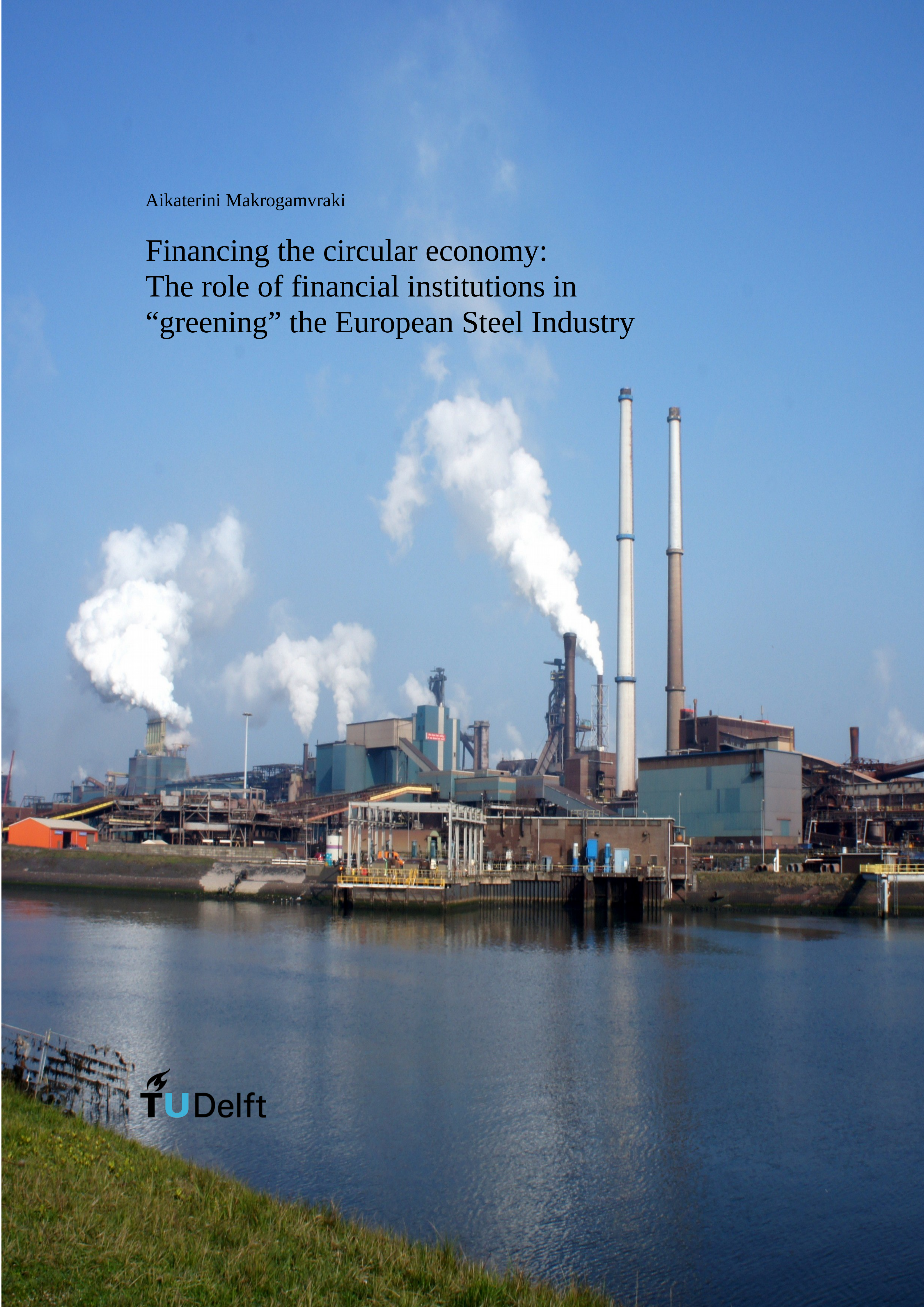
Aikaterini Makrogamvraki

Financing the circular economy: The role of financial institutions in "greening" the European Steel Industry



TU Delft

TU Delft University
Engineering and Policy Analysis

Financing the circular economy: The role of financial institutions in 'greening' the European Steel Industry

Name: Katerina Makrogamvraki
Student-no: 4906799

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1st supervisor: Storm Servaas
2nd supervisor: Bert Enserink
Company supervisor: Jeroen Westrik

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Preface

The last 6 months was special not only due to the development of this research and of the opportunity to be part of great team in ABN AMRO, but also due to the imposed COVID 19 quarantine. This period taught my that uncertainties can be coped with the help of the people in our life.

I would like to thank my external supervisor Jeroen Westrik for giving me the opportunity to be part of the team of Basic Materials in ABN AMRO, and for creating a great environment for me to learn and develop my research. I will be always grateful for the feedback on my work and the consistent guidance during my thesis.

Looking back to my time in the university, I was always lucky to be surrounded by amazing, inspiring people who helped me grow. I would like to thank Dimitri Karalekas for helping me to open my horizons during my bachelor degree.

From the very first class of Macroeconomics, I new that the only supervisor whom I would do my thesis with was Servaas Storm. I am really lucky, that I had this opportunity to work with a professor who was always there to support me with my academic tasks but most important to advice and help me grow as a person. It is a blessing to work with people that feel like family. I could not be more lucky on that and I am pretty sure that this period would have been way less fun and creative without his support. I would also, like to thank Bert Enserink who was always available for me during the master and during the thesis with critical and helpful feedback. Staying in the EPA program for a big part was due to his advice and for that I can not be more thankful.

This amazing period of the Master would not have been the same without my friends! I would like to thank all my friends from the EPA family, my two best friends back home and the "girls dinner" group. But there are two people who supported me through the whole trip of these two years! Together we laughed, faced hard times and we became a family. Elias and Fatima thank you for brightening my life!

I would like to thank my Dutch family Frouke, David, Sinne and Tonny for always supporting me. I would also like to thank Vaggelis for being always the voice of reasoning in my life. Mom and dad, nothing could have happened without

you! Also I would like to thank Age, for being my daily strength and the reason to always smile.

Executive Summary

The 22th of July 2020 is Earth Overshoot Day. This day marks the time that we (humanity) have exhausted the nature's budget for the year and our linear system of production and consumption will continue to operate during the rest of the year by running down the remaining resource stocks and over-emitting CO_2 in the atmosphere (Day, 2020). This linear-economy model is clearly unsustainable. Unlike the linear economic system, the notion of the Circular Economy constitutes a more sustainable model, which is based on the idea that the "goods of today can become the resources of tomorrow" (Ellen MacArthur Foundation, 2013).

This notion of a Circular Economy has been welcomed by the European Union and is an essential building block of the European Green Deal. With this ambitious and far-reaching policy plan, the European Union aims to become climate neutral by the year of 2050 (European Commission, 2019a). The change in legislation and policies within EU, will bring the energy-intensive industries (e.g. basic chemicals, iron and steel) in front of a radical and costly transition of their production processes that will affect their whole supply chain. Industries such as steel have the potential to reduce European emissions by 56% (300 $MtCO_2$) annually until 2050, if they adopted fully circular economy models. The steel industry, even though it has already taken steps towards adoption of circularity, is heavily affected by this institutional change.

In this research, the role of the banking sector in assisting the transition of their basic material clients, and specifically the steel industry, is examined. Our main objective is to answer the following research question: *How can the European banking industry be incentivised to assist their basic material clients and specifically the steel industry to move towards CE?* To be able to answer this question, a literature review was conducted to develop a basic understanding of the current institutions blocking and enabling the adoption of CE in the European steel industry. The results show that the European Union is actively showing interest in introducing policies, but the current Directives in many cases are not complete or mandatory creating a circular paradox, since even though steel is a quite circular material, the industry is not completely.

Using actor analysis, we next identify the main actors involved in this complex

issue and create an actors' inventory. The European Union, the European steel industry, the downstream producers (construction and automotive industries) as well as the banking sector, are selected as the main focus and are further analysed. The banking industry can and actively aims to play a role on the transition of the steel industry. The steel industry is a central part of the European economy and constant pressure from non-EU competitors forces the steel industry to be highly cost-efficient and innovative. The external competition coming from less sustainable non-EU producers makes it difficult for European steel producers to move to a more circular production model; policy measures are therefore needed to support the transition of European steel producers. Currently, within the EU inadequate legislation has led to the absence of strong secondary markets for recycled steel products, as well as made the EU a net importer of steel from less sustainable markets (e.g. Turkey).

To identify the bottlenecks that are blocking this transition of the European steel industry, the leakages in the current linear system are identified. This resulted in the conclusion that a change in steel production methods is necessary and that in the long term there is a need for more circular technologies in European steel manufacturing. The case of Tata Steel IJmuiden (TSIJ) with their pilot technology HIsarna is used to outline a circular base case scenario for steel production and help identify the blocking bottlenecks. With the use of the institutional economics mindset, these bottlenecks are separated in three categories: Technical, Financial and Institutional constraints. We interpret each bottleneck as a hypothesis concerning a factor that is hindering the transition of the European steel industry to a circular production model.

These hypotheses are then used in a series of interviews with selected actors from the banking, steel and policy sectors. Based on the empirical information collected in and new insights from these interviews, we arrive at a final, empirically-tested classification of the uncertainties and bottlenecks in the transition of the European steel industry to a circular-economy model. To cope with these uncertainties, a set of policies is proposed (a) to address the current open loops in the supply chain, (b) to deal with the uncertainties of the "transition period" until we have mature alternative technologies, (c) to help in the access of green finance and (d) to strengthen the European market.

Based on our analysis (including the interviews) we are able to answer the main question by proposing that to actively incentive the banking sector to assist their steel industry clients, the EU has to provide them with a clear, long- term policy that will help them assess the current sustain- ability performance of their clients. This way the relation of sustainability risk to the traditional risk of a client will be stronger, enabling the banking industry to be more selective in their collaborations. Moreover, by providing a tool like that, it will be easier for the bank to build know-how and act as mediator to start a conversation between the steel industry and the institutional investors regarding access of the steel industries to green finance.

