to take water-based paints out of the waste status just like steel. To do so, approvals are required from the local environmental agency for the region of Amsterdam. The first steps are to give a demonstration and proof that the model is successful. Success is in this case, the savings of raw materials without any incidents.

   This brings us to the second limiting factor health & safety. AEB is a BRZO facility which means that it has to meet the highest health and safety standards in the Netherlands. This is explained in the limiting factors section on health & safety. Developing and implementing a new process on the terrain requires a lot of extra paperwork, but the limitations are fairly easy to solve.

   The third limiting factor is related to both factors mentioned above and also to one of the discussion points. The limiting factor is that the existing supply chain becomes more distributed and complex. Changing processes lead to extra procedures and it is difficult to change work routines of the employees that are concerned with the operational activities.

4. The paint model from Amsterdam is transferable to other cities. The reuse model is rolling out in cities of Den Bosch, Rotterdam and The Hague. The remanufacturing model is only done in Amsterdam. The SBM comparison has shown that the reuse models require almost no cash investments. the following criteria should be met: support from the municipality, practical action from stakeholders, fits into the sustainability plans of the municipality, enough resources, retail channel and the involvement of local stakeholders such as social organizations and thrift stores.

To answer the main question: "*Which of the three closed-loop supply chain strategies for leftover paint is recommended for the city of Amsterdam??*"

The recommended model for Amsterdam is the remanufacturing model. It scores best on profit, environmental and social impact. It requires more investments then the other two options because it requires a larger investment. There are also risks in terms of production and quality of the paint. It is uncertain whether these targets will be achieved. In the long run, it does provide the most perspective of creating a new value chain for this waste stream. The results show that the remanufacturing model is more profitable in absolute terms but not in percentages.

Once this project is rolled out in Amsterdam. Other cities will have to make a decision to implement such a program in their cities or not. The first phase of the pilot was in in four Dutch and four Belgium cities. Amsterdam is the only city that moved on to the second phase of the pilot, which is remanufacturing. The other cities are waiting for the results from Amsterdam before they continue to the second phase.

After an initial pilot phase, a decision can be made to implement the remanufacturing model. Still, there are many other benefits that can influence key stakeholders such as saving more raw materials, creating social jobs and being a pioneer in the circular economy transition. A logical conclusion would be that many cities will start with the reuse model since no CAPEX investment is required. This is already happening now in Rotterdam, The Hague and Den Bosch.

As expected, the BAU model scores well on the economic criteria. Although there are no limiting factors at the moment. They might arise in the future once recycling becomes a more important topic.

6.1 Recommendations

The recommendations given in this section are divided into personal recommendations and recommendations resulting from the conclusion.

Recommendations to project organisers
During my study it became clear that integrating sustainability in the core business model of a company requires significant change management. Getting an understanding of current practices and the business attitude is crucial for the success of the project. Personally, I think that implementing the remanufacturing model does require a lot more extra effort than the reuse model. The reuse model requires small changes in the daily activities while the remanufacturing model requires significant changes. Adding new raw materials such as hazardous biocides, working with new machinery and finding a large workspace all make it more challenging.

There is also a difference in how the project is seen from an abstract level versus an operational level. It would be useful if participating project organisers can understand this. From an operational point of view of a waste handler, some ideas might be less effective compared to the perspective of a municipality worker. Understanding the key tasks and activities of each stakeholder can help to support this difference.

Recommendations for stakeholders in paint recycling

My recommendations for the stakeholders would involve practical solutions to implement a new CLOSC strategy for waste streams.

The participating municipality should identify bottlenecks from the regulation side. The municipality has a circular agenda for the coming years. It would be good to have more dialogue with national government agencies in order to address certain issues such as waste status. There are a lot of social organization who would like to get involved in sustainable projects but are excluded because they do not have the right licences to operate. More attention should be put into whether such an operating license is needed or not. At the moment, only companies like AEB have the right to process waste.

A key task for the municipality is to facilitate enough waste collection points throughout the city. At the moment there are six waste collection points in Amsterdam. Communication towards the citizens is another important task. The municipality can inform them about the recycling opportunities of waste paint.

