Study: Applying new sustainable models to long-life assets

MASTER FINAL THESIS

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Abstract

The goal of this research is to show how companies can move to a sustainable business model, what they will find on their path and how long-life assets can help them in the process.

The literature review is done by using articles that are made from previous researches. These articles show how sustainable business models work and how assets can help the business in their circular business model. This way could be learned how sustainable business models work. Studying about the various parts of the company showed where the changes needed to be made.

As a result of the research, we found that there are six main topics that the company has to focus on in order to become a circular company. These six topics are: the business model, the company's employees, the product that the company is trying to sell, the selling strategy of the company, how to store these products and the company's assets.

The report focusses on businesses that work with long-life assets and what they have and can do to make the change from linear to circular.

The conclusion of the research is that the change from a linear company to a circular company is difficult and need to be managed with care. Some big investments are needed in order to make the change. Assets are a big part and help for this opportunity. Increasing their lifetime will help a lot in the search for sustainability.

To make the change now is better than to do it in a couple of years. The people's awareness about sustainability is changing towards being more sustainable and buying sustainable products is a huge part of it.

If the company does not make the change now, they can be overtaken by their competitors, which can result in loss of market share.

The constraints of the report are that it does not focus on the budget part of the change and that it's not focussed on a specific sector. Therefore, in the future it would be good to do a research more focussed on a sector or more about the budget, that would be needed for the change.

Resumen

El objetivo de esta investigación es mostrar lo que las empresas se encontrarán en el camino de cambiar a un modelo de negocio sostenible, qué encontrarán en su camino y cómo los activos de larga duración pueden ayudarlas en el proceso

Este trabajo de investigación está hecho utilizando artículos que han sido usados para investigaciones previas. De esta forma se puede aprender cómo funcionan los modelos de negocio sostenibles. Analizando diferentes partes de la empresa mostró dónde eran necesarios los cambios

Como resultado de la investigación, se han encontrado 6 puntos principales en los que la empresa se ha de enfocar para convertirse en una empresa circular. Estos 6 puntos son: el modelo de negocio, los empleados de la empresa, el producto que la empresa está tratando de vender, la estrategia de venta de la empresa, cómo almacenar ese productos y los activos de la empresa

El informe se centra en las empresas que trabajan con activos de larga duración y lo que tienen y pueden hacer para hacer el cambio de lineal a circular.

La conclusión de esta investigación es que el cambio de una empresa linear a una empresa circular es difícil y tiene que ser manejado con cuidado. Se necesitan una gran cantidad inversiones para hacer el cambio. Los activos son una parte importante y ayudan en esta oportunidad. Aumentar su vida útil ayuda mucho en la búsqueda de la sostenibilidad.

Hacer este cambio ahora es mejor que hacerlo en unos años. La concienciación popular sobre la sostenibilidad está cambiando hacia ser más sostenible y comprar sostenibles es una gran parte de ello.

Si la empresa no realiza el cambio ahora, pueden ser superados por sus competidores, lo que puede resultar en una pérdida de la cuota de mercado.

El informe está centrado en empresas que trabajan con activas de larga duración y lo que tienen que hacer para cambiar de linear a circular. Las restricciones del informe son que no se centra en la parte presupuestaria del cambio y que no está enfocado en un sector específico. Por tanto, en el futuro sería bueno hacer una investigación más centrada en un sector o en presupuesto que es necesario para el cambio.

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1. Introduction

We live in a disposable society. It's easier to throw things out than to fix them. We even give it a name – we call it recycling.

– Neil LaBute

This thesis is a final assignment to complete the master's degree Technology and Engineering Management. The thesis is written under the supervision of Anna Solans and is about the difference between linear and circular economy.

1.1 Background

"Global materials use is projected to almost double from 79Gt in 2011 to 167Gt in 2060." In the upcoming decades, there will be a larger population of people with a higher income that will increase the global demand for goods and services.

As a result of this increasing demand, the mining of raw materials will increase as well. In the figure below the increase of the various categories of raw materials is shown. As shown, the non-metallic minerals are by far the biggest mining material in 2060. This category includes the materials used for making buildings. While the other categories are more used for products and goods.

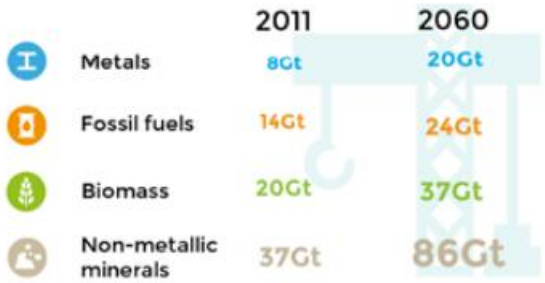

Figure 1: Increase of using raw materials from 2011 to 2060 (OECD, 2018)

The main reason more raw materials are needed is because the global population will increase with 3 billion people from the 7 billion in 2011 to 10 billion in 2060. The global economy is projected to grow on average by 2.8% annually from 2011 to 2060. In combination with the larger population that will get a higher income, a lot more products and goods will be needed to be produced. Especially the higher-end long-life products and to produce these products a lot more assets will need to be build. (OECD, 2018)

1.2 Problematization

The climate crisis is an ongoing topic that every now and then finds its way again in the news. There are studies that are focussing on how to solve this problem, but most of them are focussed on the buyer's behaviour or on the recycling of short-life products and assets.

Studies on the mindset of people are made for how to influence them in being more sustainable and on how to get them to recycle more with for example, separating garbage. While the people try to separate their garbage, a lot of the garbage will eventually be thrown on a dump or will be burned. There is a lot to win on the recovery of materials and while the share of recycling will grow 3.7x from 2011 to 2060 and the mining of materials only 2.6x, the share of recycling in the global economy is ten times smaller than the share of mining. So now that the mindset of the world population is turning toward a more sustainable lifestyle, especially for the younger generations, the companies are going to need to step up. (OECD, 2018)

Mining raw materials has an enormous impact on the environment. There are 4 different impacts that mining has on the world. First there is air pollution. Wind erosion cause the materials to go into the sky. Then there is also water pollution. Because of mining, water gets metal contamination and acid mine drainage. It effects irrigation, swimming, fishing, and domestic water supplies. (Chepkemoi, 2017)

Also, the mining gives physical damage to the nature. A lot of land is being made to open pits and piles of waste rocks. These disruptions damages flora and fauna and it would be difficult for the nature to recover. Also, because of the toxins that are released by the mining, a lot of flora and fauna is being wiped out entirely from the local nature. (Chepkemoi, 2017)

As said before the studies that are done on sustainability or mainly focussed on the buyer's behaviour and on the recycling of short-life products and assets, while there is so much to win on the sustainability of companies, especially with long-life products and assets.

There needs to be more focus on what companies can do to be more sustainable, because the world is ready to be help the environment, but companies are lacking behind.

1.3 Purpose and research questions

To encourage these companies to make the change from a linear to a circular sustainable economy, a plan needs to be made for them. With this general guide and explanation on what to expect when making this change, it will be easier for the companies to change.

When seeing the risks of not making the change and with the help the guide provides, a company will feel more convinced to go to the circular way than before. Their own assets can already help them.

The questions that arise from the purpose of the research are:

- Are the consumers interested in sustainable products?
- What are the differences between short- and long-life assets?
- What impact can long-life assets have on the sustainability of the business?
- What is the difference between a linear and circular business model?
- What to expect from changing to a circular business model?

2. Methodology

In this chapter the methodology on how to execute this research will be described. The methods that are being used will help answering the research questions in the correct way. During the research a mix of the methods qualitative and quantitative have been used by doing desk research.

2.1 Different methods

There are different methods that can be used to execute a research. To choose the methods that fit the best, the subject of the research should be looked at, the information that needs to be find for the research questions and the size of the population when necessary.

2.1.1 Desk research

For desk research secondary data is used. This is data that's already been collected by others for their researches. It can be found offline and online from different sources, such as books, articles, publications, magazines, interviews, website, etc. (Saunders, Lewis, & Thornhill, 2013)

2.1.2 Qualitative research

Through qualitative research, primary data gets collected. With this method, interviews are conducted to find detailed information. There are two types of interviews that can be conducted doing qualitative research: Semi structured and unstructured. With semi structured interviews, the interviewer has a list of theme's and questions that needs to be discussed, but those aren't set beforehand and can vary each interview. Unstructured interviews are informal and are also called in depth interviews. There are no questions set beforehand but there is an idea of aspects that needs to be researched. This gives the person, whom is getting interviewed, the freedom to talk about the subject. (Saunders, Lewis, & Thornhill, 2013)

2.1.3 Quantitative research

Surveys and questionaries are used for quantitative research. Because every person gets asked the same questions, it's an effective way to get the answer of a big sample group. When the population of the research is really big, quantitative research is an effective way to get the right answers. The collected data can be analysed in SPSS and eventually the results can be shown in a form of percentages, tables or graphs. (Saunders, Lewis, & Thornhill, 2013)

2.2 Used method

The used method in this research is desk research. All the information comes from secondary researches. Most of these researches used secondary researches themselves or a quantitative research was used for a survey. In this survey the target audience was a big sample group and according to (Saunders, Lewis, & Thornhill, 2013) this is the best way to do a quantitative research.

2.3 Reliability and Validity

To make sure that the reliability of the used sources is correct, a number of criteria was used:

- When was the article or report published?
  - If it was a long time ago, has it been updated?
  - Is it still reliable with the recent developments?
- Is the source reliable?
  - Are the writers reliable
  - Is the publisher (website or organisation) reliable?

These criteria made sure that the information that has been used in this research, is reliable enough. This is needed to provide the research with the right information to come to the correct conclusions.

About the validity of the research: the researcher made sure that the sources complied with the criteria that were set for the reliability. The researcher respected these instructions for every source.

3. Literature review

First, to reach the objective of the thesis, there needs to be talked about the literature of the subject. To be able to make a comparison or a checklist of how to be a circular business, first need to understand what a circular economy/business is. To make this comparison the literature of linear economy also needs to be discussed. How assets can help a business also needs to be understood.

In this chapter is talked about the linear economy first to understand how linear businesses work.

After the linear economy, the chapter discusses the opposite of linear economy, the circular economy. Circular economy is relatively new, so with it also comes some risks.

Sustainable finance is discussed after the part of the circular economy. This part shows how the European Union looks at the circular economy.

Assets are also an important part of the sustainability of a company. So therefore, it is discussed what kind of different assets there are and what they can help with the sustainability.

For a company it is only useful to change to a circular business model if the customers are looking for more sustainable products. Therefore, the sustainable mindset of customers is investigated.

A new model in sustainability is the Product as a Service model. This model can help businesses a lot in their change to being a sustainable company in the circular economy. There will be looked at what it is and what the advantages and risks are in this model.

