



CHALMERS
UNIVERSITY OF TECHNOLOGY

Analysis of the applicability of business models in a recycling market

A study over how the material bottom ash can contribute to circular economy

Master's Thesis in Design and Construction Project Management

ALEXANDER LUNDBERG
JOAKIM FRENDBERG

Department of Technology Management and Economics
Division of Service Management and Logistics
CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2019
Report no. E2019:031

MASTER'S THESIS E2019:031

Analysis of the applicability of business models in a recycling market

A study over how the material bottom ash can contribute to circular economy

ALEXANDER LUNDBERG

JOAKIM FRENDBERG

Tutor Chalmers: Petra Bosch

Tutor Stena Recycling: Johan Näslund & Elin Trossholmen

Technology Management and Economics
Division of Service Management and Logistics
CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2019

Analysis of the applicability of business models in a recycling market
A study over how the material bottom ash can contribute to circular economy
ALEXANDER LUNDBERG & JOAKIM FRENDBERG

© ALEXANDER LUNDBERG & JOAKIM FRENDBERG

Examiner: Petra Bosch, Technology Management and Economics

Master's Thesis E2019:031
Technology Management and Economics
Division of Service Management and Logistics
Chalmers University of Technology
SE-412 96 Gothenburg
Telephone + 46 31 772 1000

Typeset in Word
Gothenburg, Sweden 2019

Analysis of the applicability of business models in a recycling market

Alexander Lundberg, Joakim Frenberg

Department of Technology Management and Economics

Chalmers University of Technology

Abstract

Organizations' attention on sustainable development have increased in recent years and societies have become more aware of its importance. To manage this new development, organizations have begun to apply business models to quickly locate new value creation within their strategies. This master thesis aim is to investigate how organizations, with the help of business models, can create new values and circular economies for the residual waste of bottom ash, which today is handled as end covering material on landfills. Furthermore, the work investigates what actors are relevant for the business model and what barriers they highlight with finding new solutions for the material bottom ash.

The study has been finalised with a comprehensive interview study with organizations and authorities whom concern bottom ash. This, to directly get a relevant insertion of the organizations and the authorities knowledge level, concerns and thoughts regarding the bottom ash potential. The results of the interview study have afterwards been used to create a business canvas model with the aim of mapping the most important actors and partners regarding bottom ash as well as other segments that contribute to possible new value creation for the material. Finally, a SWOT-analysis has also been performed with the purpose of further analyse the bottom ash's strengths and weaknesses based on the results from the interviews.

The result showed that the biggest barriers for finding new areas of usage for bottom ash are a large dissemination of knowledge between the various authorities and the companies, but above all a lack of standard from the Swedish Environmental Protection Agency. For a new solution for bottom ash to be accepted, it will be required that the material becomes prioritized among the involved actors so that a common change is formed. The fact that a standard will be needed is also emphasizes in the SWOT-analysis that has been evaluated. But the SWOT-analysis also highlights all the possibilities that bottom ash has, including as a road construction where bottom ash has many common characteristics to be used as an alternative material to create circular economy and thereby, minimize the extraction of new valuable materials.

Keywords: Business Model, SWOT, Bottom ash, Sustainable development, Circular economy, Lack of Standard.

Acknowledgement

This master's thesis is the last part of our education program Design and Construction Project Management at Chalmers University of Technology. The master thesis has investigated and analyzed, through the application of a business model, a residual waste in the recycling market. We would like to thank the people who have participated in the interview study and everyone else who have contributed to the result of our master project. We would like to give a special thanks to our supervisors at Chalmers, Professor Petra Bosch, who has supervised us and contributed with valuable guidance throughout the master project.

Alexander Lundberg & Joakim Frennberg
Gothenburg, 2019

List of Contents

Dictionary

1	Introduction.....	13
1.1	<i>Background.....</i>	13
1.2	<i>Objectives</i>	15
1.3	<i>Research questions.....</i>	15
1.4	<i>Limitations.....</i>	15
2	Theory.....	16
2.1	<i>Sustainable development</i>	16
2.1.1	<i>Circular economy.....</i>	17
2.2	<i>Circular economy and business models.....</i>	18
2.3	<i>Examples of circular business models.....</i>	19
2.3.1	<i>Freemium business model</i>	19
2.3.2	<i>Recovery and recycling business model.....</i>	19
2.3.3	<i>Product life extension model</i>	20
2.4	<i>Bottom Ash.....</i>	22
2.4.1	<i>Challenges.....</i>	23
2.4.2	<i>Usage of bottom ash in other nations.....</i>	24
2.4.3	<i>A summary of the mentioned nations</i>	24
3	Methodology.....	26
3.1	<i>Research Design</i>	26
3.2	<i>Data Collection</i>	27
3.2.1	<i>Interviews.....</i>	27
3.2.2	<i>Participant observations.....</i>	30
3.2.3	<i>Secondary data.....</i>	30
3.3	<i>Analysis method</i>	31
3.3.1	<i>Business Canvas Model</i>	31
3.3.2	<i>SWOT</i>	31
3.4	<i>Validity.....</i>	32
3.5	<i>Reliability.....</i>	32
3.6	<i>Ethics</i>	33
4	Result.....	35
4.1	<i>Interviews</i>	35
4.1.1	<i>Lack of standard as a barrier</i>	35
4.1.2	<i>Economical profit as a barrier</i>	36
4.1.3	<i>Priority as a barrier.....</i>	37
4.1.4	<i>Circular economies vs poison free environment as a barrier</i>	38
4.1.5	<i>Unwillingness to look at other countries as a barrier</i>	38
4.1.6	<i>What would be needed for a future product?.....</i>	39
4.2	<i>Business Model.....</i>	41
4.2.1	<i>Business Canvas Model</i>	41
4.3	<i>SWOT.....</i>	45
4.3.1	<i>Strengths</i>	45
4.3.2	<i>Weaknesses.....</i>	46
4.3.3	<i>Opportunities</i>	46

4.3.4	Threats.....	47
5	Discussion.....	48
5.1	<i>Barriers for utilization of recycled materials</i>	<i>48</i>
5.1.1	Tensions related to circular economy	48
5.1.2	Lack of standard	49
5.1.3	Additional barriers towards implementation.....	50
5.2	<i>actors relevant for implementation of bottom ash?</i>	<i>50</i>
5.3	<i>What is needed to develop a business model for a new material in the recycling industry?</i>	<i>51</i>
6	Conclusion	54
6.1	<i>What are the barriers for using recycled materials (i.e. bottom ash) in areas outside landfills and for contributing to circular economy?.....</i>	<i>54</i>
6.2	<i>What actors are involved, and in what way can they influence a business model?</i>	<i>54</i>
6.3	<i>What is needed to develop a business model for a new material in the recycling industry?</i>	<i>55</i>
7	Suggestions for future research	56
8	References.....	57
8.1	<i>Books & Journal articles</i>	<i>57</i>
8.2	<i>websites & Regulations</i>	<i>59</i>

Dictionary

Incineration Plant	A publicly owned plant where burnable wastes are combusted and transformed into energy and heat.
Landfill	A place where waste material that cannot be recycled are transported to. Mostly used for hazardous wastes.
End covering	The material that is put on top of landfills to prevent rain water from entering.
Bottom ash	Bottom ash is the residual waste from the incineration plants. This is the final material that come out from the plant and is today mostly used as a construction material for end covering of landfills.
Maceration	Environmentally dangerous process where existing metals from a product or material are leaching out in the local environment.
Poison free environment	A national environmental goal created by the Swedish Environmental Protection Agency.

1 INTRODUCTION

1.1 BACKGROUND

The use of resources and management of waste are two environmental matters with strong connections to each other (Gröndal & Svanström, 2010). Today, organizations are raising their production and humans are increasing their consumption of goods and resources. Societies have created a behaviour of consumption and expenditure of materials which emits dangerous amounts of pollution and amounts of waste that the globe soon cannot handle. This ongoing acting and continuously extraction of natural resources, human activities burden the environment in a way that is not long-term sustainable and at the same time create waste mountains and growing landfills (Gröndal & Svanström, 2010).

However, attempts to prevent this negative development have started. Authorities and nations have together created new environmental incentives and regulations to promote sustainable development. For instance, the EU Commission together with the United Nations, have worked on developing EU regulations with criteria regarding when different types of waste stops being waste. This is called *End of waste* regulations (Naturvårdsverket, 2013). The goal of this policy is to more efficiently recover waste with the basic idea that waste can go from being a waste to becoming a new resource or product. This way of thinking has created new circular economies, but additional solutions are required to save the coming generations from future environmental disasters (Naturvårdsverket, 2019).

Swedish recycling organizations claim that one important key for change towards a more sustainable society will be to establish new business models for waste materials. Hence, in Sweden, the government are pushing organizations to find new solutions of re-using resources (Afuah and Tucci, 2003).

One resource that is further examined in this report is the residual waste bottom ash, which is a waste from incineration plants. The current way of handling bottom ash in Sweden is not long term sustainable. In other nations bottom ash is used outside landfills in for instance road constructions, but in Sweden it is almost exclusively used as a construction material on landfills, which by environmental and technical expert is considered as a waste of good material because of its similar characteristics with natural gravel (Winberg, 2018). However, soon many of the landfills will be end covered, which means that the demand on construction materials will be reduced. This fact could be the start of a big problem for the Swedish incineration plants, which have almost 1 million tons of bottom ash per year in waste creation. If no alternative usage is found, rather than using bottom ash as construction material on landfills, it could instead be placed in landfills as a waste material, which will cost plenty of tax for the incineration plants. If the material is used as a construction material on landfills, the tax is avoided, but if it is directly categorized as a waste material on landfills, the tax deposit is added (Winberg, 2018).

The incentives of getting substances which are now perceived as waste, like bottom ash, into a circular economy would be in accordance with both the Swedish governmental goal to become more circular sustainable as well as the new European rules from end of waste. It would give organizations access to a new recycled material, instead of extracting more valuable resources. In this way, society would take a big step in the right direction towards sustainability.

Through application of business models, it is possible to evaluate how to find new value for a waste product such as bottom ash and recycle it in a circular economy. Meaning, creating new areas of usage for a material that currently is being placed on landfill. The usage of business models can lead to the emergence of new circular flows of resources that create long-term sustainability (Gröndal & Svanström, 2010).

1.2 OBJECTIVES

The aim of this master thesis is to develop a business model supporting a circular economy with a specific focus on the relevant aspects of the waste material bottom ash. This will be done with the help of the Business Canvas Model. The Business Canvas Model is applied to evaluate if there is a chance to get the material into a circular economy, instead of being a waste material on landfills.

1.3 RESEARCH QUESTIONS

This master's thesis is based on the following research questions.

- 1. What are the barriers for using recycled materials (i.e. bottom ash) in areas outside landfills and for contributing to circular economy?
- 2. What actors are involved, and in what way can they influence a business model?
- 3. What is needed to develop a business model for a new material in the recycling industry?

1.4 LIMITATIONS

In order to not letting the master thesis becoming too comprehensive, the following limitations have been chosen.

- The report only considers bottom ash from incineration plants, no other ashes will be included.
- The master thesis studies the possible use of bottom ash outside landfills, not as construction material for end coverage.
- The report will not examine the chemical or geotechnical characteristics of bottom ash.

2 THEORY

In this chapter plenty of definitions and areas are explained. Firstly, the concept of sustainable development is explained and how it is connected to circular economy. The reason for this is to create an understanding of how bottom ash as a material can contribute to sustainability and circularity, in relation to how its benefits societies, environment and organizations. Moreover, the concept of business models is addressed and how it can be applied to create value for products. Here, some examples of different business models and how they are applied are illustrated to provide knowledge on how sustainable development can be created by using models. Lastly, a brief description of bottom ash and how it occurs is presented. This, to gain a deeper understanding of bottom ash and its characteristics, but also the challenges that are related to the material. There is a comparison between different nations and their internal handling of bottom ash is compared. This, to exemplify how other nations processing of bottom ash operates and how far they have come in areas of finding alternative usage for the waste material.

2.1 SUSTAINABLE DEVELOPMENT

The concept of sustainable development had its breakthrough in combination with the ‘bruntlandsförtäckningen’ in 1987 (Gröndal & Svanström, 2010). The aim was is to ensure that humans can live a lifetime with a quality living, but at the same time reduce the amount of resources needed. The objective involves ideal thinking of a society where the management of resources meets the ambitions for continuously better living conditions, but without risking the wellbeing of ecosystems, environment and the future for the coming generations (Geissdoerfer, Savaget, Bocken & Hultink, 2017).

There are three highlighted aspects that need to be fulfilled to ensure sustainable development. The aspects are the environmental, social and economic elements that all are features which need to be balanced by organizations to be successful and sustainable. The aspects are demonstrated in the figure 1 to illustrate how the three elements work together, and moreover show where the sustainable development is found, which is also described in the figure below (Leciejewski, 2015).