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Introduction

1.1 | Background

Our planet has limited natural resources and a specific limited capacity for regeneration. Our economies have grown so large relative to the Earth's eco-system that as a society we face the grand challenge of (potentially dangerous) climate change and increasing resource scarcity (Stockholm Resilience Center, 2020). To be able to ensure that we have enough food, water, basic materials and a stable climate, humanity has to deeply change the structure of production, consumption and energy generation in order to decouple economic growth from resource use. The focus should not just be to increase recycling, but also to prevent waste in the first place and to drastically increase the efficiency of resource use. What will be needed is a transition to a "circular economy" built on climate-neutral and circular products.

In contrast to the "linear economy" in which basic materials are used to create a product which after use ends up as waste, the circular economy is based on the assumption that "the goods of today can become the resources of tomorrow" (Ellen MacArthur Foundation, 2013). The concept has attracted the focus of governments, industries and researchers that try to explore the idea of an economy with closed material loops (Ghisellini, Cialani, & Ulgiati, 2016; Sauvé, Bernard, & Sloan, 2016). For example, the circular economy and resource management have been placed at the centre of the European Commission's European Green Deal, with proposals including a EU-wide model for the separate collection of waste and rules on minimum recycled content promising a step change in the EU's approach to resources and waste (Cole, 2019). The European Commission views building a circular economy as the number one priority of its Green Deal (Simon, 2020b).

By prioritizing the transition towards circular economy, main industries that have a negative CO_2 footprint must also adapt. Steel, is an industry that can be characterized as energy intense and quite polluting (Peters, Malfa, & Colla, 2019; Thollander & Ottosson, 2010). Despite its use in a variety of products, in the steel industry carbon emissions can not be avoided since carbon is steel needed during the production of liquid iron. Within EU and leading countries in the industry such as China, the governments and companies understand the urgency to address climate change and the responsibility of steel industry to reduce their CO_2 footprint. In the effort for change, banking sector as a crucial institution in society can also play a role. Banking institutions, except from providing lending services to their basic material clients, nowadays also try to build know-how, regarding how to help them transition towards a more sustainable production (de Jager, 2019).

1.2 | Problem Statement

This research project focuses on the role of financial institutions and banks in supporting and enabling the transition of steel to a greener circular production. Financial institutions are major players when it comes to change. The banking industry has the technical capacity and the institutional power to nudge or guide their clients towards sustainability. The focus of the research is on steel industries that are relatively energy-intensive and carbon-emitting. Our starting point is that steel is a circular material by nature (EUROFER, 2015), but steel industries are not.

1.2.1 | Academic Interest for the Research

It is interesting scientifically, to investigate how the institutions and requirements set by governments and the European Commission to move towards Circular Economy (CE) incentivize the banking sector to be part of and support this change.

To adopt circular values the steel industries might have to create new external collaborations, form new inter - firm roles, and change their norms. Moreover it is important to understand the bottlenecks and uncertainties that the steel industry may face during the transition as well as to understand the impact of the banking industry on the gradual change on their steel sector clients. Moreover, to gain insights on how established institutions help the creation of new regulations or enhance the transition towards sustainability.

For this research, CE (Circular Economy) and IE (Institutional Economics) theories will provide the conceptual frameworks within which we can identify the research gap as well as locate the analysis of the case. With the use of these topics of literature, a base- case scenario of a more circular steel industry will be designed. This case will be used as a conceptual benchmark to identify the real-world bottlenecks facing the steel industry. Moreover, with a series of interviews, this research will attempt to validate the key bottlenecks and identify the necessary steps to achieve the transition CE from the financial perspective as well as from an institutional-and-policy perspective.

1.2.2 | Practical Relevance of the Research

Besides the scientific relevance, the thesis results can also contribute to improving the processes and practices of ABN AMRO related to their involvement in bringing about a transition to a circular economy in the case of their basic material clients. Since there is need for change, the research can contribute on building a know-how, on what are the challenges in the transition and how they could be addressed and phased. Despite the fact that the thesis scope is developed around the European steel market and EU institutes, the results could be generalized and used for banking institutes in countries such as China that actively pursue the change to a more sustainable (circular) production.

1.2.3 | Societal Need for the Research

The grand challenge we face with the environmental crisis (Steffen et al. 2018) indicate that there is a societal need for research on the topic of CE that will assist policy and decision makers. To better describe this, the Three Stream Policy Window theory is used (Kingdon & Stano, 1984). According to Kingdon and Stano (1984), policy change is a result of a political, problem and policy streams. These streams, even if they are independent, they are all needed for a policy to emerge. Regarding ABN AMRO and their basic material clients, these streams co- exist and indicate that there is a societal need for a effective policy making that will allow the steel industry to move towards CE.

There is a political stream, derived from the concerns of policy makers and governing institutions that have set goals such as the Paris agreement (COP21) to incentivize companies to transition towards CE. The political stream is creating the problem stream. There are efforts for the creation of institutions that will incentivize big international companies such as ABN AMRO to move towards sustainability and promote lending to sustainable companies, but yet the change is not there and the steps taken so far do not indicate a big impact. There is a no clarity regarding the actual power of the established institutions helping the banking sector to establish sustainability KPIs for their clients.

The existence of a problem owner and of an established issue that needs further research and requires actions, leads to the policy stream. The current institutional frameworks do not seem to effectively result in clear incentives for the banking sector to push their clients towards CE. There is a lack of effective policies and frameworks that could mitigate the gap between the current institutions and the actual changes towards CE. Thus this research aims to bridge this gap.

1.2.4 | Circularity as a Grand Challenge

Our current economic system is based on linear production, since the rise of market (capitalist) economies during the industrial Revolution in the middle of the 18th century. This growth alongside technical innovation has led to better living standards and the continuous pursuit of more growth (Jones, 2016; Speth & Zinn, 2008). The economic growth in the mindset of the society is coupled with the current increase of production and consumption. The mindset of capitalism is pushing for a society that should produce products constantly, consume fast, through them away to by the new ones that are trending in the market. Thought, this behaviour has led to pollution of natural resources, depletion of resources and growth of waste. An indicator for this non sustainable mindset is the use of Gross Domestic Product (GDP) as a way to measure the wealth of a country. This measurement is connecting “economic success” with production. Though according to The Rio Declaration (Viñuales, 2015; Declaration, 1992) “the major cause of continued deterioration of the global environment is the unsustainable pattern of consumption and production”. So, we keep producing, to have a successful economy but at the same time we damage our planet (Speth & Zinn, 2008).

CE provides a mindset where the idea of re-usage and recycling is is embedded from the design of the processes of production, to the materials that will be used (Ghisellini et al., 2016). To be able to transition from the traditional linear economy to a circular economy, we need to change the society’s mindset, to pressure big corporations to adjust and create institutions that could assist the market to change. Since the issue involves urgency due to resource limitation and climate change and also because the issues involve multiple stakeholders around different sectors and countries, the transition to circularity could be characterized as a grand challenge.

1.3 | Scope

The issue of transitioning towards a circular economy is complex and involves a variety of actors. To narrow down the scope of this research, this research will focus on one particular sector, the basic materials (steel), and one specific financial institution (ABN AMRO). Steel is a resource- and energy-intensive industry with a large carbon footprint. Accordingly, turning this industry into a circular production and business model will be very challenging.

The bank ABN AMRO is selected, since they try to be innovative regarding the adoption of CE (Ghisellini et al., 2016). For ABN AMRO, it is an opportunity to explore how to decouple their business model as a bank from the operational and regulatory risks their clients might face due to climate change. Moreover, it is a chance to have an impact by helping their clients transitioning. Thinking about the circular economy is still in an initial phase, in which an institution such as ABN

AMRO can build knowledge and (a new) culture around the subject and then assist their clients and help towards the transition. Thus, this research project will add to this effort of creating know- how regarding the adoption of CE, using the case of the bank to obtain new insights and (hopefully) new answers.

1.4 | Aims and Objectives

The aim of this research is to create a background on what are the possible uncertainties that arise with the notion of circular, greener transition of the steel industry. This thesis aims to showcase that this is a complex issue that should be approached with a different non -“linear perspective”. The choice of the steel sector as an industry which will transition from being a traditional and important industry to a circular-economy model in the EU requires a multi- dimensional perspective. So, the conceptual framework of institutional economics, which emphasizes uncertainty, property rights and the interdependence of actors, as well as the theories of circularity that call for cooperation within the sector and between the industry and banks, is used.

Thus, the possible bottlenecks that might arise are studied from three different perspectives (technical, institutional, financial). The final aim is to highlight that for solving a complex, multi actor problem like the transition of an energy-intensive sector within a global setting involves cooperation of different sectors and different actors (EU, banking, industries) and a change in the way the policy makers approach it. Since it is a multiple- actor issue, we need to move from a linear thinking in one that understands the interdependence’s of circular market. Moreover, this thesis aims to provide a better idea of how different sectors view the identified bottlenecks as well as to give an advice regarding how can the banking sector helped (institutionally) to assist the steel industry in the transition.

1.5 | Research Question

The main research question is formulated as follows:

How can the European banking industry be incentivised to assist their basic material clients and specifically the steel industry to move towards CE?

This question has been divided in different sub-questions. These sub-questions will help to understand the important aspects of the research question, as well help to place the question into a larger context.