AEB is a waste processor that is focused on recycling. The following advice is not only for waste handlers for also for paint recyclers. Developing and implementing such an innovative new model should become easier. At the moment, the same rules apply for a large commercial project or a small pilot. The procedures within AEB should classify them differently so the development trajectory can become more flexible. This could save a lot of time and resources that are invested in paperwork.

AkzoNobel is a paint manufacturer with a lot of expertise. However, they are mainly focused on the larger picture of implementing a nationwide program. It would be useful if they are more actively involved in the operations. It requires extra work, but the result is that more programs can be rolled out in a shorter amount of time.

The role of thrift stores could be expanded since they already work with waste. The thrift stores have the entrepreneurial mentality to quickly adopt new technologies and execute them when companies fail to do so. Thrift stores could identify more opportunities where they can be useful. Their strength is their network with other social organizations. They could function as a social hub between companies and social organizations.

The local environmental agency is the main regulator for AEB. The local environmental agency fulfils their task based upon the policies of the national government. The national government receives a part of their policies from the EU. They have a special procedure for pilots. This procedure is very important for new projects. The limitation is that it is still rather technical. It could help if their procedures would become more understandable for project managers instead of only health & safety experts.

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Annex

Annex 1: Paint quantity per waste collection point

Branches:	All
Richtingen Hierarchy:	All
Versies:	Werkelijk (AA)
Measures:	Omzetgewicht
Maanden:	Dec-c

			2016
GEMEENTE	P88305200 LATEX VERFRESTEN	ASSEN KCA DEPOT (507970)	31.691
		DUIVENDRECHT KCA DEPOT (66296)	1.779
		GEM. AMSTERDAM NIEUW WEST (21972)	17
		GEMEENTE EMMEN KCA DEPOT (507966)	31.563
		GEMEENTE LANDSMEER (66325)	5.227
		GEMEENTE ZANDVOORT CHEMOCAR (104731)	558
		KCA DEPOT ETTEN-LEUR (613579)	0
		KCA DEPOT ETTEN-LEUR (90624)	20.699
		KCA DEPOT SPAARNELANDEN NW (104678)	49.246
		KCA DEPOT WATERLAND (66368)	5.311
		KCA DEPOT ZANDVOORT (104731)	2.726
		OOSTZAAN KCA DEPOT (66333)	3.695
		OUDER-AMSTEL KCA DEPOT (66296)	3.599
		PURMEREND KCA DEPOT (100255)	44.802
BIP Depots	P88305200 LATEX VERFRESTEN	AEB EXPLOITATIE B.V. - AP CRUQUIUSWEG (7)	14.378
		AEB EXPLOITATIE B.V. - AP H SNEEVLIETWEG (7)	36.513
		AEB EXPLOITATIE B.V. - AP MEERKERKDREEF (7)	10.560
		AEB EXPLOITATIE B.V. - AP PAPAVERWEG (7)	12.096
		AEB EXPLOITATIE B.V. - AP ROZENBURGLAAN (7)	12.664
		AEB EXPLOITATIE B.V. - AP SEINEWEG (7)	22.098
			309.222

Annex 2: AkzoNobel training about reuse paint model

AkzoNobel

Richtlijnen voor controleren en sorteren van de verf

Visuele controle → De schudtest controle → Controle van de inhoud van de verpakking

↓

Indien niet aanwezig de getinte kleur markeren → Plaatsen van disclaimerlabel → Bewaren van de hergebruikte verf

Planet Possible

AkzoNobel

Visuele check

GEVAAR SYMBOLEN → JA → AFKEUREN

↓ NEE

BINNEN MUUR VERF → NEE → AFKEUREN

↓ JA

PRODUCT INFORMATIE → NEE → AFKEUREN

↓ JA

GA DOOR MET DE VOLGENDE CHECK SCHUDTEST


Planet Possible

AkzoNobel

De schudtest

Schud de ongeopende verpakking voorzichtig!