Figure 1: An illustration that shows where sustainable development is created in an environmental process (Leciejewski, 2015)

First, there is the social aspect which considers the need for equity between generations, social groups and ethnicity. This aspect is based on the physical and mental well-being of people in relation to societies and the fair circulation of resources (Leciejewski, 2015).

Secondly, there are the economic aspects. This aspect acknowledges how people integrate their use of natural resources to create additional value propositions into their lives. It defines that resource and waste management must take place inside the limited capacity of our planet. The economical aspect also works towards a fair-trading system that encourages distribution benefits, equitably and costs. The economical view also works towards innovation and creativity of technical solutions towards a more sustainable future (Lacy & Rutqvist, Waste to Wealth - The Circular Economy Advantage, 2015).

Lastly, there are the environmental aspects. Inside these aspects area the need for maintaining the globes natural resources highlighted. It is crucial to have an ecosystem and a biophysical system that remains active in all life of the earth. The environmental aspect includes the interaction between the people and the structure of the environment and its ecosystems (Gröndal & Svanström, 2010).

Sustainable development is achieved when there is a balance between these mentioned aspects. There is no sustainability in a society or organization that only achieves some of these aspects, it is the cooperation between those aspects that will create a future that holds for future generations (Lélé,1991).

2.1.1 Circular economy

The constantly increasing and more purchasing world population has demanded enormous pressure on the joint resources. Food should be eaten; materials should be used, and garbage should be recycled. Therefore, most have realized that the old way of producing, using and throwing garbage will not succeed in the long run, and change in our behaviour systems will be crucial (Geissdoerfer, Savaget, Bocken & Hultink, 2017).

In recent years, it has become common to talk about a circular economy. But what it means is not always easy to understand. In simple terms, a circular economy is an alternative to the traditional linear economy that we have today. Instead of creating, buying and then throwing things away, the mind-set in a circular economy is to use things for as long as potential and when the resources are shattered, they are reused and recycled as much as possible (Gröndal & Svanström, 2010).

In order for organizations to succeed striving to a circular economy, it is important that people's quality of life does not get effected. Unfortunately, plenty of today's works may disappear in the re organization to a circular economy. But at the same time, it will contribute to creation of new jobs and other business opportunities that are associated with keeping materials and products in circulation for as long as possible (Geissdoerfer, Savaget, Bocken &

Hultink, 2017). For instance, more people will have to secure the value of the reused goods being sold, which include through quality controls and product brands. Other processes that need to operate for the recycling to work involves marking of what all the parts contains and consists of. Hence, parts from different products with the same material structure can be collected, organized and sold as a new raw material for new purposes (Lacy & Rutqvist, 2015)

The expression circular economy means that material is recycled or reused over and over again. It is a cornerstone of sustainable development and the opposite of today's way of producing and consuming goods. In a linear economy, material is extracted to produce products that are then thrown or burned up. In a circular economy, it is possible for people and organizations to save the resources of the earth, while reducing the waste and provide organization with more sustainable materials (Gröndal & Svanström, 2010).

Circular economy is a concept that organizations continuously strive to achieve. Hence, the working forces against it or barriers are few (Verstraete & Jouison-Laffitte, 2011).

One barrier though is that some organizations have few incentives or adapting circularity and in addition, the variation of knowledge about the subject aggravates the implementation (Lacy & Rutqvist, 2015). It is easy to assume that the most environmental option also is the most profitable, but in some cases, it is actually more profitable to extract new material since there are no technical solutions to recycle existing resources.

In some circumstances it can also be unsustainable, in terms of costs, to recycle or recover certain materials. This, because there can be chemicals with chains of additives combined in the material which make the process more difficult and costly (Perey, Benn, Agarwal & Edwards, 2018).

2.2 CIRCULAR ECONOMY AND BUSINESS MODELS

A business model or organizational model is in business administration a theoretical description of how an organization, or a business, is supposed to work. It is a conceptual tool that contains a set of components and describes their mutual relations in such a way that the business logic of a particular activity can be described concretely (Verstraete & Jouison-Laffitte, 2011). Business models are also supportive tools that are used by organizations to describe the rationale of how different activities can be delivered and create value in terms of culture, social or economic contexts. The process of creating a business model and its modification is also mentioned as business model innovation, which is a part of an organizations business strategy (Afuah and Tucci, 2003).

The Ellen MacArthur Foundation (2013) argues that reorganization of business models will have an important role in the change towards a more sustainable society. Circular business models have the ability to facilitate economically profitable ways for organizations to

continuously reuse products and materials by using renewable resources and hence find new strategic ways to operate (Ellen MacArthur Foundation, 2013).

However, the transition from a traditional business model to a circular business model could mean a radical change for organizations. In some cases, it requires a totally new approach and a new way of managing business by finding other or new market segments (Perey, Benn, Agarwal & Edwards, 2018). But the great value of circular business models is that they have the ability to create value for both companies and customers and at the same time contribute to reduced environmental impact through more efficient and sustainable resource utilization (Urbinati & Chiaroni, 2017).

The new development with organizations starting to involve circular business models in their strategic plan, also contributes to a change in the relationship between producers and consumers. Circular business models highlight the importance of producing products that last for a long time and hence can be used by more customers before its calculated lifetime is expired (Frishammar & Parida, 2019). Several individuals can by this way of thinking use the same product one after the other, or with the help of maintenance, be able to be consumed by one and the same individual during a longer time. Hence, the term "consumer" is no longer spoken of in terms of circular economy, but rather the term "user" (Lewandowski, 2015).

2.3 EXAMPLES OF CIRCULAR BUSINESS MODELS

In this chapter examples of circular business models are described and evaluated to get an understanding in how a model can operate and what element business models can consist of to create a change for organizations (Afuah and Tucci, 2003). Business models can also describe and classify organizations. Especially for commercial purposes, but they are also used by managers to explore opportunities for an organization's future development. Further, business models can serve as recipes for creative managers. Business models are also used in some cases within the framework of the reporting for public reporting (Afuah and Tucci, 2003).

2.3.1 Freemium business model

The word freemium is originated from the English word for free and premium. Organizations using the freemium model are the internet giants of Google, Flickr, Pandora internet radio and Spotify. The business model works by providing free services, mostly commercial financed, which are later widely distributed by the product owner. Hence, a premium service is provided with more functions and other advantages, but with a charge (Teece, 2010).

2.3.2 Recovery and recycling business model

Another business model that is applied by organizations and is also strongly connected to circular economy is the recovery and recycling business model (Valenturf & Jopson, 2019). This model is based on the option that waste can become a valuable resource for companies and is described in two different techniques. The first option is when organization

recapturing resources by reusing valuable energy and components from goods or products at the end of their life cycle. This would, for example, be a case where incinerators plants burn waste and use its heat to form district heating which they later sell to the local households. In this regard, the energy from waste is utilized and hence creates value. The second set deals with utilizing by-products from a production activity. This case could be applied when a sawmill takes advantage of leftover wood chips from their production and form it to a new product. Instead of it throwing it away, as the ‘waste’ does not belong to the company's core business, the wood chip can be used to create a new product such as pellets that they can sell and profit from and hence benefit the organization. The concept recovery and recycling business model thus builds on the fact that companies make use of waste in its various forms to create new values for the organization (Valenturf & Jopson, 2019).

2.3.3 Product life extension model

The product life extension model is based on the notion that companies, private persons and societies should use a product for as long as possible to continuously create a value (La Grace, Enis, Parell, 1977). These concept and categories are strongly connected to circular economy and circular flows due to its purpose of creating value of something that’s otherwise is thrown away (Linton & Jayaraman, 2007). The product life extension model breaks down into nine different categories which explains how a product’s life extension can increase (Despeisse, Ford & Viljakainen, 2015).

Repair - A company or a private person makes sure that their product is repaired instead of throwing it away. The product thus creates a value for a long time.

Recall – This is a request for a return of a product that is suspected to be faulty created.

Preventative maintenance – Routine maintenance for example a machine or a vehicle which is done to prevent problems from arising.

Predictive maintenance – This is a condition driven program which uses direct monitoring of the mechanical problems to determine the mean time for the failure or loss of efficiency for a product or a technical system.

Upgrade – To continuously raise the standard of a product or a system which creates a continuously value improvement for a product or a system.

Direct product reuse – For instance second hand or leasing. When a product directly gets a new customer or owner which uses the product again.

Remanufacture – This is a process when a product or material is remanufactured into the same product again. Examples of this processes can be when a news magazine is remanufactured into a new news magazine.

Recycle – This category is connected to the reuse of materials in an industrial process. This stage is connected to material flows in a cycling process.

Part reuse – This category is similar to direct product reuse but refers to when a part of a machine or vehicle is directly reused inside another vehicle or machine.

(Despeisse, Ford & Viljakainen, 2015).

2.3.4 Business model Canvas

A Canvas model is a tool that was developed by DR. Yves Pigneur and has become a standard for how organizations should work with innovation inside their internal processes or how to create new business areas for products (Osterwalder & Pigneur, 2010). The model maps and describes an organization in a general way based on nine building blocks which together analyses the main areas of operations, offer, customers, financial feasibility and infrastructure (Pickton & Wright, 1998). The nine segments in a business model Canvas are described below and can also be seen in figure 2.

Value offer – This area describes combinations of products and services that combined creates a value for an explicit customer segment.

Customer segment – This area maps different groups of people of organizations that a company tries to reach.

Channels – This area describes how an organization communicates and reaches their selected customers to further be able to deliver the value proposition.

Customer relations – This area describes the type of relation the organization forms with a specific customer segment.

Revenue stream – Describes the revenues a organization generates from every specific customer segment.

Key resources – Describes the different assets and resources which are required for the business model to work.

Key activities – Describes the needed activities required the organization need to achieve for the model to work.

Cost structure – Describes all the costs the model provides the organization with
 The model also describes all the partners and suppliers required for the business model to work.

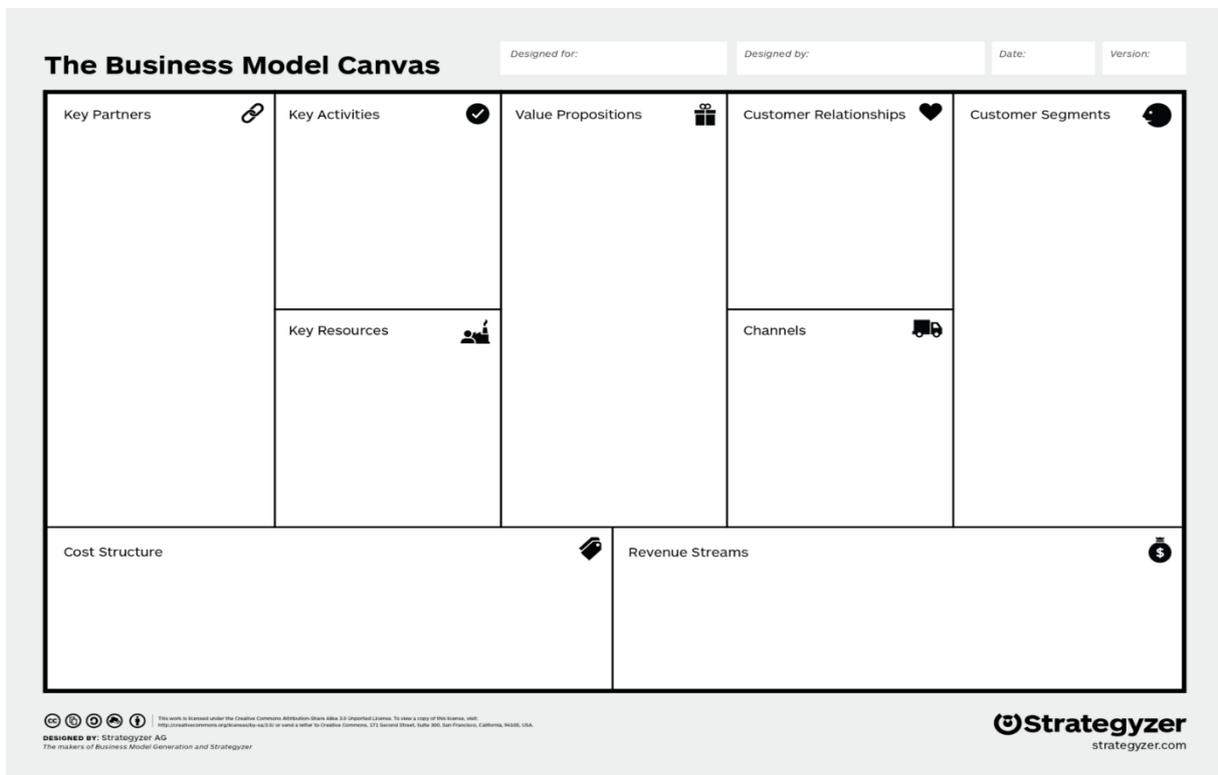


Figure 2: The figure illustrates how a business model canvas looks like and what elements it contains (Osterwalder, 2010: page 3)

The Business Model Canvas has several adaptations with complemented parts, for instance, profit (Antikainen & Valkokari, 2016). This further explains the relation between cost and income revenues and enable further profitability's, except monetary, which an organization can focus on providing in occasions for seeing new value creating areas of usage or goodwill (Greenwald, 2012).