3.1 Linear Economy

The Linear Economy follows the process of 'take-make-dispose': Raw materials are bought or collected and then made into product. These products will then be used and after use discarded as waste (figure 2). In the Linear Economy value is created by producing and selling as many products as possible. (PBL Netherlands Environmental Assessment Agency, 2019)

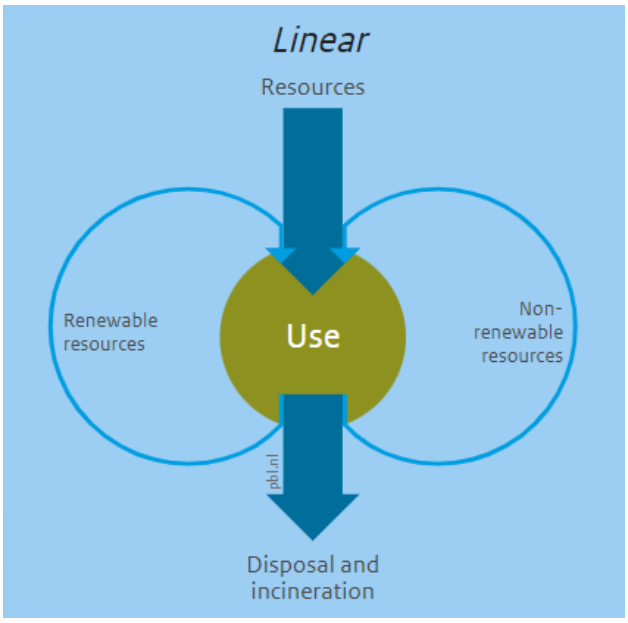

Figure 2: Process of Linear Economy (PBL Netherlands Environmental Assessment Agency, 2019)

Linear economy can be seen as an open cycle. Almost none of the products get recycled and therefore everything goes to waste. So, the main problem of the linear economy is the high usage of available resources. During the production process, resources are most of the time not implemented in the product. As expected, this results in a double negative effect, because it affects the climate and the environment. (ImpacX, 2017)

3.1.1 Disadvantages of Linear Economy

The disadvantages that the linear economy has can be divided into two groups: ecological and economical disadvantages.

Ecological

Around 68% of the raw materials in the linear economy are from non-renewable nature sources, which can be a great threat to the environment and the world. So, the production process in a linear economy puts a lot of pressure on the world's ecosystems. It puts the provision of an essential ecosystem service at risk. (Michelini, Moraes, Cunha, Costa, & Ometto, 2017)

A lot of energy is needed to collect raw materials, as well as water consumption, toxic emissions and destroying nature like forests and lakes. The production process of the product also uses a lot of energy and water, which contributes to more toxic emissions. Even when the product life ends it will end up on a dump, which is space that could be used for more nature (Lucas & Wilting, 2018). A well-known example of the results of the linear economy is the 'plastic soup'. Every year more than 300 million tonnes of plastic are produced by companies worldwide. Because of a lot of plastic waste that is dumped on land, in the sea or in the sewers, five million tonnes of the 300 million tonnes ends up in the oceans. (Plastic Soup Foundation, 2017)

Economical

Not only does the linear economy do damage to the environment, but also economically. The model jeopardises the supply of raw materials. This caused risks, which are, fluctuating raw material prices, scarce materials, geopolitical dependence and increasing demand.

- Fluctuation of raw material prices

Since the year 2006, the amount of fluctuation in raw materials prices increased a lot. These fluctuations create problems for diggers, buyers of raw materials and the market. Because of these fluctuations less investments will be made in the extraction and processing of materials with a result of increasing prices. Companies can't make any price forecasts, which influence their competitiveness on the market in a bad way in comparison to companies that are less material dependent. (Circle Economy; PGGM; KPMG; WBCSD; EBRD, 2018)

- Critical materials

A lot of products are produced with so called scarce materials. Companies make a lot of use of the material, while their availability is limited. Examples are materials like indium and chromium. The metal, computer, electronics and electrical equipment industries and the automotive and vehicle industries make a lot of use of these scarce materials. (van Berkel & Delahaye, 2019)

- Interdependence

Because the world is getting more connected, it is easier for countries to trade their products. As an example: If a country has a scarcity of water, but a surplus of oil, they will trade oil to buy grain. These materials are now connected to each other. The production process of many products also depends on water and fuels. So, with this interdependence, the scarcity of one raw material can lead to a widespread effect of the prices and availabilities of many goods. (European Commission, 2020)

- Increase in material demands

As a result of population and welfare growth, the number of middle-class consumers will increase by three billion by 2030. This means that a massive growth in demand of products and therefore materials is upcoming. In addition, the product lifetime dramatically decreased in last couple of years. Consumers want new products with the latest technology or the latest fashion. Therefore, they buy products faster without fully using the lifetime of the product they currently have. Companies respond by making their products have less quality since the product will be thrown away faster, which makes consumers want new products faster again. This results in a negative spiral which does not seem to end. (Circle Economy; PGGM; KPMG; WBCSD; EBRD, 2018)

3.2 Circular Economy

The circular economy is an economic system where waste is designed out of the business. Circular Economy is the opposite of the usual Linear Economy. Everything in the circular economy is used at its highest value for as long as possible and natural systems are being regenerated while doing that. Circular Economy is comparable with nature, where there is no waste. All the materials that are used have value in the process. When circular strategies are effectively deployed, the process will require less materials to provide similar societal needs. (Circle Economy, sd)

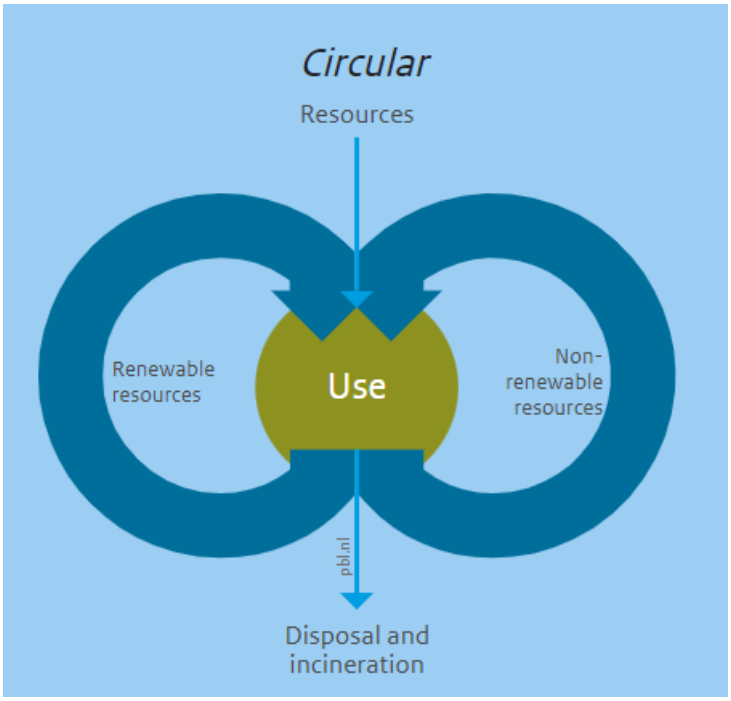

Figure 3: Process of Circular Economy (PBL Netherlands Environmental Assessment Agency, 2019)

So Circular Economy is completely the opposite of Linear Economy. A Circular Economy makes optimal use of resources and raw materials in the process. These resources and materials will be used in the way that they generate the highest possible economic value and the lowest environmental pressure.

The reuse and recycle of raw materials and products and the prevention of waste and harming the environment is the centre of Circular Economy. (Kirchherr, Reike, & Hekkert, Conceptualizing the circulare economy: An analysis of 114 definitions, 2017)

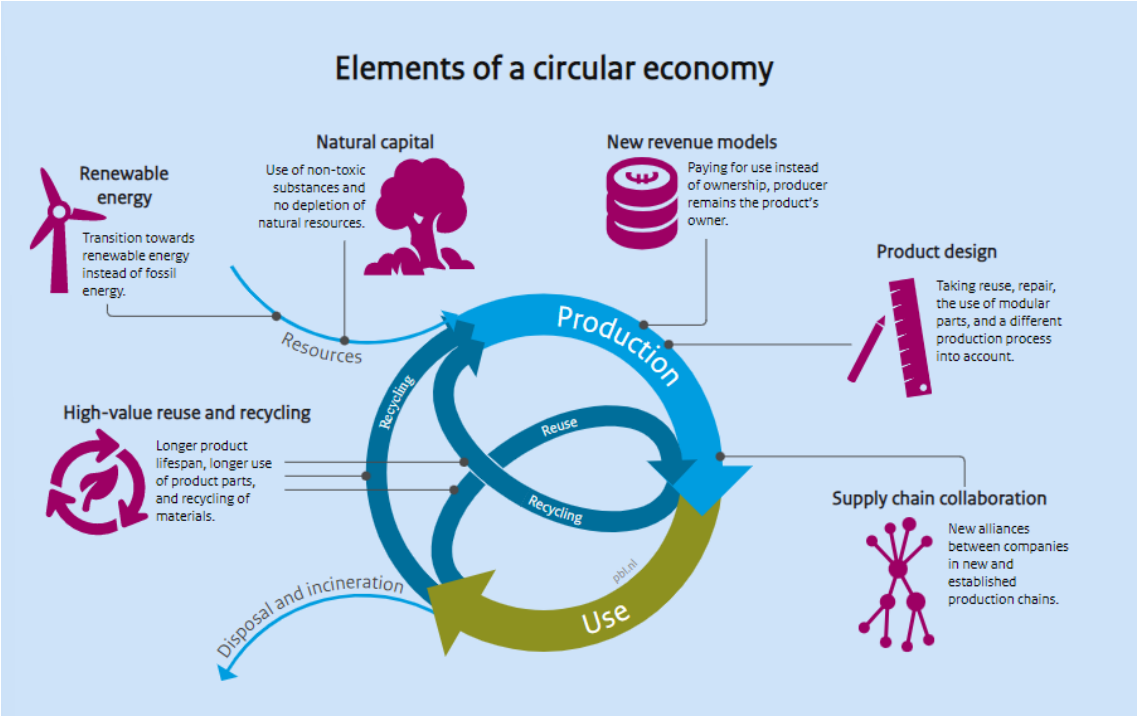

Figure 4: Element of a Circular Economy (PBL Netherlands Environmental Assessment Agency, 2019)

3.2.1 The 7R's

Circular Economy follows the '7R's': Rethink, Redesign/Reduce, Reuse, Repair, Remanufacture/Refurbish, Recycle and Recover. These R's are the base for changing into a circular economy.

Rethink

Rethinking is a particularly important part of the process in changing from a linear to a circular economy. The entire process of making the product needs to be changed. If this is not done with care and precision, the whole modification of the business model can result in a catastrophic problem and a big loss of money.

Reduce/Redesign

To change to a circular economy, the company needs to redesign their product. Their designers need to use lean design strategies to use as less materials as possible. In this process 3D-programs will be used. These programs can help reducing the number of materials that are needed to make the product. During this process, the designers need to

keep in mind the quality and the lifetime of the product. The lifetime of the product is especially important in the circular economy.

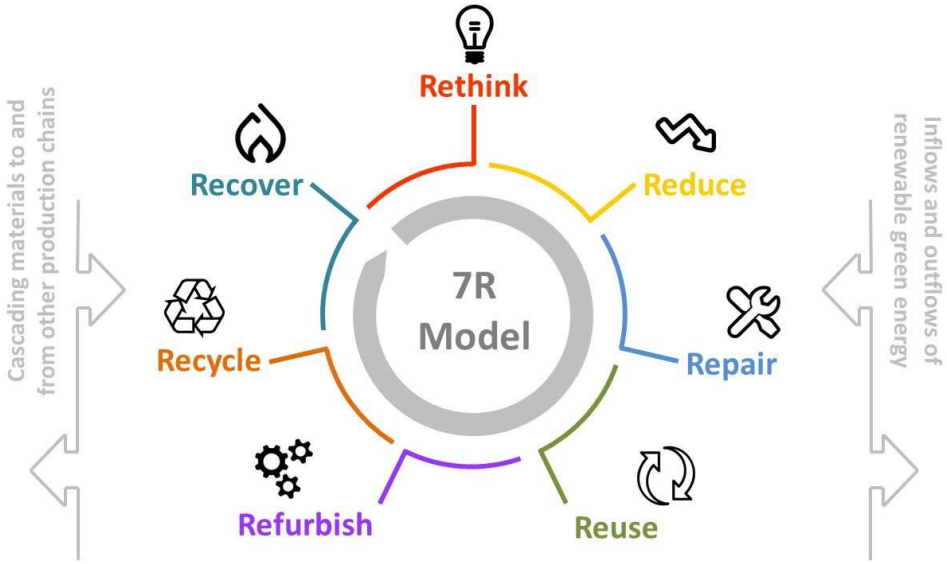

Figure 5: The 7R's Model (van Ree, 2016)

Reuse
The importance of a circular economy is that no materials or products go to waste after they have been used. So, reusing them is a particularly important part in the new business model. The difficulty in the reusing process is to get the customers selling their product to someone else and especially not throw it away as trash. A solution for this can be a recycle service, that the customers can hand in their product back at the company. Another solution can be, if the product is right for the model, is leasing the product, so that afterwards the product gets returned to the company.