- Is de verf nog volledig vloeibaar?
  - OK = verdere check uitvoeren
  - NIET OK = afvoeren volgens protocol
- Hoe vol voelt de verpakking aan?
  - OK = verdere check uitvoeren
  - NIET OK = afvoeren volgens protocol

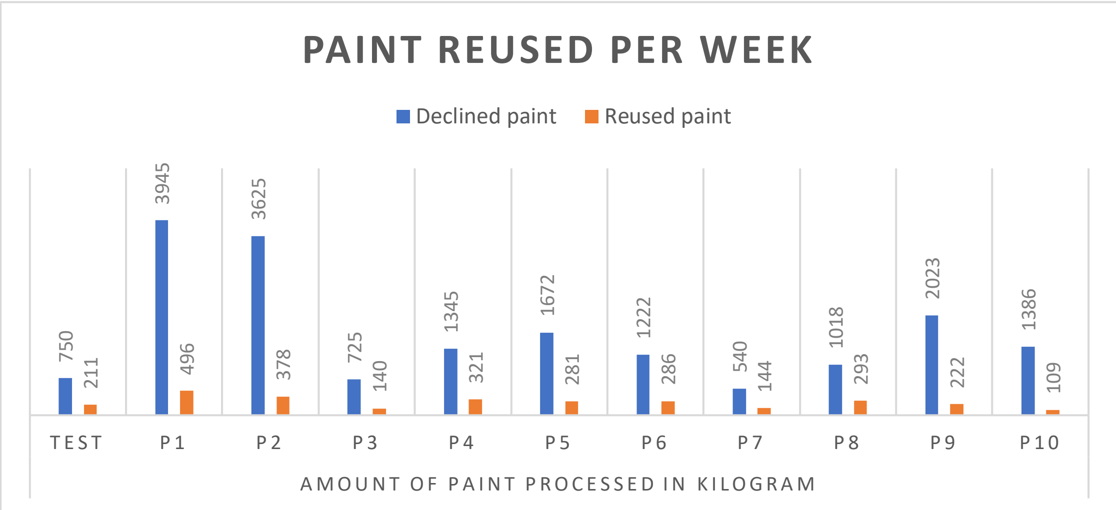
Planet Possible

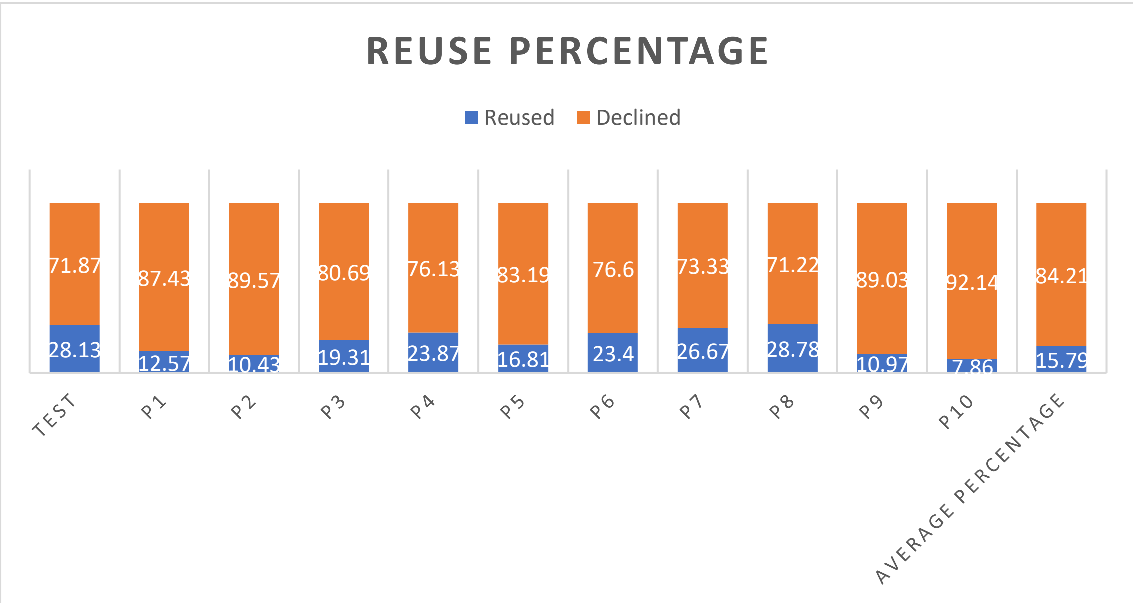

AkzoNobel
Controle van de inhoud van de verpakking
VERF GEUR
NIET OK
AFKEUREN
OK
HOEVEELHEID VAN DE EMMER
MINDER DAN 40%
AFKEUREN
MEER DAN 40%
IS DE VERF MATERIAAL OPROERBAAR
NEE
AFKEUREN
JA
VERF KAN WORDEN GOED GEKEURD
Onbruikbare verf :
Bedorven
Vellen/grof/brokken
Harde bodemkoek)

Annex 3: Kick-off opening in store Rataplan, Amsterdam.