2.4 BOTTOM ASH

This chapter explains the characteristics of bottom ash and how it occurs. This, to get an understanding of the appearance of the waste material, and what problems it can cause to the environment due to its characteristics. Also, a description of what challenges are related to the material is presented, before finishing with a comparison with other nations. The comparison of the usage of bottom ash in EU countries illustrates how the material is being used in those nations and how the development took place.

Bottom ash is a residual waste which occurs from the incineration plants' combustion boilers. The approximatively creation of bottom ash is of approximatively 1 million tons per year in Sweden and consists of particles in all different sizes and forms. Everything from sizes of

footballs to dust (Chimenos, 1999). When bottom ash from a boiler has been treated, stored and metals from the remaining ash have been fragmented by recycling organizations, the ash is defined as “grit”. Now the ash has the appearance of a grey-black sandy gravel which is surrounded by ash and small left fragments of metals. However, the ash contains plenty of pollutants materials such as zinc, lead, arsenic, copper, selenium, antimony, molybdenum, chromium and other easily solvable substances as sulphates and chlorides which make the process of using the material outside landfills difficult due to the risks of leaching (Hansson, Hälldal and Van Praagh, 2017). However, after the bottom ash is stored for 3-6 month, a carbonization process makes metals and organic compounds to bind in the bottom ash which at the end of the process results in a leaching at a much lower level than the theory mention. (Hansson, Hälldal and Van Praagh, 2017).

2.4.1 Challenges

There are two main challenges when it comes to the re-use of bottom ash, which constitute the absolute basis criteria for the material to even be considered in road constructions. They are, environmental impact and the technical demands. These are demands that all materials need to fulfil before application in construction works (Hansson, Hälldal, & Van Praagh, 2017). Therefore, some previous projects have been carried out from these two points of views, where a road in a specific project was analysed in a study carried out by Energiforsk. The two demands on environmental impact and technical demands are discussed in more detail below.

Concerning the environmental aspect of bottom ash and how it impacts its surroundings, one of the main problems of bottom ash is the risk of maceration into the environment, which has to do with the material’s metal content. When it gets hit by rainwater, it streams to the ground after having been in contact with the toxic metals. Whether the amount of poisoned water macerates into the ground could be approved, is up to the supervisory authority, which in turn emanate their decision from the guidelines created by the Swedish Environmental Protection Agency. Even though these demands could be hard for bottom ash to reach, mostly because of the amount of metals in the material, the maceration is commonly very low. Therefore, the risk of the surrounding environment is also low. This has to do with the stable shape the metals occur in and with the carbonation process the bottom ash has went through before application. The material is approximately being stored for six months, where in this process the pH-value descend alongside the maceration, which is considered to be an important part for implementation in road constructions (Hansson, Hälldal, & Van Praagh, 2017).

Regarding the technical demands, bottom ash has lower strength than crushed rock, since the material is more porous. However, the results from Energiforsk’s test illustrated that bottom ash has similar performance as crushed rock, under the circumstances that it is being used in the reinforcing layer. One of the conclusions from their test is that it is just as easy to use bottom ash as it is to use conventional gravel, regarding technical aspects. With this in mind, the overall picture of the technical demands is that bottom ash, under the circumstance like it is being used in the reinforcing layer and that an asphalt layer covers it, fulfils the technical demands, and matches the characteristics of crushed rock.

2.4.2 Usage of bottom ash in other nations

There is a variance in how far different nations have come in their development and usage of bottom ash outside landfills. The reason could be a matter of incentives were, for instance, Sweden is a nation with plenty of mountain resources which is manufactured into stone materials and gravel and further historically have been a tangible resource used by the Swedish entrepreneurs (Winberg, 2018). The incentives for finding alternative materials in the construction business in Sweden have consequentially been of low prioritizing.

However, in nations where the resources of mountains are fewer the incentives for finding other solutions have been of greater importance (Winberg, 2018).

This chapter discusses other nation's usage of bottom ash. The countries are summarized in the figure below and have been selected with the standpoint for being located in the north of Europe and being parts of the EU.

2.4.3 A summary of the mentioned nations

Nations	Finland	Norway	Estonia	Belgium	Great Britain	Germany
Yearly production	300 000 tons	200 000 tons	60 000 tons	350 000 tons	1 million tons	6-7 million tons
Area of usage	95% construction materials 5% Reference projects	Waste materials on landfills	Waste materials on landfills	129 000 tons in road business, 204 000 tons as construction materials on landfills and 24 000 tons in roads in Flanders	Waste material and construction materials on landfills	Varies depending on region. Mostly used as construction material, but in some region as roads
Current Projects	Cement industry	Looking at categorization systems	Some projects in how bottom ash can be used in brick manufacturing	Lots of reference projects with focus on road systems	Projects in how it can be used in construction and road business	Evaluates how it could be used as ballast layer in concrete
Development	A new created standard within their law regulations.	Investigations have started to find new solutions for bottom ash	Sees bottom ash as a small problem, hence no further development	Lack of mountains create big incentives to find new solutions, hence a lot of development	Lack of development due to Brexit	Looking for further development in how it can be used in road businesses

Figure 3: Summary over usage of bottom ash in other nations (Winberg, 2018)

As seen in figure 3 the variations of how different countries use bottom ash is big. As stated, it is the question of incentives that act as the driven force to find other solutions. Moreover, Belgium and Germany are the country's that have developed and found most solutions in how to use bottom ash outside landfills compared to the others. This due to their environmental laws and standards regarding landfills, but also regarding their lack of stone materials. This circumstance has created incentives where Belgium and Germany in early phases have seen bottom ash as a great substitute material. Their authorities have in early stages been provided

with information and reference projects that have made them comfortable to accept the waste material within the construction business.

Other mentioned nations that have not come that far in their development are Finland, Great Britain, Estonia and Norway. The reason to their lack of development are mostly due to low incentives for finding new solutions. Great Britain has for instance struggled with the EU, which make the bottom ash challenge a low prioritised matter. However, Norway and Finland have created new interesting project with bottom ash to investigate its potential in their countries. Finland has presently got bottom ash into their guidelines, which is equivalent to the Swedish environmental protection agency's manual of how to use alternative waste in the construction business (Winberg, 2018).

3 METHODOLOGY

In order to answer the research questions listed in the introduction, there are several ways to go. The selected approach of conducting semi structured interviews was considered as the most suitable. The study is abductive and, in this case, also qualitative. In this chapter, a brief explanation of the research design is performed, followed by the data collection process and how the analysis was conducted. Lastly, the ethics, reliability and validity of this thesis are introduced. In addition, definitions of a qualitative and semi structured interview approach are discussed.

3.1 RESEARCH DESIGN

According to Maxwell (2013), a research design is built on five components, which together formulate what a thesis should contain. The first one is *Goal*, which should answer to why the project or report is being conducted. Secondly, a *Conceptual framework* is to be included, because of how it highlights theories, literature and people that the thesis covers. *Research questions* are also part of the research design. They are related to the *goal* and should tell what the study specifically should answer. Moreover, *Methods* and *Validity* are also included. Maxwell (2013) emphasizes the importance of illustrating how the study is conducted, as well as the questioning the result and validity. For instance, how plausible are the conclusions and what other alternatives there might be, are questions that should be considered.

Having this as a point of departure when creating the fundament of how this project should be conducted. Considering the research questions, a qualitative approach was also chosen. The complexity of the questions was analysed, and it was decided that some detailed but comprehensive answers would create more accurate result than what a quantitative method would give, which has to do with the fairly low level of knowledge within the area of bottom ash in the business sector. However, some actors do possess a lot of knowledge, and by talking to them, and not performing a wide quantitative study did therefore provide representative results. As part of the analysis for selecting a research method, breaking down, not only a qualitative approach but also a quantitative method was done in the beginning of the project. A quantitative study is a neutral way of looking into something. It is suitable when conducting comprehensive studies, because of how numbers and a huge amount of data often is related. Lastly, it is also indifferent towards what has been done in the subject before (Maxwell, 2013). All of these aspects connected to a quantitative method made it adaptable for this project, but in the end, the narrow level of knowledge within the sector and the subjectivity amongst the interviewees became decisive together with the complexity of the research questions. Therefore, a qualitative method was chosen.

It should also be mentioned that the study is abductive, which is a combination of deductive and inductive. Usually, inductive studies are related to qualitative studies and the process of performing it often starts with the empirical data and then it is related to the theory. While a deductive study starts with the theory and then looks at the empirical data (Glaser, 2014). In

this particular case, both data and empirical data needed to be collected for conducting the study, therefore an abductive method seemed plausible to apply. The reason for this, was because of the preconditions. As understood, neither the interviewers, nor a majority of those within the recycling business possess enough knowledge about the material bottom ash. Therefore, it was necessary to continuously collect the empirical data needed.

3.2 DATA COLLECTION

In this project, three different methods of collecting data has been used: interviews, participant observation and secondary data, in shape of reports, studies and other documents.

3.2.1 Interviews

The main approach of collecting data in this qualitative project was through interviews. To legitimise the choice of performing a qualitative study even more, some pros and cons were analysed. Maxwell (2013) explains that the complexity of answers in a qualitative study most often provide more detailed result. Additionally, it also makes room for follow up questions when an interview is performed, which is considered to be a preferable approach when the interviewers rather need substantial answers than a lot of data, which was considered to be the case in this study. For instance, the preconditions, when beginning this project was that several authorities and companies do not have enough information or knowledge for being able to answer a questionnaire. Therefore, pinpointing those who possess most knowledge and have a lot of influence in the business seemed to be reasonable, instead of collecting more vague data from more sources. This also helped in creating discussions over what each interviewee considers to be the biggest barriers for utilization of the material outside landfills. It was also easier to question authorities and contractors. Moreover, since interviews commonly constitutes a significant part of a qualitative research, additional pros of this approach are the holistic view it provides and an openness towards the result (Maxwell, 2013).

Another perspective however, is the critique towards interviews and a qualitative approach. Hammersley (2003), explains in his book "*Dilemma Qualitative Method: Herbert Blumer and the Chicago Tradition*" that manipulation, interpretation and decisive relations are parameters that should be considered in a qualitative method. Results from interviews are easy misinterpreted, they are most often subjective and does rarely contain statistics in the same way a quantitative method does. Nevertheless, given the preconditions and the understanding of a qualitative study, it was still considered the most suitable method for this project's case study (Hammersley, 2003).

The structure of the interviews in this project was semi-structure and the reason for that is, as mentioned before, because of the purpose of creating a discussion between the interviewee and the interviewers. Also, a semi-structured setup means that the interviewers have the freedom to reply with counter-questions, they do not strictly need to follow the pre listed questions, but instead can adapt the interview depending on how it outplays itself (Bell,

Bryman, & Harley, 2019). Another reason for using interviews semi-structured was because of the rather low knowledge level that the researchers possessed before starting the project. That challenge aggravates the process of creating an accurate interview. Therefore, a semi-structured build up was considered the most suitable approach.

More in detail, the build-up of the interviews contained a beginning, where a short description of the project was presented to the interviewee as well as an introduction of the interviewers and their education. Then, the interviewee presented him or herself, and explained the business role he or she had at the organisation. After this introduction phase, the interview object started to answer the interview material, containing approximately 8-10 questions. The objective here, was of course to create discussions around the questions, hence, the semi-structured approach. Nevertheless, having a guideline worked well as something to fall back to during the interviews. At the same time, the questions in the guidelines were of great relevance for the project and needed to be answered for the mapping to be completed. Even though the guideline differed a bit depending on the person who was being interviewed, some of the key questions were the following:

- What are the barriers towards utilization of bottom ash outside landfills?
- What do you believe will happen in the future regarding bottom ash, having in mind that landfills all over Sweden is starting to become full?
- What is necessary for you as an organisation to approve usage of bottom ash? (Authority)
- What is necessary for you as an organisation to use bottom ash in other areas than it is being used today? (Contractor)

Every interview was recorded, and afterwards a summary was created. No transcriptions have been made, but rather comprehensive summaries, with the interview material as a sort of template. The length of the interviews varied a bit, mostly depending on whether there was a physical meeting or a phone interview. Since almost all physical meetings took place in cities a few hours away from Gothenburg (basis of the thesis), these interviews were a bit longer. With that being said, no interview was finished before all necessary or possible answers were provided. Overall though, most interviews were approximately one hour, but they differed between 40 minutes and two hours. The total number of performed interviews are nine. In addition, it was important to analyse what every interviewee said in relation to his or her organisation's perspective. No matter how objective a person might appear, the opinions are probably shaped by the company he or she is representing. Having this in mind when performing the interviews and when analysing them afterwards helped widen the picture. Just as it made it possible to draw conclusions of what was not said in the interviews, just as much as of the presented facts. For instance, the barriers of resources and prioritizing.