Repair
Repair components of the product so that the lifetime of the product increases. When products are expensive, it's better and cheaper to repair the components than to replace the whole product. In rethinking the whole business model of the company, repairing the product can also be a big part of the new model, to help the customer increasing the lifetime of the product. Customers can return their product for repairing and after the repair they get their product back.

Refurbish/Remanufacture
Refurbishing a product is different than repairing. Refurbishing is a product means that the company repairs components of the product but sells it to another customer than the customer they got the product back from. Therefore, refurbishing is important to not get any waste materials or products. It is a great way to increase the lifetime of the product.

With remanufacturing the company totally disassembles the products or a few of the products to use the components. All components are being reused or are repaired and combined to a new (refurbished) product.

Recycle
Recycling can be seen in two ways. Since circular economy is all about no waste, the materials that the company can't use anymore need to be recycled. These materials can be used by other companies for their products, so that they can get a new life for another product. The other way around is about that the company buys other waste materials of another company so that those don't go to waste. These can be recycled in components or into new, repaired, or refurbished products.

Recover
Recovering is the last resort for non-recyclable waste materials. Some materials can't be recycled when they're broken. Because being fully circular economy technically and economically is yet unreachable, the energy that can be generated from non-recyclable waste materials can at least be converted. These materials will be going through a waste-to-energy process to generate the energy.

(Kirchherr, Reike, & Hekkert, Conceptualizing the circulare economy: An analysis of 114 definitions, 2017)

3.2.2 Challenges of a Circular Economy

Changing a business from a linear economy to a circular economy is a big step and doesn't go without any risks in the process. To change the company into a circular economy every branch needs to be aligned. The goal for a company in the circular economy is to no longer depend on virgin/raw materials. To reach that goal the products that the company produces must be sustainably designed. The products that are used by the customers need to be fully recycled without the loss of quality. This transition is difficult and comes with risks that the company needs to manage carefully. The following categories of risks are possible to occur if the transition is not managed carefully:

Cooperation:
One of the biggest needs in the circular economy is that everybody needs to collaborate with the company. All the products of the company need to be fully recycled to achieve a fully operating circular economy. This can only be achieved by changing everyone's behaviour. All the company's products need to be recycled to have enough materials/resources to produce new products. So, the customers need to be informed about the possibility that after they used the product, they can hand it in at the company to recycle the product. When the company doesn't have enough materials/resources to produce new product, they will have to use new virgin materials. This is what the circular economy wants to counteract.

Design:
Another risk is the design of the company's product. The company must design the product in a way so that every part of the product can be fully recycled. When building the parts and assembling the product generates to much waste in the process, the company must use virgin materials. Again, this is not what the company wants to achieve the circular economy. That's why the company must design their products in a sustainable way.

Quality:
A big problem that can occur is the quality of the product. There's a possibility that the quality of the product drops, because of the use of recycled materials. Therefore, it's important that the product made with recycled materials undergoes a serious quality check before being sold. The company needs to make a procedure for these products, so that the quality of their products stays the same. The quality of the product also depends on the design of the product, explained in the design risk. When the product is well-designed, it will be easier to recycle and, as a result of that, the quality will be guaranteed more easily.

Time:
Since people are getting more aware of sustainability, time is also going to be a bigger risk every passing day. If the company starts too late with their change to a circular economy, chances are high that another company did it before them. Customers will be drawn to that other company and the company that is too late will lose customers in the process. The same applies to the duration of the change from linear to circular economy. The company can lose a bit of their market share if another company beats them in the race to circular economy.

(Kirchherr, et al., 2017)

3.3 Sustainable Finance

The current business models, the linear economy is created back in the 20th century. In this time nearly no persons or companies took care of their natural resources, their usages, and their carbon footprint. All these business models are still used nowadays by many companies. This is a problem since the people want to reach the environmental goals of the Paris Climate Agreement or the UN agenda 2030. Luckily, some companies are already aware of the problem and starting to develop and change their business models to become part of the new sustainable economy, the circular economy. (Schoenmaker & Schramada, 2019)

The new models have three aspects: economic, social, and environmental. Making a deeper look into the sustainable developing from an economic perspective means that this development is discussed under the name of ecological economies, which connect the ecology and the economic perspectives. This model points out that circular economy is the most sustainable model, because it accepts how the economic world would work within the guidelines of acting in the range of what nature gives to the world and that the companies need to follow these rules of the nature. (Weber & Feltmate, 2016)

The European Commission 2018 has three main points which need to be considered while they want to support the economic growth when it comes to sustainable finance:

- Reducing waste and improvement of the usage of natural resources
- Reducing pressure on the environment
- Addressing the greenhouse gas emissions and tackling pollution

Sustainable finance should protect the worlds resources for the upcoming generations. The current and upcoming generations should also be able to use and live of the same resources that are used now. If investors want to follow these rules they will have to only invest into sustainable businesses, which take care and protect the natures resources.

According to the European Commission 2018 the following points are essential in achieving a sustainable financing system:

- Companies must be transparent about their governance, social and environmental policies

- Get an EU classification for sustainable activities
- Investments take climate risks into account the banks' risk management policies
- Get an EU label for green financial products

(Schoenmaker & Schramada, 2019)

3.4 Assets

An asset is a resource with economic value that an individual, corporation, or country owns or controls with the expectation that it will provide a future benefit. Assets are reported on a company's balance sheet and are bought or created to increase a firm's value or benefit the firm's operations. An asset can be thought of as something that, in the future, can generate cash flow, reduce expenses, or improve sales, regardless of whether it's manufacturing equipment or a patent. (Barone, 2022)

3.4.1 Types of assets

There are four different kinds of assets that can give economic value: current assets, fixed assets, financial assets and intangible assets. All assets can also be put in two groups: short- and long-life assets.

Current assets

Assets that are expected to be sold or used in the next year are called current assets. This is in result of the standard business or personal operations. This is also the difference with long-term assets, which are used for longer than a year. Current assets are important, because they can be used to fund day-to-day operations and pay for the operating expenses. (Hayes, 2021)

Fixed assets

A long-term tangible piece of property or equipment that is owned or used to generate income is referred to as a fixed asset. These assets are assumed to be consumed or converted into cash after at least one year. That is why these assets can be depreciated in value over the years in which they are used, because of the wear and tear. (Kenton, Fixed Asset, 2022)

Intangible assets

Assets, that are intangible, are not physical. Intangible assets can be seen as brand recognition and intellectual property. Intellectual properties are patents, trademarks, and copyrights. They can be seen as indefinite or definite. Definite assets will stay a limited time and indefinite will stay for ever, such as a company name. (Kenton, Intangible Asset, 2022)

Financial assets

Financial assets are also called liquid assets, because they get their value from contractual rights or ownership. Unlike the fixed assets, financial assets don't necessarily have a physical form or worth. Their value reflects from factors of supply, demand, and risk in which they're traded. Financial assets are seen as an in-between the other assets. (Chen, 2021)

Table 1: Overview of the several types of assets

Type	Characteristics	Examples
Current	Used/sold in a year Result of standard operations Fund day-to-day operations	Cash Stock inventory Accounts receivable
Fixed	Used over the long term Can be depreciated in value	PP&E: Property Plant Equipment
Intangible	Not physical Can be created or acquired Definite or indefinite Don't appear on balance sheet	Patent Brand (name) Contract Copyright
Financial	Liquid asset, representing value Non-physical form or value needed	Cash Stocks Bank deposit

Short-life assets
Short-life or short-term assets are known for being held by a company for less than one year. Short-life assets are also defined as current assets and they will be converted into cash within a year. Examples are inventory that will be sold to customers and accounts receivables that are being converted into cash by clients paying off their debt. (Kenton, Short-Term Assets, 2021)

Long-life assets
Also known as long-term assets, long-life assets can include company's properties, plants, and equipment, while also include other assets such as long-term investments, patents, copyrights, etc. Long-life assets are reported on the balance sheet at the price they were purchased for. The name long-life assets already show that the asset will benefit the company for many years in the future. (Murphy, Long-Term Assets, 2020)

3.4.2 Asset costs
Assets have a variety in costs. The costs of the investment in the asset, the depreciation, and the operational costs.

Investment
The machinery investment ratio is the measure of the amount of investment in machinery the company has done. It indicates what the company invested into plant and equipment in comparison to the level of total income generated by the company. This ratio should be around 80%, meaning that the investment of the machinery costs around 80% of the total income generated by the company. (Rural Directions, 2015)

Operational costs
The operational costs of an asset are the costs that the company has to pay for the asset in order to keep it operating. It depends on the asset, which amount of operating costs is necessary. Operational costs include: maintenance, energy usage, and possible others to keep the asset running. (Murphy, Operating Cost, 2022)

Depreciation
The depreciation of an asset is very useful for a company. It can help them in the accounting of the business to increase the profit of the company. It can also help them for the taxes.

$$Depreciation = \frac{Investment\ in\ assest}{Useful\ lifetime}$$

As a result of this calculation comes a number that can be written off by the company every year as long as they have the asset in their possession. (Tuovila, 2022)

3.4.3 Asset Maintenance
A lot of times 'maintenance' is seen as the synonym of 'repair', but in companies, asset maintenance means preventing repairs. Asset maintenance means keeping the assets in a good condition. This can be for example: inspections or repairs. Or when talking about a car keeping the oil level high enough. (FMX, 2020)

When using asset maintenance effectively, it will take care of the lifetime of the asset and its performance. For machines it will mean less downtime and fewer repairs. Using asset maintenance in the correct way will make sure that your assets are in a good condition and function at their best performance. (FMX, 2020)

3.5 People's sustainable mindset
People's mindsets are playing a huge role in if they would buy sustainable products or not. When consumers don't want to buy sustainable products, then the whole change from linear to circular economy can harm the company. The company can lose their consumer base and in the worst case then go bankrupt.

The other way around is that the consumers only want to buy as much sustainable products as possible. If the company doesn't make the change, then they will also lose their consumer base.

So, what do the customers want now? Are they willing to buy sustainable products or what is stopping them from not buying them?

In recent research, execute by PwC (PwC, 2021), some interesting facts about the consumer's buying habit came above.

The research was done across all the generations, with exception of the oldest generation, with five statements about shopping sustainably:

- I choose products with a traceable and transparent origin
- I buy from companies that are conscious and supportive of protecting the environment
- I intentionally buy items with eco-friendly packaging or less packaging
- I am buying more biodegradable/eco-friendly products
- When shopping for products, I check the labelling/packaging for sustainability certification(s)

The results in the table are a combination of the "agree" and "strongly agree" responses. The shade of green indicates proportions of agreement relative to other generations. The darker the green the bigger the percentage.

Table 2: Results of the five statements about shopping sustainably (PwC, 2021)

	Generation Z	Young millennials (age 23-26)	Core millennials (age 27-32)	Mature millennials (age 33-36)	Generation X	Baby boomers
I choose products with a traceable and transparent origin	47%	59%	60%	62%	56%	48%
I buy from companies that are conscious and supportive of protecting the environment	49%	60%	61%	58%	53%	47%
I intentionally buy items with eco-friendly packaging or less packaging	48%	55%	60%	55%	55%	51%
I am buying more biodegradable/eco-friendly products	48%	56%	59%	58%	52%	47%
When shopping for products, I check the labeling/ packaging for sustainability certification(s)	47%	57%	58%	53%	51%	43%

Base: Generation Z (1,360); young millennials (933); core millennials (1,588); mature millennials (919); generation X (2,848); baby boomers (975).
Note: The greatest generation (the oldest group) is not shown, because the base is too low.