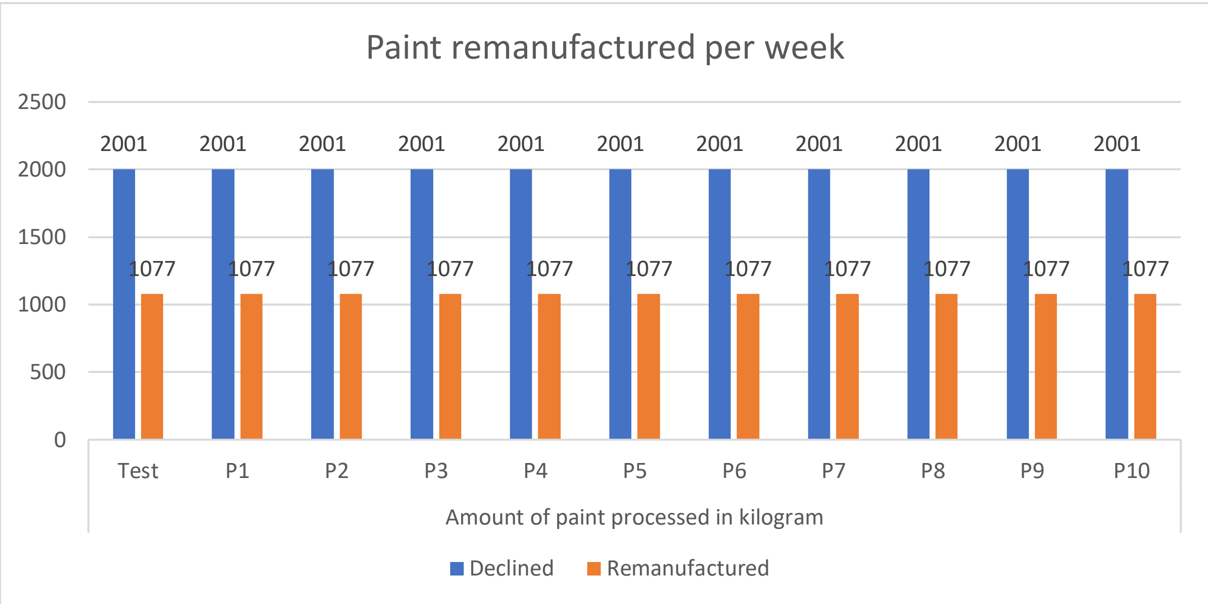
Annex 4: Marketing materials

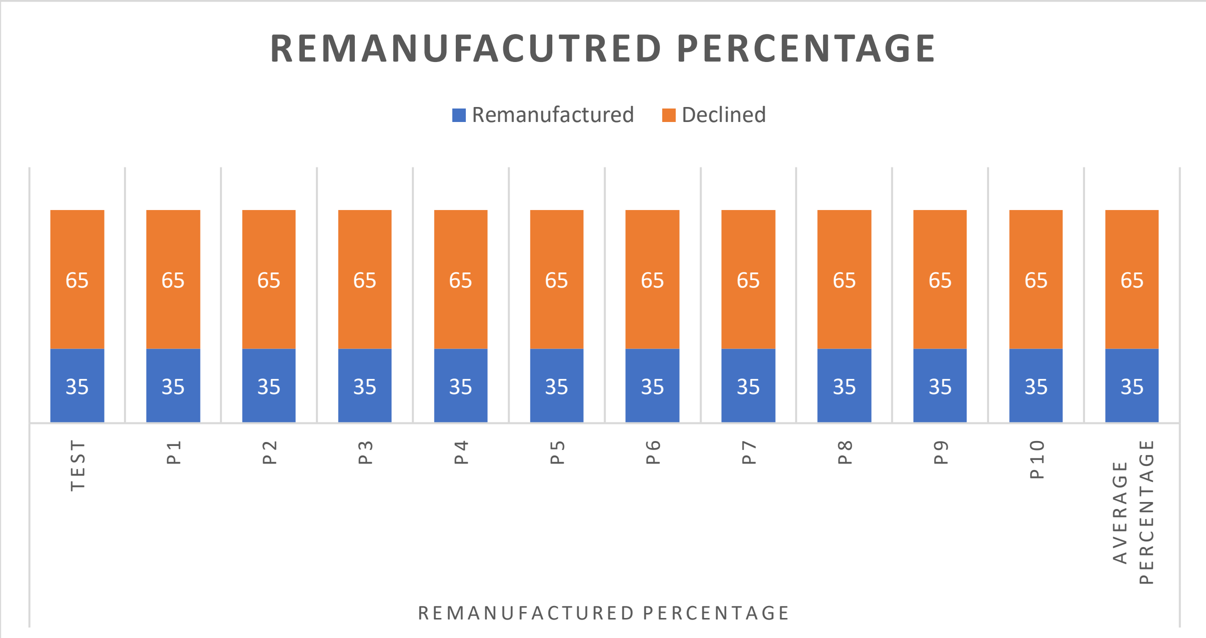
Annex 5: Quantity and percentage of paint reused





Annex 6: Expected quantity and percentage of remanufactured paint





Annex 7: List of experts involved in the project

List of experts involved in the project		
Name	Company	Involvement
Evert Lichtenbelt	AEB	Business Developer (supervisor reuse pilot)
Rik Pothuizen	AEB	Manager natural resources (supervisor remanufacturing pilot)
Robert-Jan Hoogstraten	AEB	Manager Hazardous Waste
Emiel de Boer	AEB	HSE and regulations expert
Chiel Landman	AEB	Teamleader Hazardous Waste
Francien Kardinaal	AEB	HSE and location expert
Jeroen Brink	AkzoNobel	Director Business Transformation
David Cornish	AkzoNobel	Sustainability Expert
Pauline Mulder	AkzoNobel	AkzoNobel Decorative Paints
Yanina Almeida Reyes	AkzoNobel	Expert Trade & DIY NL
Dominique van Ratingen	Gemeente Amsterdam	Projectteam member
Albert van Winden	Gemeente Amsterdam	Program manager waste collection
Abdeluheb Choho	Gemeente Amsterdam	Deputy mayor sustainability
Menno Hoekstra	De Lokatie	Manager thriftstores de Lokatie

Jan Coersen	Rataplan	Regional director thrift stores Zuid-Holland en Noord-Holland

Annex 8: Calculations / annex

Comparing SBM	Business-as-usual	Reuse paint	Remanufacturing paint
Product service	Electricity: 1501 tons of household waste is needed to produce 1 MWh of electricity (AEB, 2016). Assumption is that leftover paint contains the average calorific value for incineration. Leftover paint is 20% of 1501 tons is 20% of 1 MWh gives 0.2 MWh. Heat: 1876 tons of household waste is	• 15% of 300 tons is 45 ton • 5L buckets gives a total of 9000 buckets Electricity: 0.2 * 0.85 = 0.17 MWh Heat = 0.16GJ * 0.85 = 0.14 GJ	• 40% of 300 tons is 120 tons • 5L buckets gives a total of 24000 buckets Electricity: 0.2 * 0.6= 0.12 MWh Heat: 0.16 GJ * 0.6 = 0.1 GJ