1. What are the current institutions blocking and enabling the adoption of CE in the European steel industry?
2. To what extent is the existing regulatory regime (in a European level) helpful to the transition to CE?
3. Who are the main stakeholders involved in the steel commodity chain? What are the stakeholders' interests when it comes to the transition to a CE? Specifically, what is the role of banks in the steel industry and how do banks perceive the necessity and feasibility of the transition to a CE?
4. What are the main bottlenecks, challenges and uncertainties that will arise on the transition of the steel industry from a linear to a circular economy?
5. How to cope with these bottlenecks, challenges and uncertainties created by the shift to new circular business models and markets?
6. What new institutions and policies could (and should) be introduced in order to assist steel companies to transit to CE production and business models? Which coalitions between stakeholders can be built in order to support the shift to a CE?
7. What can banks (like ABN AMRO) do in order to support and enable the transition of the steel industry to a CE model? How feasible and cost efficient is it for banks AMRO to actually choose to lend to industries that adopt CE?

1.5.1 | Methodology followed to address the above sub questions

1.5.1.1 | Literature Review

In this chapter the literature regarding the circular economy theory will be discussed and reviewed. Moreover, this chapter will discuss the way in which the institutional economics mindset can be made useful in the analysis of how to achieve circularity in the current linear environment. Furthermore, this chapter aims to answer the first two sub-questions of the report. Thus, the current institutions placed within the European Union regarding circularity as well as the specific directives for the basic material sector and the steel industry are analysed. This chapter also assesses to what extent the current institutions are helpful in bringing a greener transition. Moreover, we will also briefly discuss the role of the European Steel industry.

1.5.1.2 | Stakeholders

To better understand the basic actors (players) involved in our complex problem-setting, a brief actor analysis is made in Chapter 2. The analysis highlights the principle actors involved and introduces more in depth the steel industry with the objective to answer the third sub-question of the report. Moreover, the banking sector, the downstream producers that use the steel products and the European Union are identified as key actors . The chapter aims to introduce the basic actors and give a better understanding of the fact that there are interdependencies between them regarding the transition to manage the Paris COP21 Agreement goals.

1.5.1.3 | Method and Base Case Scenario

The third chapter aims to give an understanding of the current linear steel production and to identify the leakages that do not enable a more circular production. This information will provide the necessary background to identify key points of transformation that can help towards moving to circularity. From these points it is clear that for a circular production changes in the technology used currently, investments and institutional changes have to be made. To better understand the issue the example of Tata Steel IJmuiden (TSIJ) is used, to create a comparison between the current linear production and two different scenarios that are more circular. This case study helps to identify possible uncertainties and bottlenecks that might arise due to this transition. These uncertainties and bottlenecks are assessed and classified in a table that is used alongside the Tata Steel IJmuiden (TSIJ) scenarios as a point of reference and dialogue in the stakeholder interviews.

1.5.1.4 | Interviews

To complete the research and validate the results from the third chapter a series of semi structured interviews is realised. In the interviews specialist from different departments of the banking sector, the steel industry and policy making participate. In the interviews the classification of the identified bottlenecks and uncertainties and the case of Tata Steel IJmuiden (TSIJ) is showcased. This creates a base for a dialogue and enriches the results of the research.

1.5.2 | Discussion

In this chapter the results of the interviews are analysed. The common aspects and views that are identified in the interviews are highlighted and the table with the bottlenecks that was developed in the third chapter is finalized. Moreover, in this chapter an advice on how to cope with these uncertainties as well as an answer in the main question is given.

1.5.3 | Conclusions

This section provides a summary of the research. The original aims and objective and whether these have been met should are discussed. It includes a section with a critique and a list of limitations of the proposed solutions. Future work that could help is also described.

1.6 | Structure

The Figure 1.1 shows the research flow that will be followed in this paper.

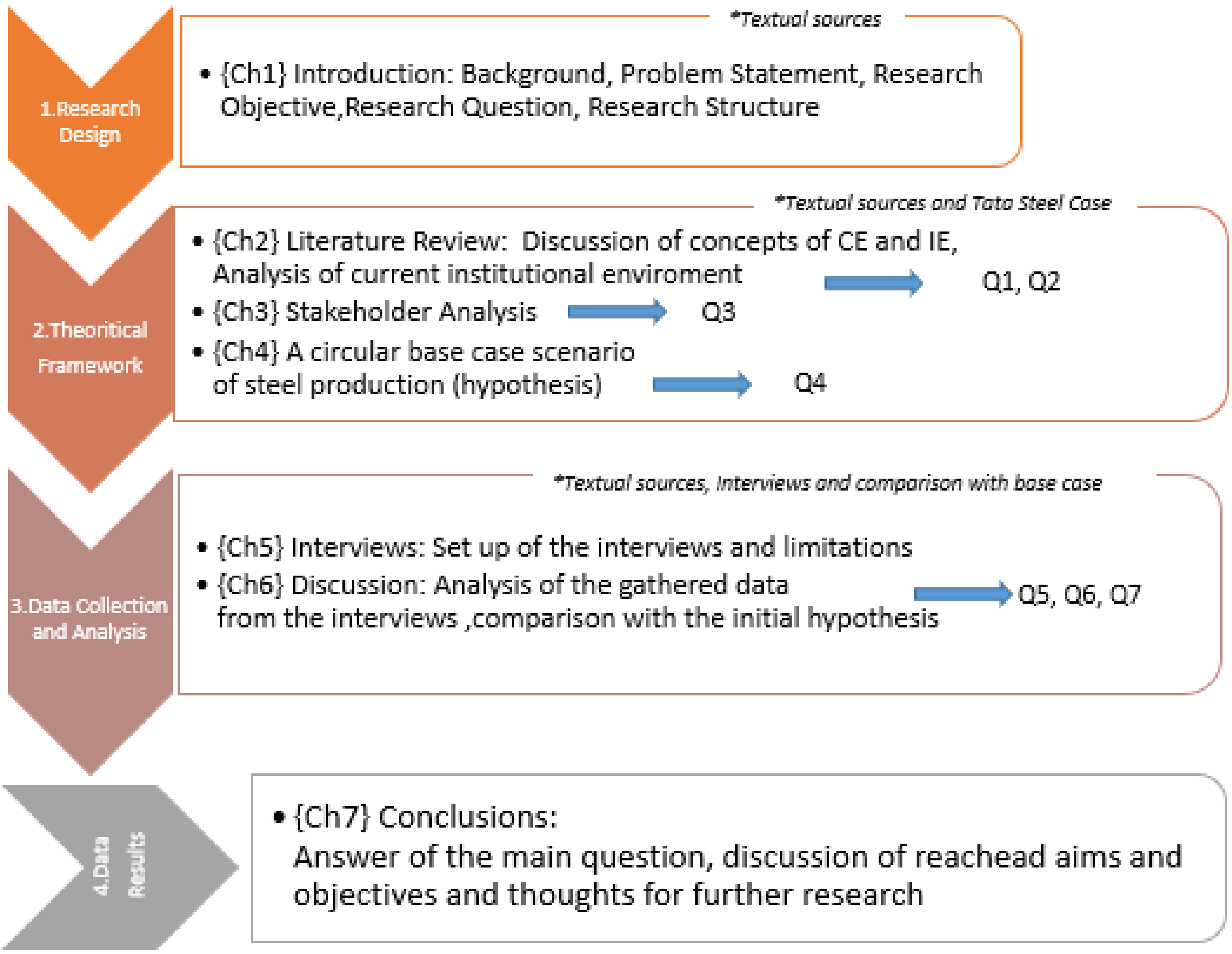

Figure 1.1: Research Flow Chart

2

Background & Literature Overview

This chapter reviews the scientific literature that will give a theoretical background to the questions that are addressed in this research. Moreover, the findings of this review will provide an answer to the first two sub-questions of the research and assist in the design of a base- case scenario of a circular steel industry. Looking into a case of a more circular steel industry will help us to identify key bottlenecks that are created through this transition. These bottlenecks will be assessed in the further analysis of the research and will be informing the semi-structured interviews that will answer the rest of the sub-questions.

2.1 | Research Approach

To be able to set a theoretical background regarding the connection of Institutional Economics (IE) and Circular Economy (CE), as well as understand the current state of the art of the issue, a literature review is conducted based on research on scientific articles. To gather articles and get a better understanding of the issue the platforms Google Scholar, Web of Science and Scopus are used. Moreover, to enhance and optimize the research of the scientific papers, the following keywords are used: Circular Economy, Institutional Economics, Basic Material, Circular Economy on Banking sector, economic value, steel industry and circular steel production. Moreover, to select initially relevant published articles the following categories are used:

- Relevant topics such as CE, IE, principals, limitations, circular industries, steel industries, industrial ecology
- Chronological order
- Challenges of CE adaptation
- Papers that group together the notion of CE and IE

2.2 | Circular Economy

2.2.1 | Origins of the theory

The theory of Circular economy has been explored from different schools of thoughts. Initial contributors on the circular economy thinking include Boulding (1966) and Pearce and Turner (1990) with a focus on environmental economics, inspired from the idea of (Boulding, 1966) about a circular system that will maintain the sustainability of human life on Earth, introduced the idea of a shift to circularity. The two environmental economists (Pearce & Turner, 1990) introduced a framework a framework founded upon the laws of thermodynamics about energy and mater degradation (Georgescu-Roegen, 1971), which can be used to analyse the transition from a linear economic system to a circular.

The notion of Circular Economy can also be found in the General Systems theory (Von Bertalanffy, 1993) and in Industrial Ecology (Ghisellini et al., 2016). General Systems Theory is proposing that the organisations are part of their environments and their interdependencies with it, so research on each organisation in isolation (i.e. disconnected from its environment or eco-system) is not useful. Thus, the behaviour that can be seen in an organisation or an economic agent should be researched in light of the relationships and interdependence's arising within this system and among the other economic agents (Ghisellini et al., 2016). So, the theory of General Systems is explaining that there is a need for a holistic system thinking, where notions such as organisational learning and development are important (Jackson, 2003).