Taking a closer look at the table of the research, the findings show that not all the younger generations are becoming more eco-friendly, but they still tilt more towards eco-sensitive behaviours with millennials in particular. A significant amount of the older millennials, the mature millennials aged 33-36, say that they prefer to choose products with traceable and transparent origins. As many core millennials, aged 27-32, agree with the statement that they buy more from companies that are more eco-conscious than others.

The insights of the research are expressing that there's an increasing interest towards sustainability. On the other hand, the data is showing that consumer goods companies or retailers shouldn't overestimate this green wave. More consumers are saying that they're eco-friendly, but still a lot of the consumers say that they aren't. Looking at the table, it indicates that generation Z might say that they're aspirational about eco-friendly buying, but this doesn't result in actually spending money on more eco-friendly products. The believe is that when companies are increasing more affordable and practical sustainable choices, that then a higher increase in customers, who are willing to buy sustainable products will appear.

This believe is substantiated by the following question that was asked to the people who disagreed to the sustainability statements or had no opinion about three or more of the statements.

The question is about, which of the statements affect your ability to shop more sustainably.

In this question 19% of the disagreeing people are saying that they are not interested in sustainability or ethically produced products at all. On the other hand, 44% say that at the moment they feel that sustainable products are priced too high. This can explain why the Generation Z doesn't score as high as thought. The Generation Z contains mostly out of students, who usually don't have much to spend, so the highly priced sustainable products aren't affordable to them.

The answers to the question also show that consumers think that the quality of the products are lower than the quality of the less sustainable variants of the product (24%). Others say that they don't have the time to shop for sustainable products (20%).

Table 3: Results of which statements affect your ability to shop more sustainably (PwC, 2021)

The results of the research also show that the group of less eco-friendly people are more likely to work away from home than working at home. These people are probably choosing for the more convenience way to shop, in result of having less interest.

(PwC, 2021)

3.6 Product as a service model

Product as a service is the concept of selling the service and outcomes a product can provide rather than the product itself. This model increased interest from companies and manufacturers to improve the profitability and sustainability of their products. With the service, customer engagement improves as well. (Essex, 2018)

3.6.1 How does Product as a Service model work?

In its purest form, the manufacturer or company of the product keeps owning the product that they're "selling". The customer is leasing the product or subscribes to the services that the company is providing with the product.

Another way product as a service works is that the customer owns the product but is not responsible for the maintenance of it. Who is exactly responsible for what, depends on the license agreement or the warranty of the product.

In all cases, the product is being used as a platform for delivering additional services to the customer by the company.

Because the product is still owned by the manufacturer, they can use sensors to monitor the state of their product. They can check certain factors, to see what kind of impact it has on the product. These factors can contain, how the product is being used as well as environmental aspects like temperature and humidity.

By monitoring these sensors remotely, the manufacturer can identify and address potential problems of their products through their data and apply preventive repairs where needed.

It will also be possible for the customer to order repairs by the manufacturer when needed. This way repairs can be done quickly and improves the customer relationship with the manufacturer.

For the manufacturer it changes their revenue stream with monthly recurring revenue. By generating a monthly cash flow, it makes their income more predictable and stable than selling their products for a project occasionally.

(Essex, 2018)

3.6.2 The possible advantages

With the product as a service model there come some advantages for the customer and the manufacturer

For the customer it is good to know that they don't have a responsibility over owning the product that they're leasing. Same for keeping the product in a good and usable state for the employees. With that also comes the risk of losing the financial investment. Because the customer doesn't have the responsibility of the product, the price of the service is usually more than just buying the product.

The other advantage of leasing the product is that the manufacturer is responsible for maintaining and repairing the product. The customer can call the manufacturer when repairs are needed, or the manufacturer can come in for a routine maintenance job.

For the manufacturer, one of the main advantages is the difference in revenue stream. By selling their product in the normal way, their revenue stream won't be stable every month. With the product as a service model, they lease their product and generate a monthly income by leasing, repairing, and maintaining the product. It helps the manufacturer to create a more stable and predictable revenue stream.

The other main advantage is that the manufacturer can create a better relationship with their customer. If the manufacturer shows that they're working hard to keep the product well maintained, the customer is more likely to stay after the lease contract ended. It generates more income and with the good reviews it can also help finding new customers.

(van Boesschoten, 2017)

3.6.3 Risks of the Product as a Service model

There're a few risks that come with the transition to the product as a service model. These risks should be carefully considered in order to make the transition to this new model.

The first risk is about the financial change in the company. As seen in the explanation there will be an enormous difference in revenue streams. It will be smaller amounts in monthly payments instead of the large amount occasionally. Because the company will receive smaller amounts every month, they need to look out for their financial activities that they need to operate their business. With the smaller amounts they can't always do their bigger financial activities, which results in taking loans from banks. When lessee companies can't pay their monthly payments, it can mean that the company might not be able to pay off their loans at the bank, which could result in bankruptcy.

The second risk is about the lifetime of the products. A products lifetime starts when the product is being used. When the customer is using the lease product the value of the product decreases while the depreciation rate rises every year. After the lease contract has ended, the product will return to the manufacturer. The manufacturer then has two options what they can do with the product. One is leasing the product again for the depreciated price or they can make repairs so that they can lease products again for the

normal price. If the repairs are not done efficiently, then the chance will rise that the company loses money over their products.

The third risk is about the market that the company is working in. More companies are changing their business model to the product as a service model. If the company changes their business model too late or not in the correct way, they can lose a lot of (potential) customers. The costs in changing the business model can rise and the company might not recover from this transition, which will result in losing a lot of money or even bankruptcy.

(van Boesschoten, 2017)

4. Comparison Linear vs Circular business (with example)

To show the differences between a company that works according to the linear economy and circular economy, there will be made a comparison with an example. The company that is used as an example is Gispen. Gispen is a furniture company, which works in the circular economy. The comparison between Gispen and a regular furniture company will be divided into a few parts where circular economy separates itself from linear economy.

But first there will be taken a closer look at the example company Gispen, to get a better feeling about what they're doing to be a circular company.

4.1 Gispen

Gispen was founded in 1916 by Willem Hendrik Gispen. The factory was located in Rotterdam. From his time as a student W.H. Gispen had many friends who were designers or architects and together they were making new products.

Gispen's mission is to strive for the creation of environments that positively influence people by their inspired sustainably designed products and workspaces.

They vision of Gispen is to become a sustainable company that challenges itself and its partners to produce innovative solutions that simulate sustainable use and at the same time contribute to other success factors of an organization.

(Gispen, sd)

4.1.1 Circular activities

As seen in the literature study, the key to being circular is to use the 7R's model as much as possible. Gispen does the same and works them out pretty well.

To start, Gispen re-thought their whole business model. They want to be a fully circular company and are partially working with a new product as a service model that will be discussed later on in this chapter.

Gispen also redesigned their furniture products to use as less materials as possible, while keeping in mind to reduce the number of new materials. The redesigning helps to put more materials from old products into the new furniture.

With the product as a service model that Gispen installed, Gispen will be reusing more old furniture than before. As said before this will be discussed later on.

For the repairing part of Gispen's circular business model they came up with a new idea called 'REVIVED by Gispen'. A company can call Gispen when their furniture is a bit damaged or out of date. Gispen will then come to the office to fix minor damages and take the more damaged furniture back to the factory. In the factory the more damaged furniture will be brought back to life by swapping the parts that need replacement and rebuild it with new parts. This way there will be less waste and energy usage.

Not only does Gispen repair furniture, but they also remanufacture or refurbish their furniture. For the remanufacturing of olds products, they also made a program called 'REMADE by Gispen'. When a company wants new furniture, they can call Gispen. Gispen will then come by your office to check the company's old furniture. Because throwing away your old furniture is not good for the environment, the company can give it to Gispen. Gispen then will check what parts of the old furniture they can use for their own new products. This way there will be a lot less waste and the old cabinet can become the new couch.

All these projects can be summarized by Recycle. Gispen recycles old furniture from companies, customers or even customers from other furniture companies, that otherwise

would be seen as waste. Gispen uses all the useful parts that they can use for their own new furniture.

The materials and parts that they can't use anymore will be recycled or upcycled. Their connections with a waste processing company helps them with this. When the old materials have been brought and processed by the waste processing company, Gispen will receive them again. These processed materials can then be used again for their new furniture.

(Gispen, sd)

4.1.2 Furniture as a Service

Gispen created a new selling strategy for themselves called: Furniture as a service. This is their take on the product as a service business model. Furniture as a service is a form of operational lease. Gispen will keep the economic risk for the furniture that they lease to a company.

With this lease contract that Gispen has with the company they will add multiple services. The company not only gets the furniture, but also future repair services. The company can request repairs whenever they want and Gispen will then send service or technician employees.

(Gispen, sd)

4.2 Comparing linear vs circular business model

The comparison starts with the business model. As will be shown in the comparison, the business model of Gispen is different than most furniture companies in the world. Next is the start of the production process with buying materials. After buying materials the production process starts, which is a particularly important step in the alteration from a linear to a circular economy. When the products are made the company needs to sell them, but even this step can be really different to the normal process of a linear economy. As seen in the literature study, extending the lifetime of the products is also a part of the circular economy. Quality is important, because if the product doesn't break the customers doesn't have to buy a new product that costs materials. All products will eventually be thrown away or break, so getting rid of these waste materials is very important for a circular business. A lot can be done to make differences in this part of the business. To end the comparison there's also a look at what it means for the financial situation of the company.

For every part of the comparison, we discover a few key notes which are needed to make a plan for changing from a linear to a circular company. So therefore, these key notes will be used in the next chapter to show the plan.

4.2.1 Business model

To make such a change from linear to circular economy, a company needs to change from its core, the business model. A furniture company most of the time works in a B2B and B2C model. Business-to-Business model is the indirect channel of selling. The company sells their furniture to another company or retailer. Business-to-customer is the direct way of selling a product. The company then sells the product directly to the end user. If the business model is changed in the right way, the rest can follow more easily.

Also, the mission and vision of the company need to be changed to give the company a direction to work in. If the mission and vision of the company aren't set in the right direction, then the company will never achieve its goals.

Linear Economy
A company in the linear economy will most of the time never see the product again. Sometimes they have a repairing part in the company, to repair products that were damaged in their warranty time. At the end of the product-life, the product will probably be thrown away and not returned to the company. So, the focus of a linear company is to sell as many products as possible to generate a lot of money. The mission and vision of the company will lead as a guidance on how to achieve this goal.

Circular Economy
A mission and vision of a circular company are different than the one of a linear company. There is a shared goal in maybe: making a lot of money or to be the biggest company in their sector. But the focus of the circular company is to it in a sustainable way. When the company made the right changes to the mission and vision then everyone working in the company can start adapting to the new way. A key role is reserved for the directors of the company. They will have to lead by example so that the rest of the employees will follow.

Important key notes:
- Create a new mission
- Create a new vision
- Directors need to lead by example

4.2.2 Buying materials
Buying materials looks like it can't be much different for a linear economy than for a circular economy, but even this step is really important to be a full circular business.

Linear Economy
Companies that buy materials, while working in the linear economy, don't have many demands in the sustainability of where the materials come from. Their demands will mostly focus on the quality of the material and the price.