	needed to produce 1 GJ of heat. 1876 / 300 = 6.25. Heat generated by 300 tons is 1 GJ / 6.25 = 0.16 GJ •		
Customers			
Value for customer, society and environment in terms of CO2 emitted	1 kg of paint produced gives 1.3637 kg of CO2 produced (AkzoNobel, 2017). Leftover paint: 300 tons of leftover paint *1.3637 = 409 tons of CO2 emitted. [2] Total amount of emitted CO2: 409 tons Amount of waste prevented: 300 tons	1 kg of paint saves 1.3637 kg of CO2 (assuming that 1 kg of paint production is saved). Savings paint production: 45 tons of reused paint * 1.3637= 61 tons of CO2 saved. [3] Remaining leftover paint: 255 tons of leftover paint * 1.3637 = 348 tons of CO2 emitted Total amount of emitted CO2: 409 – 61 = 348 tons Total amount of CO2 emitted compared to BAU model: (348 / 409)*100 = 0.85 gives 85% . This means 15% of CO2 saved. Amount of waste prevented: 300* 0.85 = 255 tons incinerated 300* 0.15 = 45 tons of reused paint	1 kg of Newlife paint gives 0.0716 kg of CO2 produced (AkzoNobel, 2017) Savings paint production: paint: 120 tons of leftover paint * 1.3637 = 164 tons of CO2 saved. Remanufactured paint: 120*0.0716 = 8.6 tons of CO2 emitted for remanufacturing process. Total amount of emitted CO2: 409 – 164 + 8.6 = 254 tons of CO2 Total amount of CO2 emitted compared to BAU model: (254 / 409)*100 = 0.62 gives 62%/. This means 38% CO2 saved. Amount of waste prevented: 300*0.6 = 180 tons incinerated 300*0.4= 120 tons of remanufactured paint
Amount of extra work created in FTE	• No extra FTE is needed to continue the work	1 FTE stands for 40 hours per week. 0.2 FTE is one day a week or 8 hours of work. • 0.2 Full Time Equivalent for	• 0.2 FTE for project management • 2 FTE for remanufacturing

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		project management. • 0.2 FTE for sorting.	
Resources			
Operational resources OPEX	- Waste processing fee: 70* 300 leftover paint= 21000 euros OPEX = 21000	- Waste - Processing fee: 70* 255 leftover paint= 17850 euros + - OPEX for reuse is 40877 euros. See annex 11 further BC. OPEX = 17850 + 40877 = 58727	- Waste processing fee: 70* 180 leftover paint= 12600 + - OPEX for remanufacturing is 133.983 OPEX = 12600 + 133983 = 146583
Distribution channels (amount of stores delivered)			
New partners in supply chain and suppliers			
Product level in waste hierarchy			
Cost structure & revenue streams	CAPEX: 0 euros OPEX: Waste processing fee: 70* 300 leftover paint= 21000 euros OPEX = 21000 See annex 9	CAPEX: 0 euros OPEX: Waste Processing fee: 70* 255 leftover paint= 17850 euros + - OPEX for reuse is 40877 euros. See annex 11 further BC. OPEX = 17850 + 40877 = 58727 See annex 10	CAPEX: 147.000 euros see annex 11. OPEX: Waste processing fee: 70* 180 leftover paint= 12600 + - OPEX for remanufacturing is 133.983 OPEX = 12600 + 133983 = 146583 See annex 11
Value capture for key actors including environment & society			
Growth strategy / ethos			Calculating potential leftover paint is done through amount of inhabitants. AEB gets around 200 tons leftover paint from

			Purmerend, Haarlem and Amsterdam. Approximately 1 million people live in these municipalities. Meerlanden has 317.000 inhabitants, which is about 1/3 of 1 million. Thus, the potential capacity is around 70 tons of leftover paint. The same goes for Utrecht (334.176) which gives 200/3 and Groningen (200.336) 200/5.