3.2.1.1 Interviewee selection

Regarding the interviews, the main task was mapping how different authorities, contractors and clients in the building and waste sectors look upon the material off bottom ash. Before a short description of each actor comes, a list of all the interviewees follows.

- The Swedish Transport Administration
- Contractor from the construction sector
- The County Administration Board
- City of Gothenburg
- The Swedish Waste Management Association
- The Swedish National Road and Transport Research Institute
- Sysav, public waste company

The Swedish Transport Administration and the selected contractor work a lot with roads, both from a client's and contractors' point of view. Hence, they were also considered to be an interesting interview object, especially in the area of implementing bottom ash in road constructions. Having the Swedish Transport Administration placing demands on the contractor to use residual waste when creating roads could for instance be one way of implementing the material. None the less, their influence and power when it comes to both what should be built and how it should be built makes them an important player in this bottom ash project. In relation to this, one of the contractor's strongest areas are road constructions, which makes them relevant for implementation of bottom ash. Their thoughts on how such an implementation process should proceed were considered to be of great interest. Having a contractor's perspective in the case study also entailed a more comprehensive overview.

The County Administration Board and the City of Gothenburg have the power to decide whether a specific material can be used in a project or not, because of their role as supervisor authority. Hence, they constitute an important role if bottom ash should be approved as a material in specific projects. Mapping what is necessary from this stakeholder for them to approve bottom ash was of great interest.

The Swedish Waste Management Association and the Swedish National Road and Transport Research Institute have influence over other actors and can through their research push for practical utilization of a specific material. Mapping all these organisations, entailed in an understanding in what will happen regarding bottom ash in the future and what needs to be done for this to happen. Even the specific incentives of each actor have been considered and taken into consideration when performing the interviews. Furthermore, The Swedish Waste Management Association have a great interest in the material bottom ash, and since they represent several public actors, like incineration plants, they want to find new areas of usage. Because, in the end, it is the incineration plants that is stuck with the material if they cannot be used as construction materials on landfills. Therefore, the incentives for the Swedish Waste Management Association made them an interesting part of the project. In addition, they also possess a lot of data and information, that enhanced the understanding of the whole process of

implementing bottom ash in road constructions. When it comes to the Swedish National Road and Transport Research Institute, they have specific influence over what material that could be of interest. Therefore, their opinions regarding bottom ash in road constructions made them a stakeholder in this project.

It should also be mentioned that an interview with the Swedish Environmental Protection Agency did not take place. They are one of the most relevant actors due to several reasons, but unfortunately they could not make time for an interview. However, they will figure a lot in this study and therefore a short description of them as an organisation follows. The Swedish Environmental Protection Agency constitutes legislations and guidelines regarding alternative materials, which makes them a fundamental player when it comes to implementing bottom ash in new areas of use. More specifically, when it comes to waste management, The Swedish Environmental Protection Agency has created a manual with guidelines over how recycling of waste in construction works should be handled (Widenberg, 2018). Concerning this manual, it is of great relevance for enhancing the possibility of using bottom ash. Because, when supervisory authorities make decisions regarding environmental approvals, they base their decisions on what the Swedish Environmental Protection Agency states in their manual. Therefore, this authority constitutes an important part of implementing bottom ash in areas outside of landfills. Regarding Sysav, it is a public waste company that operates in the southern regions in Sweden. They collect waste and through incineration transforms it to energy and electricity (Sysav, 2019).

3.2.2 Participant observations

Another method of collecting data, which has been applied in this study is participant observation. This method is part of a qualitative study, which according to DeWalt & Dewalt (2010) is a way of understanding a phenomenon and seemed to be an appropriate interpretation of this project's main task. Getting all the necessary and possible information regarding bottom ash are essential for understanding the material, as well as what needs to be done for utilization outside landfills. Execution wise, participant observing works like an observant takes part in a study or field work, where he or she listens, takes notes and joins in activities related to the subject. It is an informal way of collecting data, but non the less, it could be a suitable way of receiving as much information as possible. Then it is up to the observant to go over all the collected data and make his or her own judgement whether the facts are relevant, legit and accurate. In addition, one important aspect of a participant observation approach is that the research is ongoing for a longer period (at least a few months). Since there is a lot of subjectivity involved in the method, the more time an observant gets to collect as much data as possible, the more plausible conclusions can be drawn (DeWalt & DeWalt, 2010).

3.2.3 Secondary data

Lastly, as part of the data collection, secondary data have been collected. For instance, several reports covering business models, bottom ash and circularity, have been studied. Both, to

receive an image over the current situation regarding the recycled material bottom ash, and to get a deeper insight over how a business model can be related.

3.3 ANALYSIS METHOD

To complete the analysis in this project, mainly two different models have been used. Their application was in the shape of analysing bottom ash from three different perspectives: from an incineration plant's, a contractor and The Swedish Waste Management Association. These selections were made because of some different reasons. An incineration plant, since they are the one who possess the real problem, if an alternative usage does not turn up and because they are creating the material. A contractor was selected, because that is a way of understanding what needs to be done for implementation in another area outside landfills. The Swedish Waste Management Association's perspective was also considered to be one of the most interesting, since they are working with bottom ash the most today and are trying to find new areas of use.

The SWOT-analysis is performed from the material's perspective in order to get an understanding of its strengths, weaknesses, threats and opportunities'.

3.3.1 Business Canvas Model

To analyse the result, a model named *Business Canvas Model* was used. As explained in the literature section, it is a business management tool, which is used to visualise factors that are necessary to consider when starting a business, entering a new market or creating a new product (Osterwalder & Pigneur, 2010). One of the reasons for choosing to work with this model is because of its flexibility. The structure of the model entails that it can easily be changed if any of the inputs for each category change (Osterwalder & Pigneur, 2010). It was considered to be a suitable advantage for the analysis in this project, because of the uncertainty of what the result should be before starting the project. In relation to bottom ash in this specific case, the parameters that the business canvas model contain matched the research questions that was listed in the project. So, the flexibility of the model in combination with the relation to the research questions made it a good method for analysing the implementation of the material. The questions that were asked in the interviews derived from the shape of the Business Canvas Model, because of reasons mentioned above. This provided a holistic overview of the material bottom ash.

3.3.2 SWOT

In addition to the *Business Canvas Model*, a strategic management tool of SWOT has also been used in this study. Even though a SWOT-analysis has its weaknesses, for instance, it has been considered as a simple and naive tool. To only look at the SWOT as a tool that produces an explicit and practical outcome could lead to errors (Pickton & Wright, 1998). However, despite of its flaws, for this specific project a SWOT-analysis seemed to constitute a purpose when combining it with other collected information and the *Business Canvas Model*. Since its

strengths lie in how dynamic the tool is, its practicality and, much like its weakness, its way of expressing output (Pickton & Wright, 1998). With this in mind, this model was considered to form an important part when presenting how companies and authorities should move forward when it comes to working with bottom ash. Because of the materials complexity, an easily understandable model, could help the implementation becoming more tangible. Furthermore, in this particular case, the SWOT-model works as a tool on top of the Business Canvas Model. While the Business Canvas Model form the basis for the analysis, the SWOT supplies a straight forward way of presenting key factors for success. With this in mind, the decision was made that both models formed a purpose in combination with each other.

3.4 VALIDITY

One area that definitely should be mentioned, which has been covered and analysed when conducting this project is the questioning of the validity. Maxwell (2013) states that qualitative research projects often rely on small number of informants a majority of the data, and even though they might have been selected carefully there is no guarantee that the information provided is 100 percent valid. However, Maxwell (2013) also brings up that interviewing commonly is a valid approach for understanding someone's purpose and reason for providing the answers they deliver. This was something that was considered before, during and after each interview. The phase where selections of persons that should be interviewed was made, contained a lot of discussions. Analyses of how each interviewee could contribute to the purpose of the project and help answering the research questions, as well as analyses of what each interviewee's own purpose of participating in the study was made. It could be everything from the not looking bad, restoring a good reputation, being genuinely interested in what the end result might be and wanting to help. Regardless of their intentions and purposes of participate in the study, every answer from the interviews was analysed with the validity as the point of departure. Even during the interviews, having the validity in mind, it helped questioning some answers and creating discussions, since some answers sometimes sounded like they wanted to promote and market their own business.

Therefore, the validity was one of the most important aspects of the execution, but also when going over reports in the literature study. Some articles and books might have been more valid in the sense of authentic data, but at the same time not fitting in to this particular project. While some information matched perfectly what was needed for conducting this study but came from unreliable resources. In those cases, further auditing of those resources where made and if they in the end seemed authentic, they could be applied as interview material or as material to the report itself.

3.5 RELIABILITY

When it comes to reliability, it is something that has been considered during the whole research study. One interpretation of the term is that it should mirror the total of those who has been part of the study, and if the same study, with the same conditions and methodology

is reproduced, it should end up in a similar result (Golafshani, 2003). With this in mind when creating the interview material, the intention was to make it as objective as possible. Just as when performing the interviews. Even though the interview material to some extent was hard to keep from being too subjective, every time an opinion that seemed personal was presented, follow-up questions were asked. The overall sense is that, thanks to the semi-structured build-up, the conditions for creating discussions and keeping the study reliable increased. However, it should be mentioned that the absence of previous studies and similar projects, entailed in a lot of subjective answers.

3.6 ETHICS

The ethical aspects of this study were of great importance. When conducting interviews, there are a lot of things that should be done in a certain way for the execution to be considered ethical. Especially in qualitative research studies, since the interviewees most often provide a lot of information about themselves, both direct and indirect. Therefore, openness and honesty are essential when starting to recruit interview objects (Vogt, Gardner, & Haeffele, 2012). Sharing why the study is being conducted and in what purpose each person is being contacted. In this project, the phase of collecting interviewees were mainly conducted through emails, but in some cases also over the phone. Every time, the potential interview object had the opportunity to pass, but if the person approved of participate in an interview, he or she was provided with flexible meeting proposals. In this project, some interviews have been via telephone and some have been physical meetings. It should also be mentioned that all interviews have been made anonymous.

Before every interview started, the interview person was asked if he or she approved of the interview being recorded. The purpose of that was always for providing the conductors the best possible conditions of focusing on the interview and not having to write down notes during the whole interview. This information was always given to the interviewee, which in every case approved. During the interview, a material consisting of approximately 10 questions worked as an interview material. These questions were always sent to the interview object before so he or she could go over it if wanting to. The questions per se, differed a bit depending on whom was interviewed and what business role he or she had, but they were more or less formulated in the same way.

The decision to adopt a qualitative research method in this study, comes with a certain responsibility towards those whom is being interviewed. For example, in comparison to a survey, which is a common method in quantitative studies, conducting interviews take up much more time of each person who participate, it demands more attention and commonly they have to prepare before the meeting. In addition, the interview structure often contains more in-depth reflections and difficult questions. This could put the interviewee in a situation where he or she has to come up with more complex answers and sometimes maybe personal opinions as well (Vogt, Gardner, & Haeffele, 2012). Vogt, Gardner & Haeffele (2012) also highlight another ethical challenge when it comes to interviews in comparison to surveys. Because asking anyone to fill in a survey does not interfere with their privacy unless the

questions are of that kind. If that is the case, the person who is performing the survey could simply not answer it. While for an interview, anonymity is impossible. No matter how the interview is structured and how many that share the result afterwards, there is always at least one person, the researcher, who takes part of the answers. Therefore, performing a qualitative interview study, does imply several ethical challenges, which ought to be considered. However, regarding this project a lot of factors have been analysed and acted on beforehand, to provide the interviewees with the fairest conditions they might get.

4 RESULT

In this section, the results of the interview study are presented. Here, the authorities' and contractors' own opinions about bottom ash are presented with a focus on barriers and incentives. Furthermore, a Business Canvas Model is evaluated in which a more detailed presentation will be presented of how bottom ash can give rise to value creation via a business model. Finally, a SWOT-analysis is presented where bottom ash is broken down into the four different sub-segments strengths, weaknesses, opportunities and threats to give a final understanding of what bottom ash has for capacity and what obstacles that may exist.

4.1 INTERVIEWS

A number of questions from the interviews have been selected, and they are presented from the interviewees' perspective. This way, the subjects that did not provide accurate answers or discussions where the relevance of the study was low, could be sorted out. The selection of questions was made with the research questions as a point of departure, and they worked as a base when deciding whether an answer seemed accurate or not. Instead, five areas regarding barriers towards implementing bottom ash in other areas, apart from utilization as coverage material in landfills, are highlighted. The reason for choosing to have barriers as a silver line throughout the whole interview study, was because they provide a comprehensive overview of both the situation today and what needs to happen in the future. Therefore, illustrating the barriers connected to the material appeared to be an appropriate way of representing the material in all types of areas. In addition, the selected subjects are also supposed to represent how these organisations reason when it comes to managing their business in relation to bottom ash. This way, their answers can be related to the research questions listed in the beginning of this thesis.