Circular Economy
In the circular economy even the provider of the raw materials needs to be sustainable. This company needs some form of certificate that they're doing as less impact on the environment as possible to mine these raw materials. Only then a company like Gispen can be seen as circular.

The company need to do good research on their supply partners to see if they have the right certificates and labels to deliver them materials. Just like in the linear economy the quality of the material is still important and so is the price. Only with the price it doesn't mean when a linear material provider is cheaper that the company changes to the linear provider.

Important key notes:

- Good research needed
- Certified suppliers
- Other usual criteria

4.2.3 Production process

The production process is the part where the company can make the most impact on changing to a circular economy. Because in this part you can make the most impact, it's also the part that's most difficult to change.

Linear Economy

In a linear economy, the production process is focused on efficiency. Making products as fast and as many as possible. Depending on the company the quality of the product is also important. The product is designed to be made easily in the factory.

Circular Economy

Circular economy on the other hand focusses on other things in the production process. The product is designed to generate as little waste as possible. The product should also be made to be easily repaired or to use old parts for the new products. Therefore, the production line should be designed in a totally different way than in a linear economy. In this production process it should be easy to integrate old materials or parts in the new products.

A furniture company like Gispen needs to check if their machines that they use for building the furniture can also use old parts from previous products.

Important key notes:

- New product design
- New production line
- Integrate old materials or old parts in new products

4.2.4 Selling products

A furniture company can sell their products to three different types of customers. They can sell their products to a retailer that will sell it on to customers. They can also sell their products to a company. This company won't sell the products but will use them in their, for example, office. At last, they can sell their products directly to customers, who will use the furniture in their home.

Linear Economy

Furniture companies that sell their products in the linear economy, gets the money, and probably sees the product never again. The only way the product would come back is with warranty issues or when the company has a repairing station. After the product-lifetime is over, the product will probably be thrown away at a dump or a general recycling station.

Circular Economy
The three diverse types of customers stay the same in the circular economy. The only difference that needs to be made is that the company needs to create more awareness. The awareness that the company wants the products back after they have been used. When the customers know that the company wants their products back to recycle, reuse or refurbish them, customers will be more eager to send them back.

Gispen also sells their products in another way, by leasing them. Companies can buy the furniture with a contract. They pay for each year that they use the products. After the leasing contract ends, the products get returned to Gispen. This way Gispen doesn't lose any products or materials that they can use to repair, recycle, and reuse.

Important key notes:
- Leasing as a new selling type
- Create awareness with the selling
- Sell with opportunity of returning after use

4.2.5 Repairing products
To extend the life of the product is an ideal way to be more sustainable. Repairing the product is a key part of the extending. The approach to the repairing is different in both the linear and circular economy because they both use the repairing for different reasons, when necessary.

Linear Economy
Repairing the product in the linear economy doesn't happen when the customer is done using it and sends it back to the company. In the linear economy the repairing only happens for warranty reasons or when the company has a repairing service so that the customer can send the product to repair it, but still wants it back.

Circular Economy
Just like in the linear economy the circular economy model also works with the repairs for warranty reasons or when the company has a repairing service. While they are working the same way with this, for circular economy it doesn't stop there. They use the repairing/refurbishing also for products that customers don't want to get back. With doing this they can resell these products and by doing that they extend the life of the product.

Gispen uses their Remade by Gispen program to push companies into letting their old furniture be repaired by Gispen.

Important key notes:
- Repairs after the customer used it
- More repairs coming in
- Possible increase in technicians needed

4.2.6 Recycle/Reuse products

Recycling and reusing the products is one of the main differences between the linear and circular economy.

Linear Economy

The linear economy doesn't really focus on the recycling or reusing of products. The most that most linear companies will do, is the refurbishing of products. These aren't products that are send back because the customer has used them enough, but these are products that are send back because the customer sends it back in the reflection period or when the product doesn't work when delivered.

Circular Economy

On the other hand, there's the circular economy, which focuses a lot on the recycling and reusing of their products. They've created awareness across their consumer base that their products can be send back to the factory to extend/get a second life. Because a lot of consumers will send their products back for recycling, the company gets a lot of parts for their new products as well. So, the company can use the returning products in two ways: repair it and then reuse/resell it or to recycle it and use the parts for their new products.

In the case of recycling and reusing, Gispen uses their Revived by Gispen program to use old company's furniture for making new furniture. Sometimes for the same company or sometimes for others.

Important key notes:

- More recycling
- More reusing
- Create awareness about the recycle program

4.2.7 Financial Situation

Depending on what the company wants and what kind of company it is, the financial situation can change. There are multiple ways to sell a product in the circular economy than in the linear economy. As shown in the literature review is the product as a service model one of the main options.

Linear Economy

In the linear economy the main selling ways is the "normal" way. This way the company gets money with every purchase and never sees the product back. The other way is the leasing way. This is subscription based, so the company will get a monthly or yearly payment by the consumer or company. For a furniture company the first option is the most used, because this works the best for consumers and companies. The furniture company won't see their products back and finds it difficult to recycle them.

The company gets their money at one moment and because of this will have a higher cash reserve than a company with a leasing or subscription model.

Circular Economy
As written a lot before, in the circular economy it is important to get the products back in order to recycle and repair them. The product as a service model is an excellent model to use for circular businesses. It guarantees them that the company can repair the products in their lifetime so that they can extend it. Also depending on the contract, the company will have a guarantee that the product gets returned to them as soon as the consumer or business is done with it. The "normal" selling option is also still used by circular businesses.

The company Gispen uses this model a lot. The only risk with this model is that the Gispen doesn't get a lot of money at once when they sell their furniture to a business but gets it in monthly payments. This makes it more difficult to pay off high bills or to do big investments since they don't have the money all at once.

Important key notes:
- Possible changes in payments
- Financial risks
- More difficulty to pay off big bills or investments

4.2.8 Company assets
The company's assets are the biggest investments that a company will make. So, to make the right investments for a circular business is important. There are different ways to select the right asset for the company. Depending on the asset some of the filters can be: energy or water usage, how many products can it make, size, price, life and/or maintenance.

Linear Economy
In a linear business the most general focus, when investing in major assets, is how to get the most profit with the least amount of investment. This can mean that the business doesn't buy the best sustainable assets.

Circular Economy
The most general focus in the circular economy is the sustainability of the assets. The focus on most assets will be the usage of the assets in electricity and/or water. The disadvantage is then that the productivity of the asset can be lower than less sustainable assets. These are considerations that the company needs to consider. The circular business also focuses on the extending of the lifetime of the asset (Discussed in chapter 6)

Important key notes:
- Buy sustainable assets
- Energy usage
- Water usage
- Extending asset's lifetime

4.2.9 New investments

A company always makes room for new improvements. A linear company will mainly focus on how to improve the efficiency of the production or in new products. The circular companies will focus more on how to be more sustainable.

Linear Economy

As said above the linear companies will focus more on the efficiency of the production process. This will include investing in new machines that have a higher production rate than the older ones.

Circular Economy

Circular businesses will invest in new sustainable projects. This can differ in research and development for new projects or in new sustainable assets that can help the company being more sustainable than before.

There are various kinds of assets that the business can invest in. If the company has a warehouse or a factory than it can help to put solar panels on the roof.

Also, for some businesses it helps to purify the water after they have used it, because a lot of water can go to waste. This water will be dumped in the sewer, which can definitely be reused again once purified.

For the assets that the company owns it is important that there's a good maintenance plan. With a good maintenance plan the life of the assets can be extended. This will delay bigger investments in new assets.

Important key notes:

- Create maintenance guide
- Buy or generate green energy
- Reuse water where possible

5. Changing to a circular business model

This chapter will talk about how to change your business model to a more circular business model. There're quite some steps to follow and not all of them are easy to do. Starting to change your business model can take a long time and a lot of money. To not fail the change, every step must be done really carefully and with a lot of expertise.

Firstly, and most importantly is to talk about the business model. This is the most crucial step in the process. If this is not changed or not changed in the effective way, the whole process will be done for nothing.

After this the employees need to be on the same page as the company. If the employees don't work like how the company wants it, the change won't be executed well. So, they need to be trained.

Next up is the product. The product needs design changes to be more sustainable. Here will the employees step in as well since they need to make the right design changes.

After the product changes, is the way how the company is going to sell the product. This is also partly written in the business model but is especially important to take a look at it on its own.

When the products are made, a company needs to store them. Also, the products that are retrieved need to be stored again.

A company also needs to take care of their assets. All the assets that a company has can be made more sustainable.

At last are some other solutions that a company can consider for a more sustainable business model.

5.1 Business model

The business model is the most important part of the change. Everything starts with the strategy and vision of the company. The board decides which direction the company is going to.

The board of the company then must lead by example to the rest of the employees. When they show how every employee must behave and work for the company in order to make the company circular, it will have a huge positive impact on the change.

5.2 Employees

Without employees a company is nothing. Not only are employees important to have but have the right employees at the right positions is also very important. These employees need to redesign your product and sell it. When they don't have the right background to redesign your product, the result is going to be worse than it should be.

Do these employees have affection towards sustainability. If they don't like sustainability in the first place, they're probably way worse in selling the product that the company is trying to sell.

5.2.1 Hiring

When hiring new employees, the HR of the company will have to look at new specifications on the applicants resume. Some of the specifications are:

- Do they have affection towards sustainability?
- Do designers know how to design a sustainable/circular product?
- Can workers repair products so sustainable as possible?
- Can workers retrieve as many materials as possible from old products?

5.2.2 Trainings

Since the circular business model is relatively new, it is developing rapidly in every way. Staying up to date is therefore also a big challenge. The best way to stay up to date is to let the employees take trainings. Trainings will help the employees to develop themselves and to grow the business in a sustainable way. The employees can use their new knowledge to make changes in the way the company works. Designers can find a new way to design their products, or the sales department can think of a new more sustainable way to sell the products. HR also needs to be trained to recognise the right specifications for possible new employees.

5.2.3 New kind of employees

There's also a chance that the company needs to hire new kind of employees. Since a lot of repairs are needed to be done when the products are brought back, the company will need technicians. If the company already has them, they probably going to need more.

5.3 The product

The product is the core of the company and therefore especially important. Without the product being circular, the company can basically give up on being circular at all. Changing the business model to a circular model means that the product needs a complete redesign. This can only be done correctly by the certified employees, that the company hired or trained.

5.3.1 The Design

The whole design needs to be based on a few of the 7R's principle. The design needs to focus on the reducing, repairing, and remanufacturing of the product.

The new design needs to reduce the use of materials. It's very important to use as less materials as possible. Reducing the number of materials can make an impact on the quality of the product, so it's important to check if the quality is not decreasing when using less materials.

To repair the product more easily, it's necessary that the assembly of the product is easy to do. This way broken parts of the product can be easily removed and renewed. The broken parts can then be brought back to the factory to be recycled or remanufactured.

The last R that is good to focus your design on is remanufacture. The ability to have certain parts of your products be useable for another product is a significant help to the circular way.

5.3.2 The materials

A difficult part of being circular is the new materials that you use. You won't always be able to use the old parts of products. Because of that it is important to know where your new materials are coming from.

It is unlikely that a company that manufactures products will mine their own materials for these products. So, partnering with another company is needed to get these materials. But for the company to be circular, the company of the materials needs to be green/circular as well.

The straightforward way to check this, is to see if they have the right certificates. With certain certificates the company can prove that they are green and circular. Without this company being circular, your company can never get the right certificates to prove that you are a circular company.

An example of a material company being circular is a company that harvests wood, but for every tree they cut down, they plant a or multiple new tree(s) and let it grow. This way the nature will not suffer from the trees that are being cut down.

5.3.3 The production

With a new design, the product needs to be made another way. This means that the production line also needs changes. This can differentiate from changing the whole production line to only parts of it. This is one of the bigger investments and if not done correctly, can be a killer point for changing the business model.