Annex 9: Business Case Business-as-usual

Revenue stream:	Quantity	Euros

Paint processing for 270 euros per ton	300 tons	= 300 * 270 = 81.000 euros
Electricity calculation data		Around 8000 euros
Total Revenue stream		89.000 euros

Cost stream:	Quantity	Euros
Paint processing for 70 euros internally	300 tons	= 300*70 = 21.000 euros
Total Cost stream		21.000 euros
Profit		89.000 – 21.000 = 68.000 euros

Annex 10: Business Case Reuse

Pilot experiment:

Date	3-8-2017	3/16/2017	3/23/2017	3/30/2017	4-6-2017	4/13/2017	4/20/2017	4/26/2017	4-5-2017	11-5-2017	18-5-2017	19-5-2917	26-5-2017	1-6-2017	8-6-2017	16-6-2017	22-6-2017	29-6-2017	6-7-2017	13-7-2017	
Time	11.00 - 12.00	12.45 - 14.30	11.30 - 15.30	12:45-14:00	12:30 - 14:00	12:55 - 14.15	12:45 - 15.15	1300-14.00	13.00	13.15 - 14.45	13:00 - 14:45	13.00 - 14.00	10.45 - 13.00	13.00 - 15.00	13.00 - 15.00	08.30 - 11.00	13.00 - 15.00	13.00 - 14.00	13.00 - 15.00	09.00 - 11.00	
Amount of employees	4	4	2	4	2	2	2	2	2	2	1	2	2	4	2	2	1	2	3	2	Total
Amount of working hours	4	7	8	5	3	2.5	2.5	2	4	3	1,75	2	4,5	8	4	5	2	2	6	4	45
Amount of paint ready for processing	750	3945	3625	725	1345	1672	1222	540	1018	2023	1386	440	1519	933	1160	1998	1845	1800	1400	1809	31155
Amount of reused paint	211	496	378	140	321	281	286	144	293	222	109	86	373	140	160	535	270	354	310	316	5425
Recycling rate	28,1333	12,5729	10,4276	19,3103	23,8662	16,8062	23,4043	26,6667	28,7819	10,9738	7,8644	19,5455	24,5556	15,0054	13,7931	26,7768	14,6341	19,6667	22,1429	17,4682	17,4129

(AEB, 2017)

Business Case pilot experiment:

The pilot processes 30 tons of leftover paint in 20 weeks. The new scenario processes 300 tons of paint in 50 weeks. Time is in this case not relevant because the employees get hired per sorting hour. The materials are also related to the quantity. In this case, there is advantage of economies of scale. Stickers and Posters get cheaper when bought in bulk. The assumption is that there is a 20% discount.

Model	Process approximately 30 tons of leftover paint	Process approximately 300 tons of leftover paint
Direct internal costs	**Costs**	
Sorting	3587	35870
Externe kosten		

Marketing	120	1200
Stickers (1500)	353	3177
Posters A3 (50)	70	630
Total costs for 20 weeks sorting to process approximately 30 tons of leftover paint	**4130,50**	**40877**

(AEB, 2017)

Revenue stream:
300 tons of paint is processed for 270 euros per ton. The revenue stream is 81.0000 euros.
45 tons of paint is sold for 1 euro per kg. (AEB, 2017). The revenue stream is 45.000 euros.
Only 255 tons is processed, and 45 tons is reused. This is a cost saving of 45 * 70 = 3150 euros

Revenue stream:	Price	Quantity	Euros
Paint processing for 270 euros per ton	270 per ton	300 tons	81.000 euros
Electricity calculation data is coming		85% of BAU model is incinerated	8009*0.85= 6800 euros
Paint sales for 1000 euro per ton		45	45.000 euros
Total Revenue stream			132.800 euros

Cost stream:	Quantity	Euros
Paint processing for 70 euros internally	255 tons	17850 euros
Paint reuse process	45 tons	40877 euros
Total Cost stream		58727 euros
Profit		132.800 – 58727= 74073 euros

Annex 11: Business Case Remanufacturing

BUSINESS CASE	Upcycling latex		VERTROUWELIJK
Versie	1		
Datum laatste wijziging	11-7-2016		
Datum vandaag	15-8-2018		
Projectnummer	PM		
KENTALLEN			
Minimale IRR	PM	Conform OGSM 2017	
Verwachte IRR (incl. tax)	24,4%		
Verwachte IRR (excl. tax)	350,3%		
Rente	0,0%		
Discontovoet	8,5%		

OMZET	2018	2019	2020	2021	2022
Gate fee verf	8.400	8.400	8.400	8.400	8.400
Verf	240.000	240.000	240.000	240.000	240.000
TOTAAL OMZET	**248.400**	**248.400**	**248.400**	**248.400**	**248.400**