Industrial Ecology, has a different view regarding the system. In this school of thought researchers analyse the industrial system and the environment where the systems belongs to, as one whole. This system has flows of material, energy as well as information and is also characterized and affected by the resources and services from the Biosphere (Chiu & Yong, 2004). Industrial Ecology promotes a thinking on how to alter linear production thinking in its bases by been proactive and use Eco friendly production methods and material as well as elaborate waste management planning (Chiu & Yong, 2004; Ghisellini et al., 2016). The main goal behind this theory and its approach regarding circularity, is the creation of a production with closed cycles of materials and energy usage. The goal is to effectively flow back to the industrial process materials that in a linear production would end up as a waste. A good example is the technology of Carbon Capture and Storage where the emitted CO_2 from an industrial process can be stored and then reused. The figure 2.1 depicts the thinking of how the theory can transform manufacturing processes to more cyclical. Though manufacturing processes is hard to individually reach zero waste and emissions processes, thus there is need to view them as a part of a wider system (Ball, Evans, Levers, & Ellison, 2009).

CE is using the above theories on a macroeconomic level, to develop a new model of economic development (Chiaroni & Chiesa, 2014). CE is promoting the redesign of the way production and distribution processes are happening and to create more value of the resources that are used. The main goal of the theory is by a closed loop economy to decouple economic growth from the use of resources (UTS, 2015). CE is based on three main pillars 3R's, namely Reduction, Reuse and Recycle (Yong, 2007; Reh, 2013; Su, Heshmati, Geng, & Yu, 2013). Ellen MacArthur Foundation (2013) built on those pillars and added the following ones:

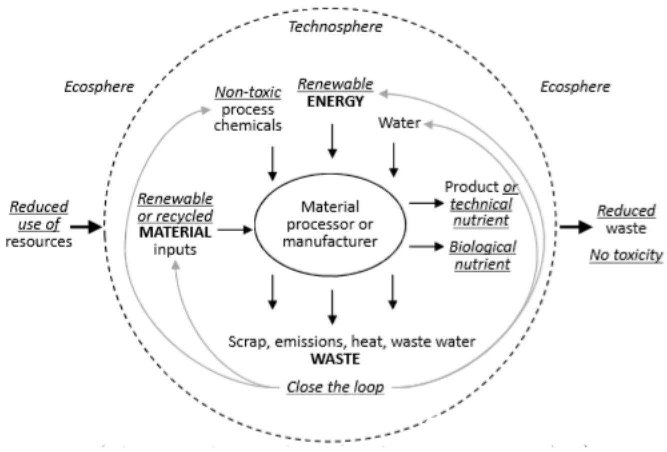

Figure 2.1: Manufacturing ecosystems model: from linear to quasi-cyclic resource flow through a process or system .(Despeisse et al., 2012)

regenerative design[1], performance economy[2], cradle to cradle[3], bio-mimicry[4] and blue economy[5] (Ghisellini et al., 2016).

[1]The regenerative design is a method that is used already in the agriculture. John T. Lyle developed concepts on how this notion can be used in more concepts(the Ellen Macarthur Foundation, 2020)

[2]The approach of the performance economy if born from W. Stahel and represents four main goals:product-life extension, long-life goods, reconditioning activities, and waste prevention. Moreover, it emphasises on the fact that our economy should swift its focus on providing services that selling products, s 'functional service economy' or else performance economy (the Ellen Macarthur Foundation, 2020).

[3]This a design approach that proposes that all the materials that are involved in the development of a product (industrial and commercial) should be viewed as nutrients that are either technical or biological. This way the design of products is centered on how to make effective designs for products that mitigate their environmental impacts through efficiency (the Ellen Macarthur Foundation, 2020)

[4]This notion is a new theory that tries to mimic the best designs made by nature and applie them in product design. According to Benyus (1997) 'a new discipline that studies nature's best ideas and then imitates these designs and processes to solve human problems'

[5]Blue economy is an open source movement that developed hands on case studies that was given to the Club of Rome. In the official manifesto of the movement is stated that 'using the resources available in cascading systems, (...) the waste of one product becomes the input to create a new cash flow'(the Ellen Macarthur Foundation, 2020)

Although, the notion of CE is engaged from scholars as an eco- effectiveness solution (Ghisellini et al., 2016), there are still questions regarding how effective this theory is in reality and if is economically feasible (Toxopeus, De Koeijer, & Meij, 2015). Also, since the adoption on CE involves a lot of changes in the current Linear industrial model, it is a multi- stakeholder issue. There is the argument that there are financial issues and different types of inter-dependencies such as property rights, arising with the adoption of CE (Schulz, Hjaltadóttir, & Hild, 2019). For example one of the issues is the need for joint investments that is required from the various stakeholders to facilitate the necessary technological and organizational innovation for the adoption of CE (Schulz et al., 2019).

2.3 | Institutions

2.3.1 | Connection of Circularity and Institutions

For Pearce and Turner (1990), there are three basic ecological functions that are pillars of the CE transition and that should be also priced. These three functions are: provision of resources, life support system, sink for waste and emissions. The issue is that the benefits provided by resources, life-support systems and sinks are not priced; these eco-system services are 'free' (no one has to pay for these services) and when services or goods are 'free', they will be over-consumed. Our economy does not feature a market where environmental "commodities" such as water and air quality can be priced (Ghisellini et al., 2016). According to Costanza et al. (1997) an estimation under deep uncertainty that represents a minimum of the value of the ecosystem services (outside of the market) is is in the range of US$16-54 trillion (1012) per year, with an average of US$33 trillion per year.

Moreover, as it was mention above, the transition is complicated and is a multi-actor process. As it is depicted from the literature (Fischer et al., 2017; Whalen & Whalen, 2018), for an organization to be able to adopt CE is a challenge since it requires cooperation with different stakeholders (Wassenaar, 2015). That means for example that an organization such as ABN AMRO would have to face a great deal of inter-dependencies (Korhonen, 2001; Gallopoulos, 2006) to be able to support their clients on moving towards CE.

A main challenge for the company would be to arrange collaborations and to coordinate relationships between their basic material clients. Another key challenge concerns the issue how to manage institutions such as property rights and risk sharing in a non-linear (circular) environment[6].Furthermore, since many clients of the bank that belong to the steel industry are located outside the EU they (steel industry) comply to different standards. So it will be a challenge to push the steel producers to CE and try to help them adjust in more sustainable standards and regulations like the ones coming from the Dutch government the EU. Moreover, another issue is that these inter-dependencies should be managed in a non-linear environment (Fischer et al., 2017). Thus there is need for change on institutional level. According to Schulz et al. (2019) "an institutional perspective allows to understand changing routines and emerging practices".

Due to these characteristics, the analytical apparatus of Institutional Economics will be useful as an instrument to help us understand the process of adaption of CE and institutional change. Our mindset was built based on the concepts and values of linear (growth) economics. To be able to engage a new reality where resource use is decoupled from production and eco-systems services are priced, there is need for usage of more theories such Institutional Economics. The differences between these two theories is that traditional (linear) Economics regard some variables as "historical" and therefore constant, that in the theory of Institutional Economics are crucial and an integral part of them (Dopfer, 1991). Thus, Institutional Economics could be an approach to help us understand the transformation of the current institutions.

The issue of the transition of the linear steel industry towards a greener, circular economy is complex and it involves different dimensions and many stakeholders. Institutional Economics can be used to help the design of institutions of socio -

[6]An industry that produces steel and follows a circular business model strives to integrate ownership and take responsibility for end of life disposal of their products. That in a linear environment is hard since ownership is affected by legal accession. That means that the steel that is used from the construction sector (a downstream producer of this steel industry) is entitled to the steel used in their production (real estate). Thus, the steel industry looses technically the responsibility of the end of life disposal. Another example is the co-sharing and sponsoring of new technologies. In cases like that, what is a collateral damage for the banking institution might have to be redefined

technical systems. The term institutions has various meanings in different disciplines. According to Hodgson (2006) institutions can be defined as systems of established and prevalent social rules that structure social interaction.

Institutional Economics provides us with concepts and notions which are very relevant to analysis of economic regulation in the steel industry. We can specifically point out the following notions:

- The allocation of fixed costs (associated with developing a new circular steel production method) among actors/stakeholders
- The allocation of property rights to the new technology (or innovation)
- The identification and management of interdependencies and externalities.

These notions can help identify the main bottlenecks and uncertainties that arise from the transition of the steel sector to a circular production.

Using the upper level of the alignment scheme 2.2, we can focus on the change of technological architecture and the general rules (institutions) that determine important economic feature in the changing sector. The alignment of institutions with the new technology up comings depends on the goals of the users (Büscher et al., 2018). To achieve a sustainable more circular supply chain there is need for specific choices for the best technology and the institutional changes to support these choices. In the case of circularity in the steel sector using the scheme, consequences of fundamental technological changes make the sector to have to change from a natural monopoly into an open infrastructure. For the steel industry to achieve circularity, there is need for coordination and cooperation with the whole supply chain of steel. Vertically integrated closed infrastructures[7] (and a steel industry could also fit in this description) have to be unbundled into complex systems with interconnected functions (Kim & Horn, 1999).