5.4 Selling the product

The way the company is selling the product does not have to change per se, but it will help the company a lot with retrieving old products. One of the important selling strategies is creating awareness at the customers. Furthermore, there are some other strategies as leasing and Product as a Service that are more sustainable than the "normal selling" method. But the "normal selling" method can't be forgotten because regular customers, not businesses, won't always buy products with contracts.

5.4.1 Creating awareness

In the past years, the world realises that there are some changes needed to preserve the earth for many years to come. To get there more customers and businesses are trying to find ways to be more sustainable in order to reach the sustainable goals that the world decided on reaching in the upcoming years. The company needs to use their circular business model as a marketing strategy to attract new customers and businesses. This way they can attract a lot of customers and businesses that are trying to be more sustainable and when the company is one of the first ones to change to the circular business model their market share can increase a lot.

5.4.2 Product as a Service

To change the selling procedure to the product as a service selling method, the company needs to make contracts with their clients. These contracts need to be signed for some years. With the contract being signed the client has the chance to buy or loan the products. In these years, the company will make necessary repairs and replacements where needed.

After the contract has ended there're some options that the client has:

- When they bought the products, they can sell it back to the company for a lower price. The company can then use these products to repair, refurbish, remanufacture, or recycle them.
- Depending on the contract the client can sell or dump the products after they bought them. This is obviously against the idea of the circular business model and the likeliness of this happening is therefore small, since the client probably chose the company for their sustainability.
- If the products are loaned and the contract ends the products will automatically go back to the company for them to repair, refurbish, remanufacture or recycle them.

5.4.3 Leasing

Leasing is a form of renting the product to a client. The product as a service model looks a lot like leasing and can be seen as a form of leasing, but without the extra services as repairs and replacements. The company stays owner of the product and therefore definitely gets the product back after the contract ends. Only during the contract, the product life won't be extended with the good repairs that the company can provide.

5.4.4 The "normal" selling

Leasing and the product as a service are contract based and because of that more focused on businesses instead of customers. A customer won't lease products that are in their home.

As spoken about creating awareness that's really important for the customer. A customer is more likely to sell their product or to dump them. The company needs to make it truly clear that they can return the product after several years, so that the company can repair/recycle it. Depending on the company they can decide if they give the customer the ability to sell their product back to the company or that they can't.

5.5 Storing products

Depending on what the company sells, storage can be a big issue. In the previous chapter furniture was used as an example. Furniture can use a lot of space in the warehouses and is difficult in shipping in high volumes. If the company can't extend the contracts with their clients, there will be a chance that the warehouses get full and there is nowhere to store the remaining products.

5.5.1 Warehousing

Because of the above problem, warehousing is important. It is important to find a point in between the maximum that the company needs and the minimum. The company doesn't want the minimum, because if for any reason multiple contracts gets ended the warehouses get overfull and the costs to store the products somewhere else can be huge. The company also doesn't want the maximum amount of warehouse space, because the maintenance of the place can cost a lot over the years. The company need to take a well calculated risk by predicting their sales and the number of contracts that they can get.

5.5.2 Retrieving old products

Getting the old products back is also a challenge that the company needs to face. Customers and businesses are less likely to send their own products back due to shipping costs. With bigger products it will get even more difficult for them. The company needs to find a way for them to make this easier for them. When the company buys their own vans

or trucks, they can pick up the products themselves. This will make it for much easier for the company, customers, and businesses to return the products.

5.6 Assets

Assets are important to a company. As spoken in the literature assets are value to the company all kinds of forms. Investing in sustainable assets is therefore a necessity for the company. It helps realising the full use of green energy by using more electric efficient machines. Also, the warehouse and factory need to be sustainable.

5.6.1 Possible new assets

As told with the new design of the product, probably new machines are needed to be bought. The company needs to check for the most sustainable machines out there. It means looking out for the best energy label that the necessary machine can have. Also, the other assets apart from machines need to be sustainable, such as the warehouse and factory. For the warehouse and factory, it is possible to buy assets to make it more sustainable. Also, when delivering products, the cars or trucks that are needed, must be sustainable as well or compensated for their impact on the world. For that reason, electric cars or trucks are a worthwhile investment.

Assets that can be used to make the warehouse and factory sustainable are:

- Solar panels
- Reusing water
- Making building sustainable (double windows, etc.)

For the machines it is good to look for the following criteria:

- High energy label
- Good maintenance plan

5.6.2 Asset maintenance

Also, a plan needs to be made for the repairs of the machine. This can increase the lifetime of the machines by a sufficient amount. It will save money and downtime, but also the machines will stay longer operative. With the longer life comes less investment in machines and it is also more sustainable, because the company won't be throwing away the old machines as fast as they could.

5.6.3 Assets recycling

Assets recycling can be done in multiple ways. When the company is done using the machine it has two options. It can send it back to the manufacturer, so that the manufacturer can recycle it and use its materials for new machines. The other option is that the company uses the materials for itself. Depending on what the company produces these materials can be useful, for the products that the company is making or for repairing other machines.

5.7 Other investments

At last, there're some investments that can help the company to be more sustainable. These investments are for the long-term. Here are the green energy and water purifier discussed as an example. These investments help the company making money in the long-term since they don't have to pay extra for electricity of water usage.

5.7.1 Green energy

There are two ways to get green energy. Some energy suppliers give you the opportunity to buy green energy. The validation of this green energy is always difficult though. The other option is to invest in solar panels. It is a big investment that eventually will pay itself back. The company will guarantee itself of using green energy for as long as the solar panels keep on working and of course as long as the sun is shining.

5.7.2 Water purifier

Some companies need water to rinse their products or for something else. A lot of times the water gets only used once in this process or until it's dirty and will be dumped in the sewer. With a water purifier the water gets purified and can be used again or can be given back to the nature.

6. Using long-life assets in a circular economy

Assets are really important to a company. From furniture to the machines, all the assets together provide the company the tools to execute their service or to manufacture their product.

There are multiple components towards asset sustainability. A well-known component is the energy label of an asset. This tells how much energy the asset consumes. As discussed in the previous chapters, also the manufacturing of the asset is important. Is this done in a circular and sustainable way?

Besides these criteria that a company or person would use to buy an asset, the company or person can do some steps themselves towards using their asset in a sustainable way.

The next couple of steps that a company or person can take all work together to the goal of extending the asset's lifetime. In some cases, the manufacturer can help with extending the asset's lifetime. For both the manufacturer and company or person come some good benefits and effects.

6.1 Extending the asset's lifetime

There are a few factors that can help with extending an asset's lifetime. The possibilities that are getting discussed are research and development and the maintenance of the asset. Research and development is more focused on future sales, while asset maintenance is for when the asset is already sold and what the consumer can do to maintain the asset.

6.1.1 Research and development

Research and development is done by the manufacturer with the intensions to make the asset better in any kind of way. Most of the time the manufacturer tries to make the asset more efficient and productive. If the asset is not a machine, the manufacturer will innovate in new assets with lower costs or of course in new assets.

The only problem with research and development is that the manufacturer can convince the buyer of buying a new asset while the other one is still working. By doing this the old asset won't be used for the full lifetime that it should be given.

So for the user of the asset, it is better for the sustainability to not invest in new improved assets until the full lifetime of their own asset has been used. Unless the user can get rid of the old asset in a sustainable way. One of the options would be to return it to the manufacturer, since they can most likely use the parts of the old asset in other products.

The other option is to hold the old asset so that the user can use its parts for the new asset. This is a less sustainable option since it is less likely that the new asset uses all the parts of the old asset.

6.1.2 Asset maintenance

There are four important steps for the consumer to follow to maintain a high quality on their assets. Doing this will increase the lifetime of the assets and decrease the downtime.

Collect data

As they always say: Knowledge is power. Collecting data from the assets is particularly important to know when the asset is in need of maintenance. When collecting data, the user can make predictions about when the asset is about to break down. The maintenance team will also be able to improve their repairs for the asset, which can result in less down time. This will be discussed in the 'Use of maintenance KPI's' section

Preventive maintenance
With all the data that is getting collected, the maintenance crew can setup a preventive maintenance plan. The costs of preventive maintenance are high at the beginning but will pay out in the long term. It will cut costs, improve the asset's performance, increase efficiency, and will eliminate unplanned downtimes. Preventive maintenance schedules are different for every company.

Preventive maintenance will cost a lot upfront, but overtime it will pay it back. In the end unplanned maintenance can costs 3-9 times more than planned maintenance. This is because the necessary parts of the asset need to be rushed to the company, compensation is needed for specialized technicians and a lost of sales revenue all together will cost the company a lot of money. (Laubach, 7 Benefits of Preventive Maintenance, 2020)

Repairs and maintenance will roughly account for 15% of the total expenses. Out of this 15%, the preventive maintenance will account for about 30-50% of the total repair and maintenance costs. This is around 4.5-7.5% of the annual operating costs (Micromain, sd). The result of using preventive maintenance can save up to 30-40% and possibly yields 10 times the return on investment (UpKeep, 2019). The preventive maintenance will upkeep the lifetime of the asset, which results in a more sustainable business.

Invest in employees and technology
The previous points, collecting data and preventive maintenance, won't work without the availability of the right employees and technology. When your employees don't know how to make a proper maintenance schedule or don't have the skills to repair the machines, the whole asset maintenance will fail to work. Investing in the useful trainings is therefore very important to keep their knowledge up to date.

There are also different technologies to help the employees with the making of the maintenance plan. These programs can collect the data of the assets and can keep track of when preventive maintenance is needed for each asset.

Use maintenance KPI's
The KPI's, Key Performance Indicators, are important to keep track on the performance level of the asset. By setting these indicators, the technology can compare their performance with the set target, which is set by the user. When the target isn't reached, the technology can intervene and call up for maintenance. (FMX, 2020)

There are different KPI's that should be tracked and managed for asset maintenance:

- Mean Time Between Failures (MTBF)

The MTBF is one of the most important KPI's when it comes to the facility management metrics. Tracking this KPI allows the company to anticipate on future breakdowns of assets by looking to the asset's maintenance and failure history.

$$MTBF = \frac{(time\ asset\ is\ in\ use - unplanned\ downtime\ due\ to\ breakdown)}{total\ number\ of\ breakdowns}$$

The result is a time in hours, which gives the average amount of time before the assets breaks down.

- Mean Time To Repair (MTTR)

MTTR is the opposite of MTBF. MTTR analyses the response time of the company's technician to resolve the breakdown in question. It is an important number, because it shows

you an estimate downtime that's needed for the repairs. The KPI also shows the company the performance of each of their technicians by calculating the mean time for every staff member.

$$MTTR = \frac{total\ maintenance\ time}{total\ number\ of\ repairs}$$

The MTTR gives an average time of how long it takes to repair a certain asset. It is a powerful KPI to make a good preventive maintenance plan.

- Overall Equipment Effectiveness (OEE)

The OEE measures the effectiveness of an asset based on three categories: availability, performance, and quality. Determine an asset's effectiveness is good to know in cases of replacements and repairs.

$$OEE = availability * performance * quality$$

$$Availability = \frac{true\ operating\ time}{planned\ operating\ time}$$

$$Performance = \frac{actual\ cycle\ time}{planned\ cycle\ time}$$

$$Quality = \frac{valid\ pieces}{total\ pieces\ produced}$$

The results of availability, performance and quality is a number between 0 and 1. These number times each other give a number between 0 and 1. A perfect asset would get a score of 1 and an asset that doesn't work at all, would get a 0.

- Asset Maintenance Cost Variance

This KPI shows the difference between the budgeted cost that was given to an asset and the actual cost of executing the maintenance. The KPI shows you feedback on the efficiency of your budget and helps you to effectively plan future budgets.

$$Asset\ maintenance\ cost\ variance = expected\ cost\ - actual\ costs\ of\ maintenance$$

Most of the time the result would be a negative number, showing the company that it should save extra budget on the maintenance of the asset.