4.1.1 Lack of standard as a barrier

One of the most often highlighted barriers in relation to bottom ash is the lack of standards. The County Administration Board and the City of Gothenburg emphasize the fact that as long as they do not have any guidelines or directives to refer to when deciding whether bottom ash is ok to use or not, they will most likely reject the material. For them it is a question of not taking risks and not being responsible for anything if something should go wrong. Furthermore, they spoke about the need of performing more projects of reference. Even though, there are a lot of reference projects from other countries, here in Sweden, they want to see more. So, both the County Administration Board and the City of Gothenburg state that as long as no guidelines from the Swedish Environmental Protection Agency are created, these two authorities will have a hard time allowing bottom ash when they act as supervisors in a construction project.

The Swedish Transport Administration mentions that a lack of standard also affects their incentive to include bottom ash as alternative material in their handbook. Here they refer to the fact that as long as there are no clear directives on how the material can be used, they have no reason to add bottom ash in the manual- or have it as a requirement in their procurement.

Perhaps the most comprehensive answer received regarding standards came from the Swedish Waste Management Association. They summarize everything with the premises that for as long as there is no standard with directives from the Swedish Environmental Protection Agency, bottom ash will not be an alternative material with the opportunity to be used outside landfills. Without a clear standard, it will be impossible to convince the County Administrative Board and the municipal supervisory offices to decide to use bottom ash in alternative constructions. According to the Swedish Waste Management Association, it will be necessary for the highest authority to deal with the problem which in this case is the Swedish Environmental Protection Agency.

Swedish National Road and Transport Research Institute also agrees on the fact that the biggest barrier towards a regular use of bottom ash as an alternative material, is the lack of standard. However, they further mention that it will not help performing a large number of reference projects that demonstrate that bottom ash is an functional material, if no authority dares to use it due to the fact that there is no directive from the highest instance, the nature conservation authority.

4.1.2 Economical profit as a barrier

Another barrier, closely related to standards, mentioned by the contractor, is the economical part. For them usage of bottom ash both needs to fulfil the environmental and quality demands as well as be financially profitable. From their perspective, it is absolutely crucial before they even consider using the material that they know before entering a project that the material meets the demands in these areas. Today, they cannot motivate waiting for approvals for months from authorities when they can use natural gravel instead. Therefore, the fact that the authorities' have not created any regulations or standards for the material today could be considered to be a barrier for the contractors' willingness to try it. Also, the Swedish Waste Management Association highlights this issue. More specifically, they emphasized the problem of the authorities not having the time and do not prioritize bottom ash, entails that they almost exclusively decide against usage of bottom ash as alternative material.

With this being said, regarding the economical barrier, the contractor does not want to be exposed to scandals of any kind, so the possibility to use bottom ash needs to 100 percent okay. Even when all of these conditions are in order, then the economical barrier is still present, because it is first now the material can fully compete with natural gravel and ungraded crushed rock. However, even if the material is more economically profitable, bottom ash will not be selected. One concrete example that was mentioned, which actually has been brought up during several interviews, is the high transportation costs. No matter the material, transporting it often costs a lot, and since the total amount of bottom ash (1 million tons a year), is fairly low in construction contexts, it could imply rather much transportation.

4.1.3 Priority as a barrier

Starting with the Swedish Waste Management Association, their reason for trying to get bottom ash into a circular system is, according to them, that soon all landfills in Sweden will be full. When that happens, bottom ash needs to be used in other areas. They stress the fact that continuing to place bottom ash as coverage material on landfills, is a huge waste of potential. The material could be placed in several different areas, and should not take up space for hazardous waste, which should be put on landfills. Moreover, since they represent the incineration plants, which are the ones who own the issue, that also becomes a reason for them to try and find new areas of use. At the moment, they are prioritizing the material highly and intend to keep it that way.

Regarding the contractor, they do not have any obligation to use the material, and at the moment, no obvious incentives to prioritize it either. They state clearly that if bottom ash fulfils every environmental criteria and every quality criterion, the material competes with the current materials on the market. This implies that, it will mostly be financial reasons that will determine whether the contractor will use the material or not. As long as it will be more profitable than natural gravel and crushed rock, they do not see any reason for not using it. In addition, as usage of bottom ash is a way of creating a circular economy, it also entails in good marketing for this contractor. Lastly, they also mentioned that they want to contribute with what they can for the environment, and if using bottom ash is one way, it also works as an incentive, even if not the strongest one.

When it comes to the authorities and the Swedish Transport Administration, they mention that they not prioritize the material. Apart from the image that was provided during the interview with the Country Administration Board, who stressed that creating more landfills would be a suitable solution when the current ones are full, the others shared an optimistic view of working with bottom ash outside landfills. However, their incentives are not strong enough today, since they do not own the problem and have other questions to deal with. For instance, the Swedish Transport Administration, do neither have any economic incentives nor is it their problem to begin with. Hence, the material is not included in their guidelines for alternative materials in road constructions for example.

The Swedish Waste Association is the main actor who owns the problem. According to the Swedish Waste Management Association they face the main problem with soon fully covered landfills. But if the problematic is not solved, the problem will be a matter for all taxpayers and hence society. As the Swedish Waste Management Association mentions a worst-case scenario is that no solution is found and hence all bottom ash is forced to be placed at landfills. This extra cost of almost 500 000 000 will in-directly be a price that mainly affects the taxpayers due to the compensation with raising taxes. So according to the Swedish Waste Management Association, in the long run the bottom ash difficulty can be a personal matter for not only the incineration plants, but for all the taxpayers as well.

4.1.4 Circular economies vs poison free environment as a barrier

Every interviewee mentioned that circular economy is both up to date and a good thing. Instead of having linear systems where products and materials end up on landfills, especially materials that could be applied in other areas is a waste of resources according to all of them. However, the actors had different views on bottom ash. For instance, one thing that, first and foremost, the County Administration Board brought up, but even the City of Gothenburg mentioned was that the environmental quality objective stated by the Swedish Environmental Protection Agency, which states that an environment should be without poison (poison free environment) clashes with circularity. When it comes to bottom ash, they rather reject circularity than risking maceration into the environment. Therefore, instead of trying to implement bottom ash in other areas and creating circular economies, authorities feel that this environmental objective makes a stronger case than circularity.

The Swedish Waste Management Association on the other hand has another view on the same clash. Because of their strong belief in bottom ash, they think bottom ash could be used without disturbing the environment and interfering with the objective set by the Swedish Environmental Protection Agency. They refer to all the tests that have been carried out, both in Sweden and in other countries, and say that the results regarding maceration are positive. With this in mind, the Swedish Waste Management Association stresses the importance of creating circular economies and states that it should constitute a considerable part of Sweden's environmental work.

Apart from the challenge regarding an environment without poison, no other argument against bottom ash and its contribution to circularity has come up. The rest of the interviewees mentioned that they also feel that circular economy is getting more and more trendy, and that its consequences are almost exclusively positive. However, as good as circular economy often sounds in theory, it could sometimes be hard to apply in practice. The Swedish Transport Administration tried to nuance the case that, even though they are positive towards bottom ash, its implementation outside landfills cannot come at any cost. The process must be done properly, and everyone must know before that the environment will not be affected.

4.1.5 Unwillingness to look at other countries as a barrier

There is no doubt that bottom ash is used in a larger extent in other nations than in Sweden. However, the reason for this is as the authorities' mention, a missing of standard and directives of how bottom ash can be used outside landfills in Sweden. Hence, it is of great interest to ask the authorities and contractors, how they relate to the fact that bottom ash is already used in other nations and why Sweden is a bit behind in this issue.

When this question was asked, both authorities and organizations were relatively united. They believe that the fact that bottom ash is already used in other nations, as for instance in road material, is something they should consider as a receipt that bottom ash has potential. That it could be seen as an argument that in the future it should be possible to find applications outside of landfills for the material. However, something that stood out was that the

authorities of both County Administration Board and the Swedish Waste Management Association believed that it does not really matter that bottom ash is used in other countries, because each country must comply with its own environmental legislation, and as long as the material does not meet the Swedish legislation, it does not matter how it is used in other countries.

As previously mentioned, more reference projects and studies of bottom ash are being requested from the Swedish authorities. However, the Swedish Waste Management Association believes that it would be interesting to import old reference tests from other nations. By doing this, it would hopefully be possible to use already existing data instead of making new costly and resource demanding reference projects in Sweden. They also mention that the bottom ash in Denmark should not be of a big difference in relation to the bottom ash in Sweden, hence the Danish tests should be relevant even in Sweden.

The Swedish Transport Administration also mentioned something interesting about our neighbouring Finland and how they have been working with bottom ash. In Finland, after plenty of lobbying work with the material, bottom ash has finally become a part of their guidelines, in their equivalent regulatory framework and handbook for how to use alternative materials in constructions. This has become a major breakthrough for the use of bottom ash in Finland, because there are now clear directives from their corresponding to the Swedish Environmental Protection Agency and can hence be used in a more extensive way outside landfills. In Finland they are now performing projects in how bottom ash can be used in roads and as a bottom layer in concrete bricks.

It was also interesting to listen to a recycling company's explanation of why Sweden is so far behind the other countries regarding the use of bottom outside landfills. They believe that everything refers to incentives, and that Sweden in its comparison with other nations has not had the same incentive to deal with the problem because of our large amount of natural resources of mountains and hence stone materials. Germany, Denmark and Belgium do not have the same amount of mountain resources and have therefore been forced to look for alternative possibilities for rock materials and this is where they saw potential in the bottom ash early. According to Sysav, this has also been one of the biggest reasons why other nations have done more projects related to bottom ash and why their legislation is more accepting regarding the use of bottom ash outside landfills.

4.1.6 What would be needed for a future product?

After the interviews were made with all the contractors and authorities, the insight became clear that a standard will be required for bottom ash to be used outside landfills in Sweden. Therefore, the question was asked again to respective authority regarding their view of how a standard could be implemented in Sweden.

As mentioned, everyone was clear that a standard will be needed in Sweden from the Swedish Environmental Protection Agency in order to use bottom ash outside landfills. But how the process would look like was in some cases a little unclear from the authorities' sides. The County Administrative Board, Sysav and Gothenburg City agreed that before making a standard, there must be considerably more reference projects in order to create additional knowledge and hence increase the competence level of bottom ash. This to prove to the Swedish Environmental Protection Agency that bottom ash is a good material and hence should be able to be used in various constructions, which also the other organizations agreed upon.

The Swedish Transport Administration also mentioned that in addition to creating more reference projects, it could also be possible to influence the Swedish Environmental Protection Agency. This would be done by taking existing information and data from already executed projects outside Sweden's borders and bring to the Swedish Environmental Protection Agency to influence them and make them realize that Sweden is behind other nations in the usage of bottom ash and need to follow the development. Moreover, Swedish authorities should hence consider other nations usage of bottom ash as a receipt that it can be used outside landfills, and that it therefore should be possible to use it under certain terms even in Sweden.

However, something that was interesting was the Swedish Waste Management Association, which in addition to this mentioned that it will also be of great importance that all the large industry organizations together, which are the Swedish Recycling Industries Association, Construction Industries Federation and the Swedish Waste Management Association are involved and collaborate to prove that bottom ash can be used outside landfills. The Swedish waste association management is responsible for the municipal recycling companies, while the recycling industries are industry organs for all privately-owned recycling agencies and the construction industries answers as the organ for all the building entrepreneurs. The Swedish Waste Management Association argue that if all these industry organs work together in the bottom ash question, they consider that it would be a great force that can influence the Swedish Environmental Protection Agency to create a standard for the material.

4.2 BUSINESS MODEL

The following two segments present how the results from the interview study and the theory can be applied in different models. First, from the perspective of a product, in this case bottom ash. It is analysed with the help of a Business Canvas Model. Then, a SWOT-analysis is performed, also with bottom ash the point of departure. Both of these models are supposed to illustrate that even though it is a product that is being analysed, a business view can be applied. Several questions, like what value bottom ash creates, for whom and what/who needs to act are discussed in the models.

4.2.1 Business Canvas Model

The figure below illustrates a Business Canvas Model where bottom ash has been analysed. The different categories are filled out from the idea that finding new areas of use for the material outside landfills. Each category is described in the following sections and an explanation as well as a motivation for how every area has been analysed are included as well. It should also be mentioned that the current application areas are also included, since that is a value that the material still creates, from the existing conditions, which the figure below illustrates.