[7]Vertically integrated industries are the ones that a company is also the owner of the supply chain. In this type of supply chains where vertically integrated companies belong, each company produces a specif product-service. There are steel industries within Europe with full ownership of their miles but also of mines.The majority has moved forward already from the complete closed vertical structures (such as the Carnegie Steel company) and there is more connection between the suppliers and the buyers of its products. With focus on how to provide their waste and byproducts more strategically to other industries or share facilities and technology, more steps towards circularity will be achieved

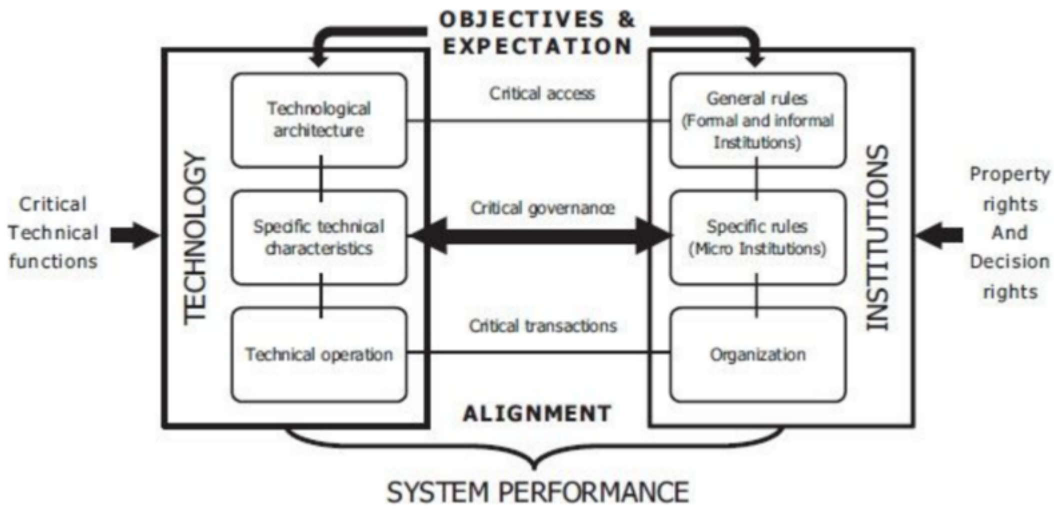

Figure 2.2: Critical infrastructure framework-Alignment scheme.(Büscher et al., 2018)

Glachant (2012) writes about the change in the regulation of network industries and describes that the object of regulation has changed after industries became exposed to competitive dynamics and the new technologies of our information society. Glachant (2012) argues that these arguments and this way of viewing the network industries could be applied in a traditional industry such as the steel sector regarding the transition to greener production The Paris COP21 Agreement targets in combination with new technologies such as Internet of Things (IoT) that enable waste tracking are creating drastic changes in the regulation of traditional industries as well. The change in technical architecture and general rules determine important economic features of the steel sector.

2.3.2 | General CE Institutions World Wide

World-wide there is a movement of businesses, supported by governments, to try and promote the adoption of the 3R's Principles. In different countries, different adoption level and institutional initiatives regarding CE can be found (Ghisellini et al., 2016). In the Table 2.1, it is shown that there is an effort for implementation of CE with specific policies in different sectors.

Table 2.1: Institutional Mindset about CE around the world

Location	**Institutions and Reality**
EU	Sectorial application of 3R Principals (mainly waste management policies)
China	CE Promotion Law
India	CE values in the society (not formal institutions)
Japan	Law for Effective Utilization of Recyclables (1991) and Japanese CE Initiative
Brazil	Environmental Certifications, Investment on restoration of degraded lands
USA	Lack of Federal Policies on CE, policies on state level
South Korea	Waste Management (2007), Act on promotion of Resources Saving&Recycling (2008), Food waste Reduction Policy, EPR
Vietnam	Environmental Protection Law (2005), National Strategy on Integrated Solid Waste Management Policies
Australia and New Zealand	CE Acceleration Agenda (2015)

Two examples of countries with big production scale, but different way of approaching CE are the USA and China. USA does not have a federal policy that pushes towards the full adoption of CE, but there are initiatives on different sectors and states. Regarding recycling there are green labeling laws, packaging recycling policies and also when it comes to certain material reuse (Davis & Hall, 2006; Ghisellini et al., 2016).

China is a country with increased production and consumption growth the last decades. China has officially the Chinese CE promotion laws (CCICED, 2008) that are following the main 3R's principles, but their production and consumption on a national level does not meet yet those standards (Ghisellini et al., 2016). According to the second article of the CCICED (2008), "The term "circular economy" herein is a general term for the activities of reducing, reusing and recycling in production, circulation and consumption". Although, China as a country has a big environmental impact with their production, there is effort and investments on innovation regarding CE (Su et al., 2013).

In Japan, Korea and Vietnam there is vivid interest to work in all the principles of CE. With actions and policies in different sectors these countries are trying actively to implement the circular values within their society and their production processes (Ghisellini et al., 2016). While, in South America

2.3.3 | European Union and Circular Economy

In the European Union (EU) there is a growing momentum to introduce common strategies within the countries to follow the 3R's principles. The goal within the EU is to help in synergy and common efforts within the country members, as well as the motivation of countries to develop CE friendly policies on a local level (Ghisellini et al., 2016). Main concern is the structure of strategies on how to mitigate GHG emissions, landfill, hazardous waste and improve resources circulation (Sakai et al., 2011; Ghisellini et al., 2016).

In July 2014 the European Commission, under the ex-president Barroso, introduced the CE package with the title: "Towards a circular economy: a zero waste program for Europe". This programme had as its main focus recycling and waste management with the goal of 70% recycling for municipal waste and 80% on packaging waste by 2030 (Rizos, Behrens, Kafyeke, Hirschnitz-Garbers, & Ioannou, 2015; Ghisellini et al., 2016). What happened to this version of the circular economy package illustrates the complexity of structuring a coherent programme that is actually effective and adopted from all EU member countries. The measurements in this policy plan were criticized for being focused mainly on only one aspect of the circular economy (waste management), thus innovation in new production and business models was not helped (Rizos et al., 2015).

The subsequent EU commission under the presidency of Jean-Claude Juncker (2014-2019) withdrew this plan and nominated a more ambitions one. The "Closing the Loop - An EU Action Plan for the CE" is focused on innovation and tries to combine the full circle of the 3R's principles. Thus, this package is trying to integrate CE in the phase of design, material choice, production, disposal and recycling.

According to the Rizos et al. (2015) a main directive of this policy package is the Eco-Design Directive that provides a framework that uses eco-design principles and aims to boost the environmental performance of energy using products. According to (Dalhammar, Machacek, Bundgaard, Overgaard Zacho, & Remmen, 2013) the Eco-Design Directive Directive 2009/125/EC has added value since it also has an increased the competitiveness of the European Industry. In the literature criticism can also be found, observing that the scope of the directive is limited and there are long processes to develop the proposed guidelines of the directive (Bundgaard, Mosgaard, & Remmen, 2017; Rizos et al., 2015).

The EU is actively trying to include strong policies regarding resource efficiency and that can be seen due to the central role that this topic holds on the Europe 2020 strategy (Rizos et al., 2015). However, we must note that the rates of implementation and effectiveness of consistent policies on a national level are still low (Rizos et al., 2015).

2.3.3.1 | Circularity and the Basic Material Sector

The sector of Basic Material represents a stock category that includes companies that are working on discovering, development and processing of raw materials(Devidend.com, 2020). According to Kopp (2019), "Companies included in the basic materials sector are involved in the physical acquisition, development, and initial processing of the many products commonly referred to as raw materials. Oil, gold, and stone are examples". Raw materials are substances generated naturally, with some of them being finite and some can be recycled (Kopp, 2019).

Raw materials are essential for our production. They can be found in daily electrical appliances such as smartphones, vehicles and construction. For the EU, it is a priority that that the supply of raw materials within the Union is sustainable. This sector currently is an integral part for the economy of the Union since it contributes on the economic growth and competitiveness of the EU member countries. According to the Von der Leyen European Commission (2020e) a variety of economic sectors and more than 30 million jobs as well as the transition of the Union towards renewable energy, are heavily connected with the supply of raw materials.

2.3.3.2 | Excising Policies for the Basic Material sector

The European Commission (2020c) announced the 'Raw Materials Initiative' with the aim to assist the Member States' national policies on raw materials. This strategy is created to include all the raw materials, except the agricultural production materials and the ones that are used for fuel (European Commission, 2020d). The sustainable supply of the raw materials is a goal of the Europe 2020 Strategy (The European Commission, 2020) The following are the three key points of this strategy, as listed in the European Commission (2020c):

- Fair and sustainable supply of raw materials from global markets
- Sustainable supply of primary raw materials within the EU
- Resource efficiency and supply of secondary raw materials through recycling

Exchange of best practices

For the EU, a fair and sustainable access to raw materials on global markets is a basic pillar. With their initiative of the Raw Materials Diplomacy, they actively try to create a network of countries that will align with the Union and will lead to strategic partnerships (European Commission, 2020f). Under the initiative of the EU Raw Materials Diplomacy, in the years of 2014, 2015 and 2016 workshops were organised by the European Commission with the advanced mining countries (European Commission, 2020e). In these workshops, the best practices regarding the mining policies and technologies were discussed.

The Extractive Waste Directive (2006/21/EC)

This Directive is providing guidance and measures for procedures that aim to mitigate the negative effects of extractive waste on the environment as well as in the society (European Commission, 2020d). This Directive is aiming to push the European Union Member states to enforce that the operators involved in extracting deliver a concrete waste management plan. According to (European Commission, 2020d), this plan should showcase how the operators are planning "to mitigate, treat, recover and dispose extractive waste taking account the principle of sustainable development. There, the Article 5 (1) of the Extractive Waste Directive

2006/21/EC (EWD) is interesting for steel producers that have mining activity but also for monitoring of the sustainability performance of their suppliers.

Every Member State is required to deliver a report to the European Commission on how did they implement the Directive in a local level. This report should be based on a questionnaire and according to guidelines that were given from the Commission (European Commission, 2020d). These guidelines are developed following the classification of waste facilities as well as the Waste Management (Prohibition of Waste Disposal by Burning Regulations 2009). This report should be sent in the Commission every three years, so the Commission can publish an official report withing nine months of the report delivery according to the Regulation (EC) 2150/2002 and Regulation (EU) no.849/2010. Even though the Member States are obligated to deliver their reports to the Commission, this guideline is not followed by all the Members (Kulczycka, Dziobek, & Szmiłyk, 2019). That leads in an insufficient reporting, resulting on harder monitoring from the European Union side.