- Cost to replace vs. cost to repair

Maintenance can get really expensive. As the asset gets older, more maintenance will be needed in order to keep it running efficiently. At one point this KPI comes in. Is it better to replace the asset or to still repair it?

$$Cost\ to\ repair = annual\ expected\ cost\ of\ maintenance\ on\ old\ asset$$

$$Cost\ to\ replace = \left(\frac{cost\ of\ replacement}{replacement\ asset's\ lifetime}\right) + expected\ annual\ maintenance\ costs$$

Which of the above calculations is the cheapest one, is the choice that the company has to go for.

- Unplanned maintenance percentage

Tracking the unplanned maintenance that needs to be executed, gives the company an idea of how successful the preventive maintenance plan is working.

$$Unplanned\ maintenance\ percentage = \frac{unplanned\ maintenance}{total\ maintenance}$$

If the ratio for unplanned maintenance towards the total maintenance is around 10-20% the preventive maintenance plan is working. When the unplanned ratio is exceeding the planned maintenance, the company needs to go back to the MTBF KPI to make a new preventive maintenance plan

- Work order resolution time

This KPI is a time indicator of how long it takes from when a maintenance is requested until the technician says that the repair is finished. The KPI gives the company an idea of how effective their team is working to resolve the maintenance issues. The shorter the time the better.

(Laubach, 7 Asset Maintenance KPIs You SHould Be Tracking and Managing, 2020)

6.1.3 Benefits for both company and consumer

A longer lifetime for assets could offer different benefits for both companies and possible consumers. This hypothesis is also for the study into the potential of the circular economy. (EU, 2014)

There are four different aspects for a longer lifetime for assets:

The use of sustainable materials

What kind of material is used for the asset makes an impact on the environment, since it is related to the lifetime of the asset. To extend the lifetime of the asset, the manufacturer should consider the material and how to preserve the value.

The consideration of which material to use, is determined by a few factors:

- Is it a scarce material?

Some materials are rare in the world and by using them they the price will rise. The material can also become extinct if not taken care of carefully.

- Is the material recyclable?

It is important to know if the material of the asset is recyclable. Some materials aren't able to be recycled, think of some sorts of plastic. These plastics can't be used for anything else and therefore will be thrown away. They will most likely end up on a dump or be burned causing toxins to pollute the air.

Enduring knowledge and skills

To extend the lifetime it's also important to have the knowledge and skills to maintain the quality to keep using the asset in their best shape. This means knowing how to maintain, repair and refurbish the asset. Not for all assets are highly skilled employees needed, so simple trainings can develop these skills and knowledge.

Extended utility

An assets economic value is also determined by its lifetime. So, extending the utility of the asset also means that the economic lifetime of the product is being increased. This enables the company to focus on the utility of the product instead of the product itself: the product as a service model.

Continuing transactions
While a lot of companies selling assets see extending the assets lifetime as negative financial impact, it should help them with strengthening their relationship with their clients. With extending the lifetime the company fears of loss of sales, since the other companies need less products of them and for that loss of market share. (Montalvo, Peck, & Rietveld, 2016)

6.1.4 The effects of longer asset lifetime

To better understand the effects of extending the assets lifetime, there is an overview made. Extending the lifetime has positive effects on the economic, social, and environmental parts of the asset. On the other hand, extending the lifetime has also a negative impact on the economical part.

Positive economic effects
The positive effects on the economical part are mostly in creating net value. A longer asset lifetime will reduce the total costs of the asset till the end of its lifetime. The asset will have to be replaced less times in the future. This also includes the waste collection of when the assets lifetime is over. Companies and customers like assets with a longer utility because they get more value out of their asset or product. (European Investment Bank, 2013)

Positive social effects
To increase the assets lifetime, there will be repairs needed. This will increase the job possibilities for populations with lower and medium skills, since more jobs for technicians will be available (European Investment Bank, 2013). Also, the consumer will have an increased confidence in the companies, since they're being more sustainable with their products. (Warneryd, 2008)

Positive environment effects
The positive effect that it has on the environment is that it has decrease of the impact on the environment. The assets will be less likely to be thrown away since their lifetime is extended.

Negative economic effects
The only negative effect is economically for the manufacturer of the asset. Since companies and people need to buy their products not that often, because of the increase in lifetime, the sales will drop a bit. (Stegeman & Jansen, 2015)

Also, with the repairing comes another liability for the manufacturer, because they are most likely to be called to repair the asset or the consumer has to train the repairmen themself. (Massarutto, 2014)

The innovation of new products by the manufacturer jeopardizes the incentive if the new innovations are replacing the products. The consumers are also in doubt of selling their asset and replacing it with a new and better, maybe even more sustainable model.

7. Discussion of the solution

As seen in the literature review, the circular business model is going to be the future of every business. The people are getting more aware about the problem of the climate, which is happening.

These people will change their buying behaviour towards more sustainable products and the companies are going to need to adapt to their wishes in order to remain competitive to their competitors.

When taking the risks into account, the change from a linear to a circular business is not easy. Many businesses will delay the change, but eventually have to do it, since competitors are going to do it before them.

There're a lot of criteria to focus on while making the change. The guide definitely shows that there's a lot of work to do to make the change to a circular business a success.

Assets are an important part of changing to a circular business. With improvement in the maintenance of these assets, the lifetime of the assets can be extended. This is more sustainable since the assets don't have to be thrown away as much as they used to. It also helps financially, because the company or person doesn't have to make as much investments as before.

Circular business is the way of the future, so eventually all the businesses have to be circular.

8. Budget summary

The total amount of hours to complete this thesis is 840 hours. The hourly rate is 13€, so the total budget for this research comes at 10.920€.

9. Analysis and assessment of environmental and social implications

The change from linear to circular economy can have a huge impact on the world's environment and on social implications. This chapter will discuss the difference that the circular economy can make. First on the environmental consequence that the change can make and at last the social impact.

9.1 Environmental implications

The circular economy is seen as the sustainable business model. So, the circular business model will have a huge impact on the environment of the world if the business changes their business model.

The businesses with a circular economy business model will use way less new materials than businesses with a linear economy model. Without the much use of new materials all the places where materials are mined are less necessary. For example, less trees will need to be cut to generate the materials needed to produce the products. With the new materials that are being mined, the company that mines them makes sure that they take good care of the environment. They take good care by giving something back to the environment.

All the machines that are used by the company to produce their products use a lot of energy. It will make a significant impact when all the businesses change to green energy. Without the use of fossil fuels, there will be less CO_2 in the air and that will stop the global warming and increase the air quality of the world.

Many companies also need to use a lot of water to make their products, to for example rinse the materials. This water gets polluted and then dumped into the sewers. They can filter the water to then when filtered give back to the nature around the factory.

Also extending the lifetime of the assets means that the useful life of the assets is being optimized. Less assets need to be bought this way and the manufacturer can produce less, which results in less materials being used.

9.2 Social implications

Since the circular economy is focused on businesses, will the social consequences have less impact than the environmental impacts. Still, there're some impacts that the circular economy will have on the world.

First, the change from linear to circular economy will create a lot of awareness for the people around the world. The companies have the most impact on the worlds environment and have a great opportunity to lead by example for the people of the world. When the people see that the companies are becoming more sustainable, they will try to become more sustainable themselves.

When more companies become circular and sustainable, the customers will have more options to choose the more sustainable product. The customers will be more motivated to buy the sustainable option instead of the one that is bad for the environment.

10. Conclusion

Since the last years, the people are getting more aware of the problems that we're creating regarding the climate. So, if people can choose between two products, where one of them is sustainable and the other is not, the people will choose the more sustainable product.

By choosing not to change the company's business model from linear to circular, the company will get in trouble eventually. People will change from your company to another company for buying the product that they want. The company will lose their market share and the change can become more difficult, because of the loss of money.

If the company chooses to make the change now in comparison to in a few years, they will hold their original market share and maybe even enlarge it by taking away customers from competitors.

The company's assets are a big part of the change. The intellectual assets of employees will allow the company to make the change with the right knowledge at their disposal. When the company doesn't have this knowledge, they either must train their employees or hire new employees that do have the knowledge.

The assets will help the company producing their products in the sustainable way. Either by making the products out of old materials or by providing the warehouse and factory with green energy.

Extending the assets lifetime is also an immense help to improve their sustainability. A good worked out maintenance schedule is the investment that a company needs to make to reach this goal.

Although it seems that the linear business model is easier to work with, because the company doesn't have to think about the sustainability, the linear business model is only focussed on the short-term. The mindset of the consumers is changing and there will be no room for a linear business.

The circular business model is the way to think for the future. Not only for the planet, but also for the company. The assets that the company produces or makes can make an enormous difference in this project. Make the change sooner than later or otherwise the company will be left behind by the others, who were willing to make the change and succeeded in adapting to the customers wishes.

11. Future work proposal

This research focused more on the general part of the difference between linear and circular economy and the change from to linear and circular economy. So, there's a lot more in-depth research that can be done in multiple parts.

There're two kinds of future researches that are a good opportunity to work out more about the circular economy.

First of all, it will be a good research to focus on a specific sector. When researches are more focused on a sector, the companies within that sector will have more knowledge about the circular economy.

The company will have a more detailed description of what they must do to change to a circular economy business model, because they will have the exact knowledge of how to do it in their sector.

While researching one of these sectors, the person doing the research can also focus on what kind of impact it will have on the budget and the cash-flow of the company. There will be some changes, which are good to know in advance for the company.

Also, the number of investments that will be needed for new machines, using green electricity, etc. is an important research that needs to be done in order to make an efficient change from a linear to a circular business model.

12. References

Barone, A. (2022, January 27). *Asset*. Retrieved June 2022, from Investopedia: https://www.investopedia.com/terms/a/asset.asp

Beer, M., Spector, B., Lawrence, P. R., Quinn Mills, D., & Walton, R. E. (1984). *Managing Human Assets.* New York, United States: The Free Press. Retrieved May 2022, from https://books.google.es/books?hl=nl&lr=&id=od3-HJUPIucC&oi=fnd&pg=PA1&dq=employees+assets&ots=dKGKVr7aTO&sig=RYzoVvqUqPJg5-NYHC0n5C4ZBZU&redir_esc=y#v=onepage&q=employees%20assets&f=false

Chen, J. (2021, March 20). *Financial Asset*. Retrieved June 2022, from Investopedia: https://www.investopedia.com/terms/f/financialasset.asp

Chepkemoi, J. (2017, April 25). *What is the environmental impact of the mining industry*. Retrieved June 2022, from WorldAtlas: https://www.worldatlas.com/articles/what-is-the-environmental-impact-of-the-mining-industry.html

Chukwu, D. G., & Egbuhuzor, C. A. (2017). *Tangible Assets and Corporate Performance: Evidence from the manufacturing industry in Nigeria.* Enugu, Nigeria: Department of Accountancy Faculty of Management Sciences, Enugu State University of Science & Technology. Retrieved May 2022, from https://www.researchgate.net/publication/336241796_Tangible_Assets_and_Corporate_Performance_Evidence_from_the_manufacturing_industry_in_Nigeria

Circle Economy. (n.d.). *The circular economy is nature's equivalent of 'living within your means'*. Retrieved February 2022, from Circle Economy: https://www.circle-economy.com/circular-economy/what-is-the-circular-economy