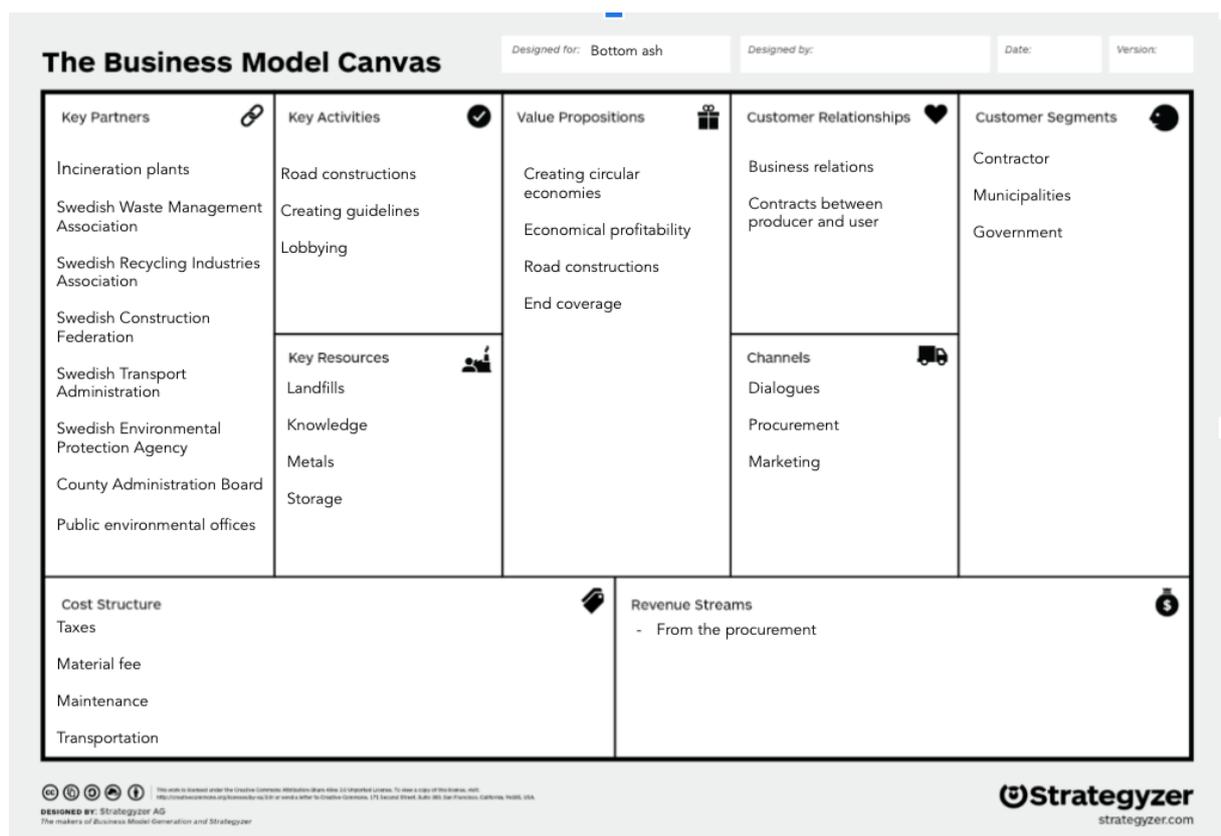


Figure 4: Business Canvas Model over bottom ash.

4.2.1.1 Key Partners

Starting in the Business Model Canvas are the key partners. Regarding the authorities and the public actors, the figure 4 below, illustrates how the different actors are related to each other. Even though it is not a complete truth about who works under whom, it provides an image

over what the relationship between them looks like. This could be considered as a result from the interviews and was necessary for understanding the value creation within the business models from bottom ash's perspective. Several authorities are key partners in the Business Model Canvas, and therefore the relation between them is important to grasp the whole picture of how bottom ash could be implemented in areas outside of landfills.

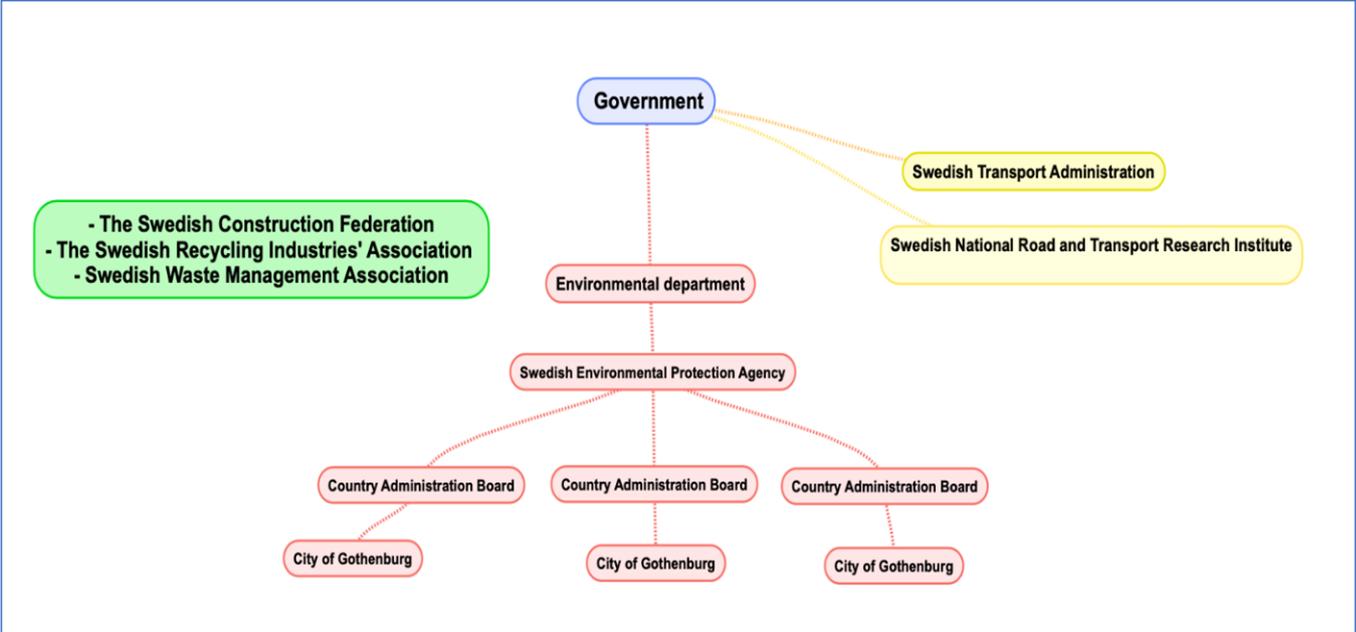


Figure 5: Illustration of how authorities in Sweden relate to one another.

In figure 5, two trade organisations are also presented. Neither of them have been interviewed, but both constitute a significant role in when it comes to the implementation of bottom ash in new areas. For instance, The Swedish Construction Federation and The Swedish Recycling Industries Association, have both a lot of influence over the Swedish Environmental Protection Agency. If a material like bottom ash should be included in their guidelines, pressure from these organisations could have a significant impact. In short, they are trade organisations that represent companies within their sector. The Swedish Construction Federation represents the private side within the construction sector and the Swedish Recycling Industries Association represents the private side in the recycling sector Hence, they are both to be considered as key partners within the Business Canvas Model.

Lastly, the incineration plants and the Swedish Waste Management Association are key partners. The incineration plants are producers of the material and the Swedish Waste Management Association are the ones doing the lobbying, because they own the challenge of finding new areas of use when the landfills are fully covered. Hence, they are two of the most obvious key partners.

4.2.1.2 Key Activities

Considering the *Key Activities* in the Business Canvas Model, they are listed with the thought of how bottom ash can be used outside landfills and in what areas specifically. For instance,

road constructions are one of the main areas where bottom ash is used in other countries. The characteristics of the material suits road constructions well as stated before, and therefore, working towards implementing it, in that area is a key activity. Another key activity is how it should be implemented. The lobbying performed by the Swedish Waste Management Association is therefore considered to be one of the most important things for the implementation of bottom ash outside landfills. This lobbying is directed to the Swedish Environmental Protection Agency, and more specifically, towards their guidelines. It is necessary that bottom ash finds its way into their guidelines, so that the usage of the material becomes clear. Creating/including in current guidelines, are thus also a key activity.

4.2.1.3 Key Resources

Key Resources for bottom ash are landfills, knowledge, metals and storage. Starting with the tangibles, even though landfills does not contribute to the circular economies, and this study aims to find areas outside of it, landfills are still a key resource in the transition phase. Changing areas of use do not happen over nights. Hence, landfills constitute an important part and a key resource for bottom ash. Metals are important, both for its value and for the risk of maceration that comes with it. Space for storage is necessary, both for the carbonation process, but also because of the amount of material. Lastly, knowledge could be considered as an intangible resource and having knowledge about the material is definitely a key resource, for making implementation in other areas possible.

4.2.1.4 Value Propositions

Furthermore, *Value Propositions* are something that permeates the whole business model. When it comes to bottom ash, the values the material can create are the following: circular economies, road constructions, economical profitability and end coverage of landfills. Circular economies are related to how usage of bottom ash in areas outside landfills contributes to circularity instead of linearity and it could be considered as an environmental value. Road constructions are a concrete value, which simply could be explained by people getting conditions to travel from one point to another. The economical profitability concerns those who might earn money on working with the material, something that several actors could do. For instance, contractors may receive money for taking care of the ashes. Lastly, end coverage of landfills is still a value proposition. Today, there is still a need for covering landfills, and for that bottom ash constitutes a good alternative.

4.2.1.5 Customer Relationships and Customer Segments

Even though this Business Canvas Model covers a product and not an organisation, the two categories; *Customer Relationships* and *Customer Segment* explain who the customer is from an organisational point of view. For instance, contractors are considered to be customers, because of how a producer might try and get them to use the bottom ash in areas outside of landfills. Thus, they are a customer to incineration plants and also in one interpretation, for the bottom ash itself. Another way of looking at the customer segment is that they society and the government are customers. One area where bottom ash might be applied is in road

constructions, and if that is the case, the government has probably discovered the need of creating this specific road. When bottom ash helps constructing the road, the government becomes a customer. Just as the society in some extent also could be considered a customer, when bottom ash makes it possible for inhabitants to travel via road from one point to another. Regarding the customer relationship, from a bottom ash perspective, most relations are through business. Producers, recycling firms and end users are involved actors, which makes the relationship more or less only professional. Probably, the relations are often created through a contract, where instructions of the material in different ways are discussed.

4.2.1.6 Channels

Closely related to *customer relationship* is *channels*. This alternative presents what channels are being used for working with the material. Dialogues, marketing and procurement are most likely in which the communication takes place, depending on who's perspective is discussed. For instance, the Swedish Waste Management Association is trying to market the material and is therefore using several different channels to do this. In the process of working with the material more concretely, dialogues and procurement are methods that work as channels, for example, incineration plants and contractors.

4.2.1.7 Cost structures and Revenue streams

Regarding the cost structure and the revenue streams, how bottom ash can contribute to an actual cash flow is through the deals that are made in the procurement phase. Somewhere between the actors who are involved, money will be transferred, and therefore also generate a revenue for someone. The cost structure by contrast, consists of more factors. Costs of handling the material, maintenance, taxes and transportation are all aspects that create economic challenges for bottom ash. No matter which actors they are related to, these costs need to be dealt with.

4.3 SWOT

In this chapter, a SWOT-analysis will be presented to sum up what strengths, weaknesses, opportunities and threats bottom ash has, which are based on the collected material. These categories are further described after the figure 6 below to explain each part.

Strengths	Weaknesses
<ul style="list-style-type: none"> • Characteristics regarding technical and environmental criteria which fulfills current demands, when applied outside of landfills • Good for end coverage of landfills • Fairly low density – enhances transportation 	<ul style="list-style-type: none"> • Consists heavy metals – Something authorities are concerned about • Theoretical risk of maceration • Lack of knowledge • Time consuming handling of the material • Risk for expensive handling of the material
Opportunities	Threats
<ul style="list-style-type: none"> • Creation of circular economies • Road and construction works • Economic profitability • Saving resources 	<ul style="list-style-type: none"> • Authorities do not take responsibility • No finding of a solution • Competitive materials • Transportation • Lack of incentives

Figure 6: SWOT-analysis of the material bottom ash.

4.3.1 Strengths

As mentioned in the interviews with The Swedish National Road and Transport Research Institute, Bottom ash is a material with many good technical and environmental properties, which makes it possible for the material to replace natural gravel and crushed rock in for instance road constructions. In terms of how it is used in other countries, it can also be seen that bottom ash is an acceptable material that is already used in contexts outside landfills, and not only as a construction material on landfills.

However, even though bottom ash could be used outside landfills, it must not be forgotten that the material also has great characteristics to continuously be used as end cover material on landfills. As mentioned in the interviews, even if new ways for usage are found for bottom ash, it will always be necessary to have an end covering construction material at the landfills, where bottom ash is mentioned as good material.