EU Circular Economy Action Plan

The Commission Roadmap, is including guidelines and outlines of future measurements that will by applied in different sectors such textiles, buildings and electronics with the aim to mitigate the waste. According to the statement of Frans Timmerman ((vice president of the European Commission under the Presidency of Ursula von der Leyen)) that is in charge of the European Green Deal, "to achieve climate-neutrality by 2050, to preserve our natural environment, and to strengthen our economic competitiveness, requires a fully circular economy,". The sector of resource extraction and processing is quite important for the European Union to achieve their climate neutrality goals, since is responsible for half of the output of CO_2 emissions within the European Union (Simon, 2020a).

According to European Commission (2018a) the following Directives are part of the Circular Economy Package 2018, that within 2020 the European Union member states are called to follow:

- Directive (EU) 2018/851 of the European Parliament and of the Council of 30 May 2018 amending Directive 2008/98/EC on waste.
- Directive (EU) 2018/850 of the European Parliament and of the Council of

30 May 2018 amending Directive 1999/31/EC on the landfill of waste.

- Directive (EU) 2018/849 of the European Parliament and of the Council of 30 May 2018 amending Directives 2000/53/EC on end-of-life vehicles, 2006/66/EC on batteries and accumulators and waste batteries and accumulators, and 2012/19/EU on waste electrical and electronic equipment.

- Directive (EU) 2018/852 of the European Parliament and of the Council of 30 May 2018 amending Directive 94/62/EC on packaging and packaging waste

Even though European Union recognises the effects of resource usage, in this plan the focus is mostly in the mitigation of the municipal waste and the right of consumers to repair their devices. Moreover there is no specific measurements for industries that have high emissions and could be characterized as energy intense (Simon, 2020a). The steel sector is included in this category as well and even though the specific industry could benefit from transitioning to a circular model, the lack of measurements does not help them move towards.

European Green Deal

In the European Green Deal that was launched by the European Union (EU), the European Commission is stating its commitment to working towards sustainability. In the table 2.3 the various elements that are part of the European Green Deal can be seen. It is shown that the European Union is trying to make sure that the Union will "leave no one behind" by supporting and financing the transition.

Regarding the energy intensive industries where basic material such as steel and chemicals are part, the Commission poses the decarbonisation of these industries as a necessity (European Commission, 2019a). This sector is essential for European Economy and there is considerable a competition from the industries around the world. According to the European Commission (2019a) the modernisation of the steel sector towards a circular approach is essential.

The energy-intensive industries from their side as well, recognise the need for change to align to the Paris Cop21 Agreement and the challenges coming up due to the needed transformation (technologically and financially). These industries are vital for different value chains, thus they are vital for the European economy (European Commission, 2020e). To be able to contribute to the European Green

Deal, a High Level Group has been created that consists of experts and representatives from 11 industries that are responsible for more than half of the European Union's energy consumption. As part of the Green Deal, this group delivered a policy framework that is providing recommendations for the highly energy intensive industries (such as aluminum and steel) (European Commission - Press Release, 2019). The recommendations of this group include a number of steps that could help to provide the right market signals to bring in investments that will help companies to move towards circularity in a cost effective way. Moreover, the need for investment in innovation is underlined, as well as, training of workers to adjust in a different skill set that is needed (European Commission - Press Release, 2019).

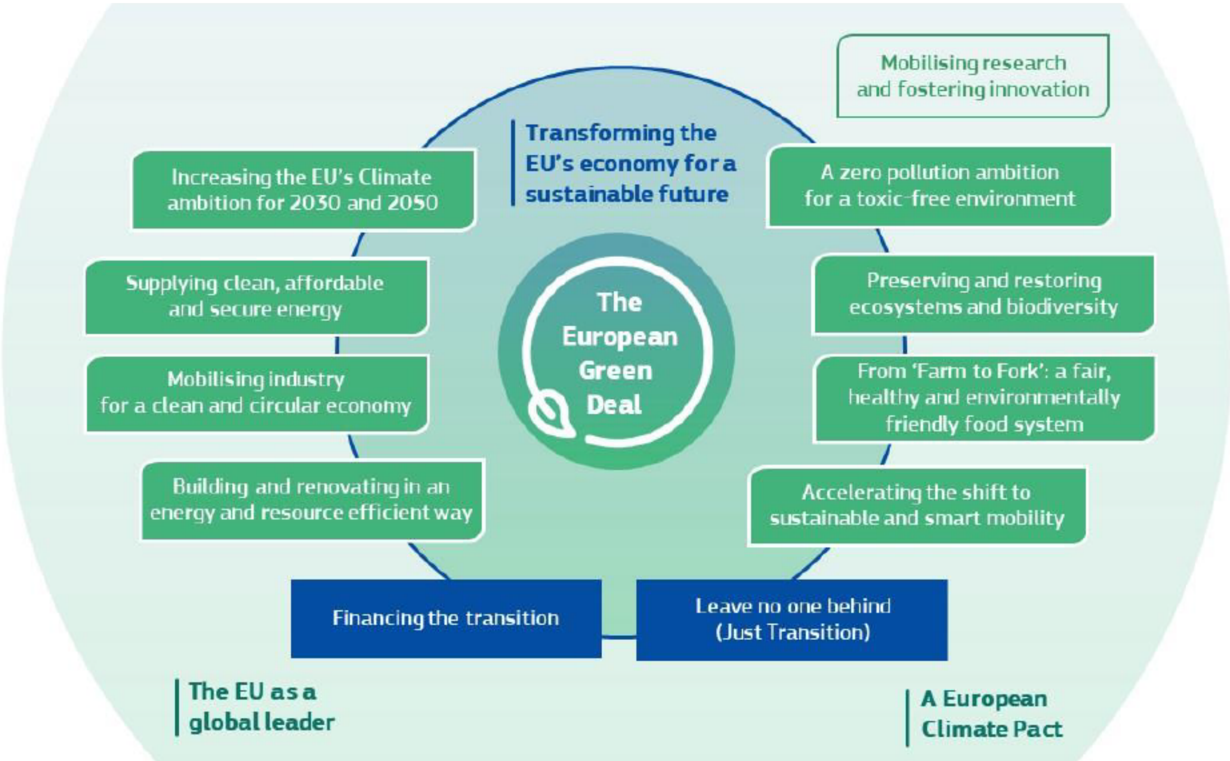

Figure 2.3: European Green Deal.(European Commission, 2019a)

Sustainable Finance

To be able to move towards sustainability and transform the European steel industry towards circular economy there should be a financial investments as well. To mobilize the private sector to also invest in this transformation, the European

Union designed 3 actions as depicted in the figure 2.4. The first action is the Taxonomy Regulations, which is a general framework to help towards the creation of an EU classification system to support green financial activities (European Commission, 2019b). The second action is to enhance sustainability related disclosures by March 2021. With these disclosures organisations that are active in the financial markets will have to provide to their clients the impact of sustainability on their strategy and financial returns. The third action is the adoption of two new benchmarks (climate and ESG) will be introduced. This action aims to help investors make investment choices that are greener.

An other measurement that the European Union is planning to take is to lunch the Reward Sustainable Finance Strategy. The goal of the strategy is to give further incentives to the private sector to choose sustainable projects for investments (European Commission, 2019). Moreover, more than 40% of EFSI (European Fund For Strategic Investments) projects that are part of the infrastructure and innovation plans, are aiming to contribute on the European Unions goal to reach their Paris Cop21 targets (European Commission, 2018b). Furthermore, according to European Commission (2018b), the European Union proposed that 25% of the next Multinational Financial Framework will focus on achieving these goals. The European Union currently with this actions aims to be an encouraging force to leverage private and public investment towards the transition of the basic material sector to the circular economy values.