Circle Economy; PGGM; KPMG; WBCSD; EBRD. (2018, May). *Linear Risks.* Retrieved March 2022, from Circle Economy: https://assets.website-files.com/5d26d80e8836af2d12ed1269/5de8eff3bbf4da023e254ea4_FINAL-linear-risk-20180613.pdf

de la Fuente, A., González-Prida, V., Crespo, A., Gómez, J., & Guillén, A. (2018). Advanced Techniques for Assets Maintenance Management. *Elsevier*, 6. Retrieved May 2022, from https://www.sciencedirect.com/science/article/pii/S2405896318313843

Ellen MacArthur Foundation. (n.d.). *What is a circular economy*. Retrieved February 2022, from Ellen Macarthur Foundation: https://ellenmacarthurfoundation.org/topics/circular-economy-introduction/overview

Essex, D. (2018, September). *Product as a Service*. Retrieved March 2022, from Techtarget: https://www.techtarget.com/searcherp/definition/product-as-a-service

EU. (2014). *Towards a circular economy: A zero waste programme for Europe.* EU. Retrieved May 2022, from http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52014DC0398

European Commission. (2020). *Study on the EU's list of Critical Raw Materials (2020).* Luxembourg: Publications Office of the European Union. Retrieved March 2022, from https://op.europa.eu/en/publication-detail/-/publication/c0d5292a-ee54-11ea-991b-01aa75ed71a1/language-en/format-PDF/source-search

European Investment Bank. (2013). *The economic appraisal of investment projects at the EIB.* Luxembourg: European Investment Bank. Retrieved May 2022, from http://www.eib.org/infocentre/ publications/all/economic-appraisal-of-investment-projects.htm

Farhana Dulia, E., Mithun Ali, S., Garshashbi, M., & Kabir, G. (2021, October). Admitting risks towards circular economy practices and strategies: An empirical test from

supply chain perspective. *Elsevier*. Retrieved March 2022, from https://www.sciencedirect.com/science/article/abs/pii/S0959652621026329

FMX. (2020). *5 Asset Maintenance Best Practices.* Retrieved June 2022, from FMX: https://www.gofmx.com/wp-content/uploads/2020/10/5-Asset-Maintenance-Best-Practices.pdf

Geanina Silviana, B. (2019). Intellectual Assets Management Model. *Elsevier*, 5. Retrieved May 2022, from https://www.sciencedirect.com/science/article/pii/S2351978919303610

Gispen. (n.d.). *Gipsen*. Retrieved March 2022, from Gispen: http://www.gispen.com

Google. (n.d.). *About*. Retrieved April 2022, from Google Scholar: https://scholar.google.com/intl/nl/scholar/about.html

Grösser, S. N., Reyes-Lecuona, A., & Granholm, G. (2017). *Dynamics of Long-Life Assets.* Springer Open. Retrieved January 2022

Hassanain, M., Froese, T., & Vanier, D. (2003). *Framework of model for asset maintenance management.* Journal of Performance of Constructed Facilities. Retrieved May 2022, from https://www.researchgate.net/profile/Thomas-Froese/publication/44050408_Framework_Model_for_Asset_Maintenance_Management/links/02e7e525506c688de9000000/Framework-Model-for-Asset-Maintenance-Management.pdf?_sg%5B0%5D=started_experiment_milestone&origin=jou

Hayes, A. (2021, October 20). *Current Assets*. Retrieved June 2022, from Investopedia: https://www.investopedia.com/terms/c/currentassets.asp

ImpacX. (2017). *Circular Economy Vs. Linear Economy*. Retrieved February 2022, from ImpacX: https://impacx.io/blog/circular-economy-vs-linear-economy/

Kenniskaarten. (n.d.). *Circular Economy*. Retrieved February 2022, from Kenniskaarten: https://kenniskaarten.hetgroenebrein.nl/en/knowledge-map-circular-economy/ce-disadvantages-linear-economy/

Kenniskaarten. (n.d.). *Disadvantages Linear Economy*. Retrieved February 2022, from Kenniskaarten: https://kenniskaarten.hetgroenebrein.nl/en/knowledge-map-circular-economy/ce-disadvantages-linear-economy/

Kenton, W. (2021, March 4). *Short-Term Assets*. Retrieved June 2022, from Investopedia: https://www.investopedia.com/terms/s/shortterm.asp

Kenton, W. (2022, March 11). *Fixed Asset*. Retrieved June 2022, from Investopedia: https://www.investopedia.com/terms/f/fixedasset.asp

Kenton, W. (2022, March 20). *Intangible Asset*. Retrieved June 2022, from Investopedia: https://www.investopedia.com/terms/i/intangibleasset.asp

Kirchherr, J., Hekkert, M., Bour, R., Huijbrechtse-Truijens, A., Kostense-Smit, E., & Muller, J. (2017). *Breaking the Barriers to the Circular Economy.* Deloitte. Retrieved March 2022, from https://circulareconomy.europa.eu/platform/sites/default/files/171106_white_paper_breaking_the_barriers_to_the_circular_economy_white_paper_vweb-14021.pdf

Kirchherr, J., Reike, D., & Hekkert, M. (2017). Conceptualizing the circulare economy: An analysis of 114 definitions. *Elsevier*, 12. Retrieved March 2022, from https://reader.elsevier.com/reader/sd/pii/S0921344917302835?token=C4051EBE56FB40129E1D820B80B3322680F080066C2EBFF7A00C3FE1ACAE26C1792C73330A7D83542A737DDEDF4E7B6A&originRegion=eu-west-1&originCreation=20220615092654

Laubach, S. (2020, July 17). *7 Asset Maintenance KPIs You SHould Be Tracking and Managing*. Retrieved June 2022, from FMX: https://www.gofmx.com/blog/asset-maintenance-kpis/?utm_source=eguide&utm_medium=document&utm_content=asset%20maintenance%20best%20practices

Laubach, S. (2020, June 12). *7 Benefits of Preventive Maintenance*. Retrieved June 2022, from FMX: https://www.gofmx.com/blog/benefits-of-preventive-maintenance/#reason-7

Lucas, P., & Wilting, H. (2018). *Using planetary boundaries to support national implementation of environment-related sustainable development goals.* Retrieved February 2022, from PBL: https://www.pbl.nl/sites/default/files/downloads/Using_planetary_boundaries_to_support_national_implementation_of_environment-related_Sustainable_Development_Goals_-_2748.pdf

Massarutto, I. (2014). The long and winding road to resource efficiency: An interdisciplinary perspective on extended producer responsibility. *Resources, Conservation and Recycling*, pp. 11-21. Retrieved May 2022

Michelini, G., Moraes, R. N., Cunha, R. N., Costa, J. M., & Ometto, A. R. (2017). From linear to circular economy: PSS conducting the transition. *Elsevier*, 5. Retrieved February 2022, from https://www.sciencedirect.com/science/article/pii/S2212827117301567?via%3Dihub

Micromain. (n.d.). *The Case for Preventive Maintenance*. Retrieved June 2022, from Micromain: https://www.micromain.com/preventive-maintenance-study/#:~:text=The%20report%20does%20not%20distinguish,of%20the%20annual%20operating%20costs

Montalvo, C., Peck, D., & Rietveld, E. (2016). *A Longer Lifetime for Products: Benefits for Consumers and Companies.* Brussels. Retrieved May 2022, from https://www.europarl.europa.eu/RegData/etudes/STUD/2016/579000/IPOL_STU(2016)579000_EN.pdf

Murphy, C. B. (2020, November 28). *Long-Term Assets*. Retrieved June 2022, from Investopedia: https://www.investopedia.com/terms/l/longtermassets.asp

Murphy, C. B. (2022, March 17). *Operating Cost.* Retrieved June 2022, from Investopedia: https://www.investopedia.com/terms/o/operating-cost.asp#:~:text=Key%20Takeaways,and%20administrative%20(SG%26A)%20expenses.

OECD. (2011). *New Sources of Growth: Intangible Assets.* Retrieved May 2022, from OECD: https://www.oecd.org/sti/inno/46349020.pdf

OECD. (2018). *Global Material Resources Outlook to 2060.* Retrieved June 2022, from https://www.oecd.org/environment/waste/highlights-global-material-resources-outlook-to-2060.pdf

O'Sullivan, A., & Sheffrin, S. M. (2021). *Economics: Principles in Action.* Washington, DC, United States: Pearson Prentice Hall. Retrieved May 2022

PBL Netherlands Environmental Assessment Agency. (2019, September 27). *Opportunities for a circular economy*. Retrieved February 2022, from PBL Netherlands Environmental Assessment Agency: https://themasites.pbl.nl/circular-economy/

PBL Netherlands Environmental Assessment Agency. (n.d.). *Opportunities for a Circular Economy*. Retrieved February 2022, from Themasites: https://themasites.pbl.nl/o/circular-economy/

Plastic Soup Foundation. (2017). *Plastic Facts & Figures*. Retrieved March 2022, from Plastic Soup Foundation: https://www.plasticsoupfoundation.org/en/plastic-problem/plastic-soup/

PwC. (2021). *The global consumer: Changed for good.* PwC. Retrieved May 2022, from https://www.pwc.com/gx/en/consumer-markets/consumer-insights-survey/2021/gcis-june-2021.pdf

Rural Directions. (2015, December 14). *Machinery Investment Ratio.* Retrieved June 2022, from Pinion Advisory: https://www.pinionadvisory.com/wp-content/uploads/2019/08/Machinery-Investment-Ratio.pdf

Saunders, M., Lewis, P., & Thornhill, A. (2013). *Methoden en technieken van onderzoek* (5th ed.). Amsterdam, Nederland: Pearson Benelux. Retrieved June 2022

Schoenmaker, D., & Schramada, W. (2019). *Pricniples of Sustainable Finance.* Oxford, United Kingdom: OUP Oxford. Retrieved March 2022, from http://search.ebscohost.com/login.aspx?direct=true&AuthType=sso,ip,cookie&db=e000xww&AN=1166329&lang=nl&site=ehost-live&scope=site

Stegeman, H., & Jansen, T. (2015). *From circular materials cycles to a circular macro economy with scenario's for the Netherlands*. Retrieved May 2022, from Rabobank Wereldwijd: http://www.rabowereldwijd.nl/site/PublicationArticle/110978573

Tuovila, A. (2022, March 9). *Depreciation.* Retrieved June 2022, from Investopedia: https://www.investopedia.com/terms/d/depreciation.asp

UpKeep. (2019). *Maintenance Statistics: Predictive & Preventive, Labor & Costs*. Retrieved June 2022, from UpKeep: https://www.upkeep.com/learning/maintenance-statistics

van Berkel, J., & Delahaye, R. (2019). *Material Flow Monitor 2016 - technical report.* Den Haag: CBS Den Haag. Retrieved March 2022, from https://www.cbs.nl/nl-nl/achtergrond/2019/10/materiaalmonitor-2016-technische-toelichting

van Boesschoten, R. (2017, February 2). *Product as a Service - het verdienmodel voor de circulaire economie*. Retrieved March 2022, from Nederland Circulair!: https://www.circulairondernemen.nl/bibliotheek/product-as-a-service-het-verdienmodel-voor-de-circulaire-economie

van Ree, H. J. (2016, August 5). *The 7R Model for a Circular Economy*. Retrieved March 2022, from LinkedIn: https://www.linkedin.com/pulse/seven-practical-ways-get-our-planet-back-shape-van-ree-mba/

Warneryd, K.-E. (2008). The psychological underpinnings of economics: Economic psychology according to Gabriel Tarde. *The journal of Socio-Economics*. Retrieved May 2022

Weber, O., & Feltmate, B. (2016). *Sustainable Banking: Managing the Social and Environmental Impact of Financial Institutions.* Toronto, Canada: University of Toronto Press, Scholarly Publishing Division. Retrieved March 2022, from http://search.ebscohost.com/login.aspx?direct=true&AuthType=sso,ip,cookie&db=e000xww&AN=1166329&lang=nl&site=ehost-live&scope=site