In terms of the density of bottom ash, it is also lighter than other construction materials. This is a characteristic that, as mentioned by the Swedish Waste Management Association, easily can be forgotten. In terms of transports, it is a great advantage if the transported materials do not weigh as much. Hence it become less expensive since every transportation contains more material.

4.3.2 Weaknesses

Regardless of whether bottom ash is a material that most of the Swedish authorities agree on has plenty of positive properties to be used outside landfills, it also contains hazardous substances. Bottom ash contains plenty of environmentally hazardous substances, which is the fundamental contributing problem why the Swedish authorities do not dare to accept the use of it in other circumstances than as end cover material at landfills. It is the thought of maceration that is considered to be the largest weakness for bottom ash.

Other weaknesses for bottom ash are as the authorities mentions, is the large lack of knowledge and a lack of standard with clear directives for how to use bottom ash from the Swedish Environmental Protection Agency. Here, Swedish Waste Management Association primarily believes that the lack of standards is a consequence of the large lack of knowledge. They also mention that the key for this will be to create more reference projects to improve the level of knowledge about the material among authorities.

Another weakness mentioned in the interviews is the lack of incentives to use the material. The originally used materials for road construction, such as stone materials are inexpensive to buy, which makes it difficult for contractors to choose materials such as bottom ash. According to Swedish Waste Management Association, it will be required that the bottom ash will be economically beneficial compared to other materials, which can be a challenge.

Starting a project today is also time consuming. As by the contractor mentioned, the time for getting acceptance for bottom ash is a major weakness with the material. For instance, if the contractor decides to use an alternative material, they do not want to delay an entire road construction, just to use bottom ash.

4.3.3 Opportunities

The most commonly occurring argument, and also the strongest that was mentioned in the interview study is that bottom ash, by finding new usage areas, can save existing resources and create new circularities and economical lops. As Swedish Waste Management Association and Sysav mention, by re-using bottom ash it will save virgin materials at the same time save place for other waste materials on landfills.

As mentioned by the Swedish Waste Management Association earlier, other countries already use bottom ash outside landfills, mostly in road construction, which is one big opportunity for the material to be used inside in Sweden as well. As the County Administrative Board described, the fact that other nations already use bottom ashes outside landfills can be seen as a big opportunity in Sweden. Hence the Swedish authorities can use existing data and research from outside the Swedish borders in order to avoid making extensive projects in Sweden. In this way, it can save both capital and resources in terms of not having to do re-do projects that have already been examined before.

4.3.4 Threats

There are many threats for bottom ash. One mentioned threat that the entire industry is afraid of which have been raised in the interviews, is that no new solutions are found to handle bottom ash outside landfills. The consequence of this threat is, as Sysav mentioned, that when the landfills will be fully end covered, the incineration plants will be forced to put bottom ash as a waste material on landfills instead. That will be both very expensive due to landfill taxes, but also have consequence for the Swedish landfills, because if that happens the expected time before they will be full today will expire a lot faster than what has been calculated for.

Another threat raised by the Swedish Waste Management Association, is that the existing materials which the construction organization uses today in, for example, road construction are cheap and easy to obtain. It will be a great challenge to find the right incentive for companies to use the material, as what the Swedish Transport Administration mentioned is easier to use approaches that are familiar than to apply innovation that is foreign.

Lastly, a threat that the Transport Agency raised which could be the biggest barrier towards a sustainable use for bottom ash, are the logistic solutions regarding transport. As Sysav mentioned, it is not possible to transport material from Gothenburg to northern Sweden. Hence all use for bottom ash must exist in local areas to create an economic sustainability in using the ash.

5 DISCUSSION

The complex issue of finding new solutions to what should be done with material that earlier has been placed as construction material on landfills, formed the basis of this study. The aim was to map actors that have a connection to bottom ash in relation to circular economy as well as present those actors who have influence over what could be done with the material. This has been done with the help of business models, where the empirical findings are presented and analysed. In this section, the empirical findings are related to the theory. The research questions that are stated in chapter 1, work as a basis for the discussion, where some of the barriers towards implementing the material in areas outside of landfills are presented and debated. Also, a short summary of the SWOT-analysis and the business model canvas are discussed, especially in how they relate to circular economy.

5.1 BARRIERS FOR UTILIZATION OF RECYCLED MATERIALS

The first research question covers how recycled materials can contribute to circular economies, and in this case it is presented from the perspective of barriers. Thus, the discussion derives from what is needed for bottom ash to create circular flows. After having analysed the interviews, it became clear that circular economies often sound good in theory but that it is not always as easy to apply in practice, which is highlighted by Lacy & Rutqvist, (2015) and by Perey, Benn, Agarwal & Edwards, (2018), when they discuss barriers towards the concept.

5.1.1 Tensions related to circular economy

Regarding circular economies, as stated by Verstraete & Jouison-Laffitte, (2011), the concept is something organisations work more towards for each day. This is understandable, since in theory, creating circularity sounds like something that is good for the environment, and even though that is the case in most of the practical cases as well, the challenge of applying it should be nuanced. After having conducted the interview study and having faced the fact that authorities emphasize the clash between circular economy and poison free environment a large barrier towards bottom ash was introduced. Authorities motivate their rejections of implementing bottom ash in i.e. road constructions with the risk of maceration. However, as the interviews presented in combination with the literature from Winberg (2019) where other nations were analysed, it became clear that bottom ash works well in road constructions. Therefore, the situation carries a complex contradiction. Using roads as an area of application, circular flows are created, and the results do not indicate any maceration into the environment. In spite of this, authorities do not prioritize the subject, which seems to be the consequence of few resources and other priorities. Thus, the comprehensive complexity, in combination with the fact that the material is used in other nations but not reused in Sweden, which also contributes to the complex picture of bottom ash in combination with circular economy.

The combination of information from interviews and for example, from Perey, Benn, Agarwal & Edwards, (2018) puts light upon an interesting take on the material. The incentives of creating circular economies are just as important as the incentives of using bottom ash in areas outside landfills. Adding the information from the different interviews it gets clear that it is necessary for those who aim to implement the material in new areas, that using circular economies as an argument is not enough. That particular reason needs to be broken down and analysed further. If it is not economically profitable and not possible to apply circularity in practice, motivating the usage for any organisation becomes difficult. Even though, it was not directly mentioned in the interviews, when analysing them it became clear that the practical applicability of circular economies may be an additional barrier towards implementing bottom ash outside landfills.

5.1.2 Lack of standard

After the interview data collection, it became clear that the main barrier towards a solution for bottom ash, is the lack of standard with clear directives of how to work with the material from the Environmental Protection Agency. The reason why there isn't a standard in their handbook is a question of incentives and prioritization from the Swedish Environmental Protection Agency. According to the interviewees the Swedish Environmental Protection Agency considers that they have more important areas to prioritize, but a standard would be the solution to many of the total problems.

Without a clear standard it will also be hard for the contractors to get enough of incentives to use bottom ash because of all the uncertainties regarding the authorities and their willingness to accept the material. This is also closely related to the main challenges regarding bottom ash, discussed by Hansson, Hålldal, & Van Praagh, (2017).

If a standard is created with clear directives on how to use bottom ash within different construction works, it would provide authorities with guidelines and information of how to use bottom ash inside various constructions. The current situation in which no information about bottom ash is placed inside the authority's handbooks and there are unclear incentives to prioritize the material, could be supported by the development of a standard which can support the creation of new incentives to use the material.

As the County Administrative Board described in an interview, today authorities do not dare to accept applications for the use of alternative materials where there are environmental uncertainties around. Therefore, the precautionary principle is almost always applied, where authorities rather say no to usage than yes. This was also confirmed by the City of Gothenburg, who also highlighted that it is the lack of standard that makes their acceptance towards accepting alternative materials very low. All of this can be related to what Hansson, Hålldal, & Van Praagh, write in their report (2017), where they highlight the challenges with bottom ash. Technical and environmental challenges that do not have any standards that can be followed, are aggravating the process for organisations like City of Gothenburg and the County Administrative Board to make decision, which they emphasize in the interviews.

5.1.3 Additional barriers towards implementation

Moreover, another barrier towards bottom ash is the major lack of knowledge from contractors and authorities on how the product could be re-used. To create incentives to use the ash, the authorities must also have their own knowledge that it can be used within constructions. It is not enough that it is only stated among some authorities that it is a good material. All organizations must therefore have their own picture of how bottom ash can be used outside landfills, and how they can gain from the creation of new alternative solutions. From the interviews, it was also clear that some of the organizations were not fully aware of the consequences of not finding an alternative solution to the material. The risk with end-covered landfills and all the consequences it brings to the entire waste and construction industry are important to consider. Moreover, if all the authorities and contractors would instead have the same picture of the fundamental problem as well as knowledge of how bottom ash can be used outside landfills, it might also affect the willingness and incentives to find a solution.

Lastly, the interviews showed that the variations in incentives also contribute to a barrier for bottom ash. Historically it has been the variations in incentives that contribute to how much work and capital the key partners are willing to risk to get the product out on the market. Today, it is the Swedish Waste Management Association together with the incineration plants that are the partners that work most proactively to find alternative usage for bottom ash. This is because they are the ones who have the biggest incentives in regard to soon fully covered landfills and hence a large risk of costs in terms of deposit fees and taxes. The fact that the Swedish Transport Administration or the interviewed contractor does not work as actively with the issue, since they do not have the same basic incentives and value proposition to work towards a solution. Of course, as mentioned they all are positive for innovation, and in the long run might as well be affected in terms of demands of recycled materials inside road construction. But today, they do not have the reasons and incentives to spend capital in an area that is not of their highest prioritizing.

5.2 ACTORS RELEVANT FOR IMPLEMENTATION OF BOTTOM ASH?

Regarding the actors who are involved in the implementation of bottom ash in areas outside landfills, all of them are presented in Business Canvas Model and also how they relate to each other. However, the interdependency between could be discussed further. When several actors, as in this case, impact the decision making towards usage of bottom ash and implementation of recycled materials into a circular system the whole situation becomes complex.

As figure 5 in the empirical data illustrates, one way to go is actually to reach as high as possible – the government. They are the ones who let the Swedish Environmental Protection Agency know what to focus on, as well as they are the ones with most power. Therefore, when the incentives now are increasing, the government might prioritize this issue in a larger extent than it is today. As mentioned by Gröndal & Svanström (2010), circular economy is a cornerstone in sustainable development and both of these concepts are something that the Swedish government wants to work with. With this in mind, the Swedish Waste Management Association, who are the ones performing most of the lobbying, could try a different

approach. At the moment, they are trying to influence the Swedish Environmental Protection Agency, when looking at another level might be more beneficial for their work. Because, even though the government does not work continuously with the issue, they still possess a lot of influence over the decision-making process. Which in turn, contributes to the complexity of the situation.

However, looking at the other authorities like the County Administrative Board and the City of Gothenburg, influencing them could also be another approach. Even though they do not have as much power as the Swedish Environmental Protection Agency when it comes to deciding what areas to prioritize, they in their turn might be able to influence other authorities if they push the issue for those organisations. This approach does probably contain a lot of lobbying and it probably needs a lot of pressure from contractors who are willing to try the material. If they can present several cases for the County Administrative Board and the City of Gothenburg, these authorities might be able to influence what issues the Environmental Protection Agency Prioritize, if they can spot a trend that these questions will continue to appear. One obstacle with this approach though, is what is mentioned by Hansson, Hälldal, & Van Praagh, (2017). They discuss the two main challenges related to bottom ash which are environmental impact and technical demands. These are both factors that the County Administration Board and the City of Gothenburg feel are difficult for bottom ash to achieve, and therefore, the material is often rejected from these authorities. This became clear from the interviews, and in the relation of the County Administrative Board and City of Gothenburg to the lobbying work, these demands might have too much of an impact for the material to be implemented.

Regarding the complexity of the situation, the fact that there are several actors who have the power to make decisions but very few who have the knowledge that is needed to make approvals, aggravates the situation. It became clear from the interviews that it is easy to make excuses by referring to the lack of standard, while in practice the amount of decision making authorities themselves actually could be seen as part of the issue. Bottom ash is a material that appears at many different actors, and by existing in that kind of environment, one interpretation of the problem is that it is more difficult to deal with the implementation process. In addition, as mentioned, it is easier to avoid the issue and just refer to another authority when decision regarding bottom ash need to be done. This is also related to what Lacy & Rutqvist (2015) emphasizes, that the lack of incentives is in some cases too comprehensive for some organisations, which goes for both authorities and companies like contractors.

5.3 WHAT IS NEEDED TO DEVELOP A BUSINESS MODEL FOR A NEW MATERIAL IN THE RECYCLING INDUSTRY?

Developing a business model is a complex design that requires a broad knowledge of the different aspects the new product is related to (Verstraete & Jouison-Laffitte, 2011). For instance, in order to create a business canvas model, it is required that the organization has good understanding of the materials characteristics and moreover the ability to carry out a

comprehensive mapping of the product. Here, for example, it must be examined which actors are involved, distribution channels and what value the product can create for the organization. Hence, to understand where the value for bottom ash is found and what focus areas should be prioritized primarily.