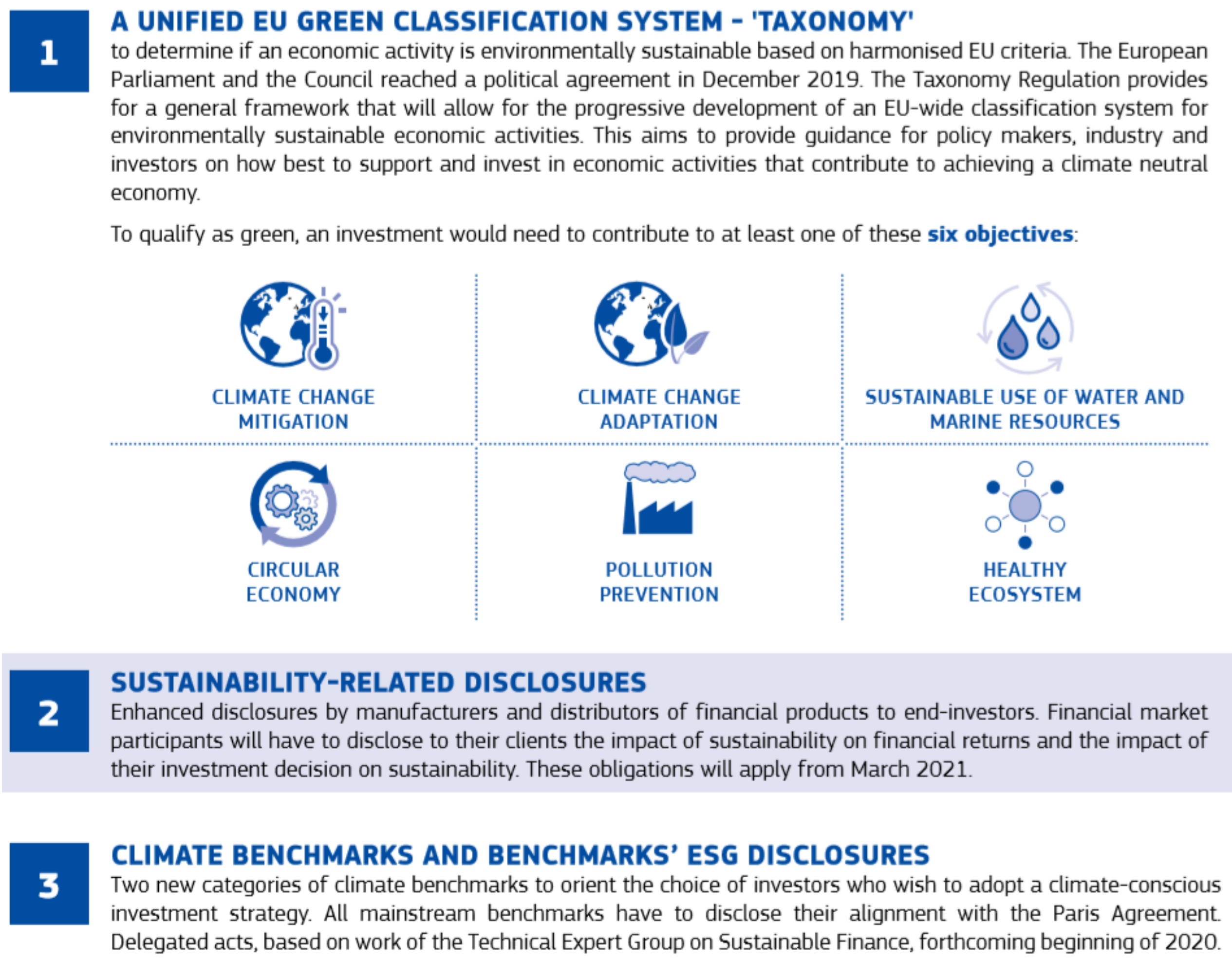

Figure 2.4: 3 key pieces of legislation will incentivise and channel private sector investment into green and sustainable development.(European Commission, 2019b)

The financial sector is a crucial player in this transition, as it can help the European Union achieve the Paris COP21 goals and, specifically, support the basic material sector in its move towards circularity. They can reorient capital flows and investments and help their clients become more efficient with a lower financial cost (European Commission, 2018b). In the Clean Planet for All plan[8] of the European

[8]In November 2018 the European Commission made public the a set of documents presenting a strategy for achieving by 2050 a European Union that is zero carbon. This set of documents provided a way to create a dialogue among the European member states and institutions with the purpose to create a long term strategy for EU. One of the essential elements of this strategy

Commission (2018b) it is underlined that if the banking sector is to be able to move its funds into sustainable projects, the European Union should in the first place create a well functioning Capital Markets Union. By creating a Capitals Market Union the aim is for removing the bottlenecks from a free flow of capital across the European Unions by helping private risk sharing and increasing options of investors. There reforms needed to make sustainable finance more accessible so that goals for of a low-carbon, more circular, climate resilient economy can be achieved (European Commission, n.d.).

To do so, the European Union provided solutions such as the unified classification system on sustainable economic activities, know also as the Taxonomy that is also discussed above. According to the Clean Planet for All plan of the European Commission (2018b) the taxonomy is providing "rules for low-carbon benchmarks and improved disclosure requirements for investment products". This way they try to make sure that there is transparency regarding the investments. By making sure that there is transparency there is mitigation on the risk that assets that could be characterised as energy intensive or depend on fossil fuels are depreciated before the end of their life circle (European Commission, 2018b). In the same mindset, institutions such as the European Central bank and the European Investment Bank can also be key players that can support the transition towards circularity.

2.4 | Steel Industry

2.4.1 | Steel Industry in Europe

The steel sector is an integral part of the European Industry as it is linked in a number of other European industries. The European Union holds the second place of steel production in the world with the production output of 177 million tonnes per year, that translates to 11% of global output (European Commission, 2020c). Currently there are 500 production sites that are located in 23 Member States

is the increase of investment in the European energy infrastructure (from 2% of GDP per year to 2.8%). To be able to achieve this, private investment on low carbon projects is needed (German Environment Agency, 2018) of the European Union giving the industry a cross boarder dimension (European Commission, 2020c).

The steel industry due to the nature of the material is already implementing values inspired from a close loop economy. Steel can be recycled 100% and that is a process that can be repeated all the time, without the material losing its properties (European Commission, 2020c). Currently, around half of the steel production within the European Union comes from secondary sources (recovered sources) as scrap metal. Even though the demand for steel was hurt during the crisis, according to EUROFER (2015) "steel is in-use longevity" that translates to the fact that availability of scrap is not sufficient to cover the demand of steel. Thus, still iron, the "primary" material is still important for the steel production. Due to that, there is need for the industries to move towards sustainable production of steel. Especially since steel is an important material for the development of sustainable energy production.

2.4.2 | European Institutions regarding Circular Steel production

The steel industry is part of the basic material and energy- intensive industries. Thus, the guidelines from section 2.4.1 are applicable for steel as well. In this section, a closer look at the institutions and their form within the steel industry will be presented.

Regarding the European Green Deal, the steel industry is called to follow the recommendations that are proposed from the High Level Group that consists from representatives from all energy intense industries(European Commission - Press Release, 2019). The main points of their recommendations according to European Commission - Press Release (2019), are the following:

- Creating markets for circular products (secondary markets) and climate-neutral products.
- By pushing large scale pilot projects that focus on clean technologies.

- Moving to alternative “climate-neutral energy and feedstock sources”. That means, making sure that there is access on these sources on competitive prices.
- Development of an industrial transition observatory to assist the industries on the transition and monitor their development.

More specifically this group has created the following steps regarding circularity in the industry:

- Move to circular economy with the aim to mitigate the CO2 emissions of the industry, by more efficient use of material and resource efficiency in the value chains
- Implement new measurements that will assess products according to the life-cycle approach
- Support the development of technological solutions and design methods that support the circularity values
- Exploit the opportunities to use secondary raw materials
- Promote that use of renewable and carbon based recyclables beyond energy production

To be able to support these actions, the group recommendations underline the need for investments that will be supported by European Funds as well as better and easier access to private financing. According to Hight-level Group on Energy-intensive Industries (2019) there is need for facilitation of access to private capital from financial institutes, at affordable cost and inclusion of de-risking instruments. To be able to increase the funding that comes from the financial institutes there is need for the public sector to participate on the projects as export credit agency that can cover the CAPEX of building the infrastructure of a new technology. This way the financial institutions feel more secure to participate in the finance of a project like this, since the involvement of the public sector reduce risk. Though, if we look at the example of USA, where the steel industry is a leader to green production, there the investments to greener production come through the free market. Furthermore, it is mentioned that the Commissions Action Plan on Financing Sustainable Growth should also include measures and actions to assist the competitiveness of the industries and transition towards sustainability (Hight-level Group on Energy-intensive Industries, 2019).

The European Circular Economy Action Plan, is an important action and main part of the European Green Deal towards the move in the circular economy. Moreover, is the latest most updated strategy of the European Union regarding circularity (European Commission, 2020b). Regarding the steel industry the important parts of the plan is the ones that include products policy. According to EUROFER (2020) "the secondary raw materials market and the process related residues" are the key point of the plan for the industry. The Eco Design Directive that is part of the Circular Economy Action Plan, will assist the industries to create an assessment for the life cycle of products. As well as, the creation of a secondary raw materials market was well received from the steel industry (EUROFER, 2020). To promote circularity within European Union it is important to make able that a secondary product that can be used safely again, and can be put in the market again.

According to the press release of the (EUROFER, 2020) there are elements, that still so be reconsidered and developed. The plan for a circular economy regarding an industry such as steel, should take into account the nature of the products and provide specialised guidance per product. Moreover, in the press release it was stated that recycling can be very effective but it is important to make sure that there is balance between "recycled content" and design for "end-of-life recyclability" as well as that there are incentives so that the steel scrap produced in European Union stays within the union (EUROFER, 2020). Regarding the waste management of secondary materials fuels, the waste management industry that is called to monitor and provide treatment, does not have the needed frameworks to phase this challenge (SCHARFF, n.d.). Thus this plan should be seen more as a point to begin establishing the idea of circularity.

2.4.2.1 | Missing points on the current Institutions leading to a "circular paradox"

Steel can be a good example of being 'circular', but the steel industry is not. The reason is that the existing policies so far attempt to implement the circularity values of recycling, re-manufacturing, reusing with a linear mindset. Currently steel is one of the most recycled materials within the European Union. Steel is produced with the use of iron that is infinitely recyclable combined with different materials such as carbon and nickel (de Miranda Pinto, 2019). The different combinations of these materials create different kinds of steel that are used in different applications.

With rapid urbanization in the developing countries, the demand for steel in these (global) markets is increased. That means that the stock of steel has also to grow and new steel will be produced. Thus, the industry still is relying on extractive activities that produce waste and also consume energy. Moreover, to be able to implement the values of circularity, there should be secondary markets within the European Union (EUROFER, 2020), were steel can be collected, refurbished and brought back to the economy. With the increased demand of steel from the developing countries, the scrap steel that is a secondary product is leaded outside of the European Union (de Miranda Pinto, 2019). Currently, Europe is supplying the developing countries with alloys that are more simple and bulk oriented (Pauliuk, Wang, & Müller, 2013). Even though it is not a necessity to have these products come back in a secondary market within Europe to achieve circularity, the less we monitor how steel circulates the more losses we have on the environmental side since all these alloys down-cycle.

By approaching circularity with a linear mindset, we do not effectively change the mindset of the industry. It is important that there are incentives that give the steel industries within Europe the motivation to find value on resource ownership (de Miranda Pinto, 2019). By creating a sense of resource ownership, the steel makers will feel responsible for their product from the production phase, until the end life of the product and the way it is disposed (land field or recycled). The current institutions such as the European Green Deal and the Circular Economy Action Plan, do not propose hard, specific measurements, rather than proposals that make it hard for industries to prioritize actions that increase resource ownership and to get in a financial risk of changing their current methods. Moreover, actions such as the Taxonomy road map does not provide enough financial investment to stimulate financial institutes to help the steel industries invest in circularity.