CAPEX	2018	2019	2020	2021	2022
INVESTERINGEN					
Investering systeem					
Licentie-kosten	40.000				
totaal systeem	30.000				
Inrichten locatie	10.000				
Overige materialen	60.000				
Reserve	7.000				
TOTAAL INVESTERINGEN	**147.000**	**-**	**-**		**-**
AkzoNobel investering	-				
Gemeente Amsterdam investering	-				
TOTAAL INVESTERINGEN AEB	**147.000**	**-**	**-**		**-**
VOORBEREIDINGSKOSTEN					
TOTAAL VOORBEREIDINGSKOSTEN					
TOTAAL CAPEX	**147.000**	**-**	**-**	**-**	**-**

Af te sluiten lening (investeringsfaciliteit gemeente Amsterdam)	**-**				

OPEX					
OPEX					
	2018	**2019**	**2020**	**2021**	**2022**
Afhankelijk van capaciteitsbenutting systeem					
Maintenance	1.200	1.200	1.200	1.200	1.200
FTE Reiniging	-	-	-	-	-
FTE operatie	75.000	75.000	75.000	75.000	75.000
Utilities: energie	1.843	1.843	1.843	1.843	1.843
Transportkosten	5.940	5.940	5.940	5.940	5.940
Grondstoffen					
Materialen (emmers, additieven)	36.000	36.000	36.000	36.000	36.000
Verwerken van outputstromen					
Afgekeurde verf	-	-	-	-	-
Overig					
Overhead	-	-	-	-	-
Vloeroppervlakte (locatie, gebouw, etc)	10.000	10.000	10.000	10.000	10.000
Erfpachtcanon	-	-	-	-	-
Marketing & sales	1.000	1.000	1.000	1.000	1.000
FTE buiten operatie	-	-	-	-	-
Veiligheid	3.000	3.000	3.000	3.000	3.000
Verzekering	-	-	-	-	-
Dervingskosten huidige oplossing	-				
Opex overig	-	-	-	-	-
TOTAAL OPEX	**133.983**	**133.983**	**133.983**	**133.983**	**133.983**
TOTAAL Winst	**114.417**	**114.417**	**114.417**	**114.417**	**114.417**

AFSCHRIJVING / AFLOSSING / INTEREST					
	2018	**2019**	**2020**	**2021**	**2022**
Afschrijving		29.400	29.400	29.400	29.400
Aflossing		-	-	-	-
Interest		-	-	-	-

RESULTATEN					
	2018	**2019**	**2020**	**2021**	**2022**
EBITDA	114.417	114.417	114.417	114.417	114.417
EBIT	114.417	85.017	85.017	85.017	85.017
EBT	114.417	85.017	85.017	85.017	85.017

TAXES TOTAAL (INCL CARRY FORWARD)	28.604	135.672	71.113	92.367	21.254
E	85.813	-50.654	13.904	-7.350	63.763

NCW / IRR					
	2018	**2019**	**2020**	**2021**	**2022**
Kasstroom voor NCW berekening en IRR incl. tax	- 61.187	-21.254	43.304	22.050	93.163
Kasstroom voor NCW berekening en IRR excl. tax	- 32.583	114.417	114.417	114.417	114.417
NCW (incl. tax)	37.323				
NCW (excl. tax)	315.394				
IRR (incl. tax)	24,44%				
IRR (excl. tax)	350,31%				

(AEB, 2018)

Revenue stream:	Quantity	Euros
Paint processing for 270 euros per ton	300 tons	81.000 euros
Electricity calculation data is coming	60% of BAU model is incinerated	8000*0.6= 4800
Paint sales for 2000 euro per ton	120 tons	240.000 euros
Total Revenue stream		345.800 euros

Cost stream:	Quantity	Euros
Paint processing for 70 euros internally	180 tons	12600 euros
Paint remanufacturing process	120 tons	133.983 euros
Depreciation machinery per year		29.400 euros
Profit		345.800 – 12.600 – 133.983 – 29.400= 169.817 euros