To analyse the results from the interviews further, a SWOT analysis was used. The SWOT demonstrated which problems that were related to material of bottom ash based on the current situation. What was interesting to conclude is that the threats and weaknesses that the SWOT demonstrates most likely will be resolved if a Standard from the Swedish Environmental Protection Agency had been implemented. As previously mentioned, a standard can most likely prevent areas such as lack of knowledge among authorities as well as preventing the risk of not finding new areas of usage for the material because of the new easier way of handling of the material due to the clear guidelines it will provide. In the area of threats, the lack of incentives was pointed out, which also can relate to the lack of standard problem. With a standard, stronger incentives among contractors will be implemented to use bottom ash inside their construction due to hopefully new acceptance among authorities to use the material. The situation can be summarized by the fact that the issues for bottom ash regarding its weaknesses and threats could be solved and hence the daily situation could be transferred into the categories of opportunities with economic profitability, circular economies and resource savings. A standard from the Swedish Environmental Protection Agency will most likely be the main factor toward this change. Hence the SWOT-tool can also work as a helping tool when creating a business model for a material. It can help seeing what the current situation looks like with all the threats and weaknesses, as well as seeing what opportunities a product can have if the current situation is solved.

As mentioned in the theory by Ellen MacArthur Foundation (2013), a circular business model can also imply a radical change for an organisations business approach. This is also strengthened by Lewandoski (2015), who believes that the creation of circular business models is based on the prediction that organizations must change their business approaches to extend a product's lifetime before it is finally consumed. Regarding bottom ash, the previous strategy for the ash has been to place it as a construction material on landfills which has ended the circular loop for the material for years. When creating a new business model for the ash, a totally new business approach and circular thinking will be required to find the new sustainable solutions. This is also linked to how Geissdoerfer, Savaget, Bocken & Hultink (2017) describe that organizations have realized that the old way of producing, using and throwing away garbage will not succeed in the long run, and change in our behavioural systems will be crucial. Therefore, by finding alternative solutions outside landfills for the ash, involved organizations will have the opportunity to re-use existing material, and at the same time prevent the ongoing extraction of valuable resources, which are not sustainable. So, to develop a new business model for a recycling material, there must be a strive for business flexibility when creating the new business approaches. Otherwise, it will be difficult to see the new solutions.

Another interesting part to discuss are the different business tools and models that is highlighted in this thesis. As mentioned by Teece (2010), Valenturf & Jopson (2019) and Despeisse, Ford & Viljakainen, (2015), there exists a lot of different business models with various focus. For example, the recycle and reuse business model, the freemium business model and the life extension model would probably have a hard time being able to be applied on the bottom ash case as they do not penetrate as deeply into the material itself but are rather more theory oriented about the purposes of profitability, reuse and recycle as well as digitalization and marketing. For example, the business model of recycle and reuse and the life extension model discuss how resources can have a longer consuming lifetime through recycling as well as different ways it can be implemented on the various products. Regarding bottom ash, they are interesting to mention because it is exactly what the organizations want with the ash regarding to recycle and extend the product lifetime in order to reuse bottom ash outside landfills. But considering how the implementation of bottom ash outside the landfills should be done, it is difficult to use the models since they do not analyse deeply enough into the material regarding everything it affects and what potential bottom ash could have.

However, with help of the canvas method, this study has mapped important parts and value propositions for the bottom ash. With these highlighted segments the recycling industry should be able to create a new business model for the bottom ash. A model that does not exist today, but with help of the canvas business tool, it can be created in the future to find values in using the ash outside landfills.

6 CONCLUSION

This master thesis has been conducted in order to present an overview of the situation today regarding bottom ash, and for what needs to be done for implementation of the material in areas outside landfill. The aim was to use a business view and see how different models can help the implementation process. In addition, how all of this contributes to circular economy have also been one of the reasons for executing this project. For concluding the master thesis, the research questions now work as a foundation.

6.1 WHAT ARE THE BARRIERS FOR USING RECYCLED MATERIALS (I.E. BOTTOM ASH) IN AREAS OUTSIDE LANDFILLS AND FOR CONTRIBUTING TO CIRCULAR ECONOMY?

For using bottom ash in areas outside landfills, it has become clear that there are several barriers. The most obvious and most comprehensive one is the lack of standard for knowing how to deal with the material. The fact that there are no guidelines or directives that explain how the material should be handled in for example road constructions makes it difficult for supervisory authorities to approve usage of the material. Knowing this, contractors hesitate and choose to work with other materials instead. Their incentives towards trying bottom ash are too few today. Even though a lot of research points towards that both the environmental demands and the technical demands a road needs to fulfil are achieved by bottom ash, the process of approving the material is still very complex. It is first and foremost the Swedish Environmental Protection Agency who is mentioned by the interviewees. It is they who can include bottom ash in their handbook for usage of alternative materials in road constructions, and therefore also they who needs to act upon the issue. Related to this is also the lobbying work from the Swedish Waste Management Association. They are trying to influence the Swedish Environmental Protection Agency and are pushing for them to create directives for the material. This is performed with the hope of in the end creating circular flows and thereby also circular economies for the material.

Other barriers that also affect the implementation of bottom ash in areas outside landfills are for instance variation of incentives and the lack of knowledge among relevant organisations. They are slightly related to each other and have to do with the fact that neither authorities nor contractors have the incentives that might be needed for them to start using the material and in that way also speed up the implementation phase. In addition, as the situation looks today, several organisations would not know how to do it either, even if they had the right incentives.

6.2 WHAT ACTORS ARE INVOLVED, AND IN WHAT WAY CAN THEY INFLUENCE A BUSINESS MODEL?

In the process of creating a business model over bottom ash, several actors are involved. As mentioned in the paragraphs above, the Swedish Environmental Protection Agency is an important actor, since they can create guidelines for the material that other authorities like the County Administrative Board and the City of Gothenburg can refer to when they act as supervisory authority. In those cases, today, they are in need of having some guidelines or directives so that they know whether they should make approvals or rejections when a contractor wants to use bottom ash, given the specific conditions there are for every specific case. Furthermore, contractors, incineration plants and the Swedish Waste Management

Association are also actors who have an impact on the implementation of bottom ash and in that way also influence a business model. Contractors since they are the ones who actually uses the material. Incineration plants, since they are creating the ash in their incineration process and thereby also owns the issue of finding areas of use. Lastly, The Swedish Waste Management Association since they are representing the incineration plants, they are helping them trying to find new areas of use.

6.3 WHAT IS NEEDED TO DEVELOP A BUSINESS MODEL FOR A NEW MATERIAL IN THE RECYCLING INDUSTRY?

To create a business model for a new material in the recycling industry, it will be important to have a broad understanding of what the daily situation regarding barriers and opportunities looks like as well as all the different actors and their variations in incentives.

For an organization to develop a business model for a new product it will also be crucial that the organization for the new product has a clear view of what value proposition the company can produce from the new product. This, to know how much time and capital they may be willing to spend to get the product out on the market.

Utilities that can be used to create a new business model can be a Canvas model, which gives organizations an extensive picture of all the actors, processes and what value proposition the product can contribute with to the company. Other tools that also give a good view of the obstacles and the opportunities regarding the new product is a SWOT analysis tool, which demonstrates where the major barriers exist, but also to what the possibilities and opportunities the new product can introduce.

7 SUGGESTIONS FOR FUTURE RESEARCH

This study has focused on the waste material bottom ash and how it can create new values by using business models. The master thesis has only focused on authorities and their views on the material regarding barriers and what they see for opportunities to implement bottom ash in constructions outside landfills. However, the work has not focused on the economic aspect or on how legislation looks like in other nations. To examine the economics regarding transportation and other logistical challenges would also be an interesting to investigate in future researches in terms of implementing bottom ash.

Another interesting point of view refers to the burnable waste that is sent and combusted inside the incineration plants. As mentioned, bottom ash is a rest material from the incineration plants and hence mainly consists of ashes from the burnable waste and materials that have not been combustible inside the incineration plant. It would be interesting to do future research and develop a business model regarding the burnable waste material that is sent into the incineration plant. This to analyse the ingoing waste flows into the incineration plant and moreover try to make it as pure as possible from non-burnable materials.

Logically, if the amount of non-combustible material that is sent to the combustion plants is decreased, the amount of created bottom ash from the incineration plants must be reduced. If the industries were to overcome this problem, which also is the origin of the problem concerning bottom ash, then a large part of the bottom ash problem should be gone since less amounts of bottom ash would be created.

8 REFERENCES

8.1 BOOKS & JOURNAL ARTICLES

Antikainen, M., & Valkokari, K. (2016). *A framework for sustainable circular business model innovation*. *Technology Innovation Management Review*, 6(7)

Bell, E., Bryman, A., & Harley, B. (2019). *Business Research Methods* (Vol. 5). Oxford: Oxford University Press.

Despeisse, M. A. Viljakainen, S. Ford, (2015). University of Cambridge

DeWalt, M. K., & DeWalt, R. B. (2010). *Participant Observation : A Guide for Fieldworkers* (Vol. 2). Plymouth: AltaMira Press.

Frishammar, J., & Parida, V. (2019). Circular business model transformation: A roadmap for incumbent firms. *California Management Review*, 61(2), 5-29.

Geissdoerfer, M., Savaget, P., Bocken, N. M., & Hultink, E. J. (2017). The Circular Economy—A new sustainability paradigm?. *Journal of cleaner production*, 143, 757-768.

Golafshani, N. (2003). *Understanding Reliability and Validity in Qualitative Research* (Vol. 8). Toronto: The Qualitative Report.

Gröndahl, F & Svanström, M. (2010). *Hållbar utveckling: En introduktion för ingenjörer och andra problemlösare*. Chalmers: Studentlitteratur.

Hammersley, M. (2003). *Dilemma Qualitative Method : Herbert Blumer and the Chicago Tradition*. London: Routledge.

Hansson, N., Hälldal, A., & Van Praagh, M. (2017). *Nyttiggörande av slaggrus i utanför deponier*. Energiforsk.

Lacy & Rutqvist. (2015) Waste to Wealth - The Circular Economy Advantage,

Lewandowski, M. (2015). Designing the Business Models for Circular Economy—Towards the Conceptual Framework: Institute of Public affairs, Faculty of management and Social Communication, University of Lojasiewicza, Krakow.

Lélé, M. (1991). World Development; *Sustainable Development: A critical view*.
Pages: 607-621

Linton, J. D., & Jayaraman, V. (2007). A framework for identifying differences and similarities in the managerial competencies associated with different modes of product life extension. *Journal International Journal of Production Research*.

Maxwell, A. J. (2013). *Qualitative Research Design An Interactive Approach* (Vol. 3). Los Angeles, United States of America: SAGE.

Osterwalder, A., & Pigneur, Y. (2010). *Business Model Generation A Handbook for Visionaries, Game Changers, and Challengers*. New Jersey: John Wiley & Sons.

Perey, R., Benn, S., Agarwal, R., & Edwards, M. (2018). The place of waste: Changing business value for the circular economy. *Business Strategy and the Environment*, 27(5), 631-642.

Pickton, W. D., & Wright, S. (1998). What's swot in strategic analysis? *Briefings in Entrepreneurial Finance*.

R, La Grace, B. Enis, A. Parell. (1977) Business Horizons: *Extending the product life cycle*.
Pages 46-56:

Teece, J. (2010). Long Range Planning; Business Models, *Business Strategy and Innovation*.
Pages 172-194.

Urbinati, A., Chiaroni, D., & Chiesa, V. (2017). Towards a new taxonomy of circular economy business models. *Journal of Cleaner Production*, 168, 487-498.

Valenturf, A. Jopson, J. (2019). Science of the total environment; *Making the business case for resource recovery*. Pages 1031-1041.

Verstraete, F., & Jouison-Laffitte, E. (2011). *A business model for entrepreneurship*. University of Bordeaux, France

Vogt, O. P., Gardner, C. D., & Haefele, M. L. (2012). *When to Use What Research Design*. New York: The Guilford Press.

8.2 WEBSITES & REGULATIONS

Naturvårdsverket. 2019. Stöd I miljöarbete, Income, 2019-02-28

<https://www.naturvardsverket.se/Stod-i-miljoarbetet/Vagledning/Avfall/Avfall-eller-biprodukt/>

Naturvårdsverket, 2013. När avfall upphör att vara avfall. Income 2019-02-28

<https://www.naturvardsverket.se/Stod-i-miljoarbetet/Vagledning/Avfall/Nar-avfall-upphor-att-vara-avfall/>

Winberg, D. (2018). *Avsättning av Slaggrus: Möjligheter I Norge, Finland, Estland, England, Belgien(Flanders)*. Unpublished manuscript.

Sysav. (den 24 05 2019). *Sysav.se*. Hämtat från Welcome to Sysav: <https://www.sysav.se/en/>