2.4.3 | Steel Industry and circularity

2.4.3.1 | Understanding Steel

Steel is a material that is central in our everyday life since is used in many different value chains (European Commission, 2020c). It is produced from iron ore that is in rocks and minerals and scrap that are recovered materials from recycling (that have monetary value). There are two kind of steel making process:

- The primary steel-making process. Which uses the basic oxygen steel making method to produce liquid iron that is carbon rich (pig iron) and is converted into steel with the use of a blast furnace. The other method to produce primary steel is by melting scrap steel or direct reduced iron DRI (sponge iron) with the use of an electric arc furnace (Deo & Boom, 1993)
- The secondary steel-making process which relies on refining the crude steel and then proceeds to processes such as casting it in ladles. Here also alloying agents are used and inclusions are altered or completely removed to make sure that the secondary steel that is produced is high quality (Ghosh, 2000).

2.4.3.2 | Steel industry currently

Historically steel making played an important role in the development of our societies and today is a big part of the European Economy.The European steel industry is the second largest in the world after China. According to the (European Commission, 2020c), the output of the European steel industry is over 177 million tones per year. This amount depicts the 11% of the global steel output (European Commission, 2020c). The industry is crucial for a number of other industries and has a presence with production sites in 23 European countries. Accounting purely the direct contribution of steel in the European Union, the industry is contributing

EUR 20.7 to the European GDP (Godden, 2018). But except from the direct monetary value, the steel industry is purchasing 103 billion euros of supplies from other sectors within the European Union. This support to other European supply chains, indirectly contributes to the creation of 2.5 million jobs (Godden, 2018).

2.4.3.3 | The future of the European Steel industry

The future of steel industry is integral with the future of the European Union. Lately due to the financial crisis the industry was tested since the demand for steel declined during the post-crisis recession. From a longer-term perspective, there are various disruptive factors that can have an effect on the future of the industry including industry consolidation, geopolitical uncertainty such as the impact of the rise of China, or the Covid-19 lockdown recession, the impacts of digitisation as well as of e-mobility. Other potentially disruptive variables include fluctuations in interest rate as well as the change in the customer preferences and needs (PWC, 2020).

This latter change can be quite crucial, since customer needs are evolving, as buyers of steel are becoming more aware of the ecological implications of their spending, and hence there is a growing concern for the environmental footprint of the products they use. This change is driven by the environmental crisis we face and it brings new regulatory changes as well. A good example is the company Orsted, that is the offshore wind market leader. The company has as a goal to decarbonize its whole supply chain by 2050. To do so, they openly engaged all their industry leading suppliers (such as steel and cooper producers)to follow them, so they can achieve their goal(Radowitz, 2020). Amongst their notion to their suppliers was that they disclose their emissions as well as they also set goals to achieve their transition to sustainability (Radowitz, 2020).

Thus, the notion of circularity is more becoming more important than ever. It is important that the steel industry will adopt in time to the regulatory changes towards sustainability, as well as anticipate the changes and build know how in advance. Steel as a material has an advantage since it can be circular (in principle and by design) and it is an important factor for the sustain- able technologies of the future such as turbines and solar panels (The European (The European

Commission, 2020).

However, notwithstanding the fact that steel production can be made circular , the industry steel relies on the extractive activities, since secondary steel production (based on scrap and recycled material and zero-carbon energy) still is not enough to cover fully the demand of our growing world (de Miranda Pinto, 2019). The production of new steel still, is generating waste and requires a lot of energy. The production of new steel still is generating (unnecessary) waste and requires large amounts of (fossil-fuel) energy. That is why it is essential for the industry to invest fast on exploiting the potential of lessen the dependency on finite raw materials and move to a more circular chain. To do so, there is need for funding from both public and private sector and thus regulatory framework that supports this activity(The European Commission, 2020).

2.5 | Chapter Summary

In this chapter the literature of Circular Economy was provided, as well as how the way of thinking of the Institutional Economics, could help to phase a multi-actor issue such as the transition of the steel industry towards circularity. Moreover, the current institutions regarding circularity world wide and in a European level were addressed. The focus of the chapter is the basic materials industry and more specific the steel industry. In the chapter the institutions that are enabling or blocking the transition of the steel industry are examined. Currently, there is evident interest from the European Union to promote the circular values in the steel industry with actions such as the Green Deal that includes the European Circular Economy Plan. At the same time, there is evident lack of specific measurements to incentive the industry to transition and also to support this transition, leading to a circular paradox. In the end of the chapter, the steel industry is briefly introduced. In the following chapter, a better understanding is given for the actors involved in this case and a further explanation for the current environment in the European Steel industry.

3

Actor Analysis

3.1 | Introduction

To answer our research question, we will use Actor Analysis, a method developed and used to support decision making and strategic advice activities (Scholes, 1998). In this research the Actor Analysis will be employed to identify the main stakeholders involved in the change of the European steel industry towards circularity, their formal relations as well as their dependencies within this system. The scope of this analysis is on a macro level and our aim here is to provide information about the actors involved and identify the critical relevant ones within the context of our research. To be able to develop this analysis the following steps from Enserink et al. (2010) where used:

1. Formulation of the problem as a point of departure
2. Making an inventory of involved actors
3. Mapping of formal relations
4. Problem formulation of main actors
5. Analysis of the interdependencies
6. Determination of consequences of the findings

3.2 | Problem Formulation and Actors Inventory

The problem owner of this research is the banking sector and their issue is how they can help their clients to accelerate the transition towards circularity. The analysis is conducted with the aim to identify the main actors involved in this "system", having as a center the steel industry in Europe. With the term 'actor' we refer to the agents that have an interest (in the European steel sector and its transition to a CE model) and can also influence it directly or indirectly (Enserink et al., 2010). Our analysis is examining the steel industry at a macro level. Thus, the actors involved are categorised in bigger groups. Below the table 3.1 presents our inventory of key actors. Moreover, specific actors who have a central role in the European steel industry, are analysed so the reader can have a better understanding of them.

3.2.1 | European Union

A robust steel industry is of important value for economic growth, sustainable job market and international competitiveness (European Commission, 2016a). The steel sector has been essential as the base of many different industries such as the automotive one. The steel industry is responsible for 1.3% of EU GDP (European Commission, 2016a). The sector is has been modernised (still less extensive compared with the US) and tries to be coherent with the aims of the European Union for greener production by trying to develop energy- and CO2-efficient plants (EUROFER, 2020). With the European Union been committed to reach the Paris Cop21 Agreement targets, there is pressure for the steel industry to adapt to these stricter (carbon emission) aims.

To be able to support this transition and in general the sustainable growth of the sector, the European Commission has made available different funding programs (Horizon 2020, structural funds, and the research fund for coal and steel) (European Commission, 2020c). We also mentioned in Chapter 2, that the European Union is committed to the Paris COP21 Agreement and thus stricter rules to enable the

Table 3.1: Actors Inventory

Actor	**Issue of Interest**
EU	Policy to guide the sector in line with the Paris COP21 Agreement targets
ITRE (EU Committee)	Committee on Industry, Research and Energy
Local Governments	Policy in country level
Import markets of raw material (supply)	Demand for raw material
European mining companies (supply)	Demand for raw materials
Recycling Companies	Processing (recycling) of steel products or products that include steel components
"By products" Industries	Industries that use steel by products
Downstream producers	Steel users for their manufacturing processes (e.g. the automotive industry)
Retailers	Small, medium and large sized enterprises
End Users	Product users
Export markets	To be able to produce cost-competitive steel products
Banking sector	Providers of finance (funds) and expertise
EIB	European Investment Bank
EUROFER	The European steel association
Research centers	Innovation on the sector

transition of energy intense industries have been introduced (for example: the EU-Emission Trading System (EU-ETS)[1]. Due to the fact that we leave in an open, globalized economy there are uneven climate policies, the fear about carbon leakage due to lack of competitiveness for energy intense industries keeps the European Union from implementation of effective climate policies (European Commission, 2020a).

[1]According to European Commission (2016b) “The EU ETS is the cornerstone of the European Union’s drive to reduce its emissions of greenhouse gases which are largely responsible for warming the planet and causing climate change. The system works by putting a limit on overall emissions from covered installations which is reduced each year. Within this limit, companies can buy and sell emission allowances as needed. This ‘cap-and-trade’ approach gives companies the flexibility they need to cut their emissions in the most cost-effective way.”

3.2.2 | European Steel Industry

The European steel industry is a sector that is highly innovative regarding sustainability. The following figures and sections will help understanding the current situation regarding the steel sector. As we mentioned above, the industry directly employs thousands of high skilled people and directly and indirectly the steel sector suppots 2.2 million jobs in the European economy (European Commission, 2019b; EUROFER, 2019). Every year the industry produces on average 170 million tonnes of steel in 24 different member states (European Commission, 2020c; EUROFER, 2019). Comparing the total value of turnover, within the other EU industries the steel sector comes third after aerospace equipment and dairy products. The steel industry is closely connected with the European Union's manufacturing industry (especially automotive) and the construction sector, because industries use steel output in their own activities. The steel industry is an important exporter to developing countries as well (EUROFER, 2019). The European Steel industry is a key player in the global market (with share of 18% in the global steel market). In the table 3.2 are the market shares of world steel production:

Table 3.2: Regions of crude steel production at 2017

Region	**% Share**
Asia	68.7
Europe	18.5
North America	6.9
South America	2.6
Middle East	2.1
Africa	0.9
Australia/ New Zealand	0.4

3.2.2.1 | Imports and Exports of the European Steel Industry

The European Union as well as steel industry is closely connected with the global industry. In the Figures 3.1 and 3.2, the European steel imports and steel exports in the year 2018 can be found. The European total imports of steel in 2018 consist of flat products (74,9 % total imports). The main countries that supply these products include Turkey, Russia and South Korea. Regarding Europe's steel exports in 2018, 64,2 % aeel re flat steel products. The top three destinations of the European steel exports in 2018 are the USA, Turkey and Switzerland (EUROFER, 2019).

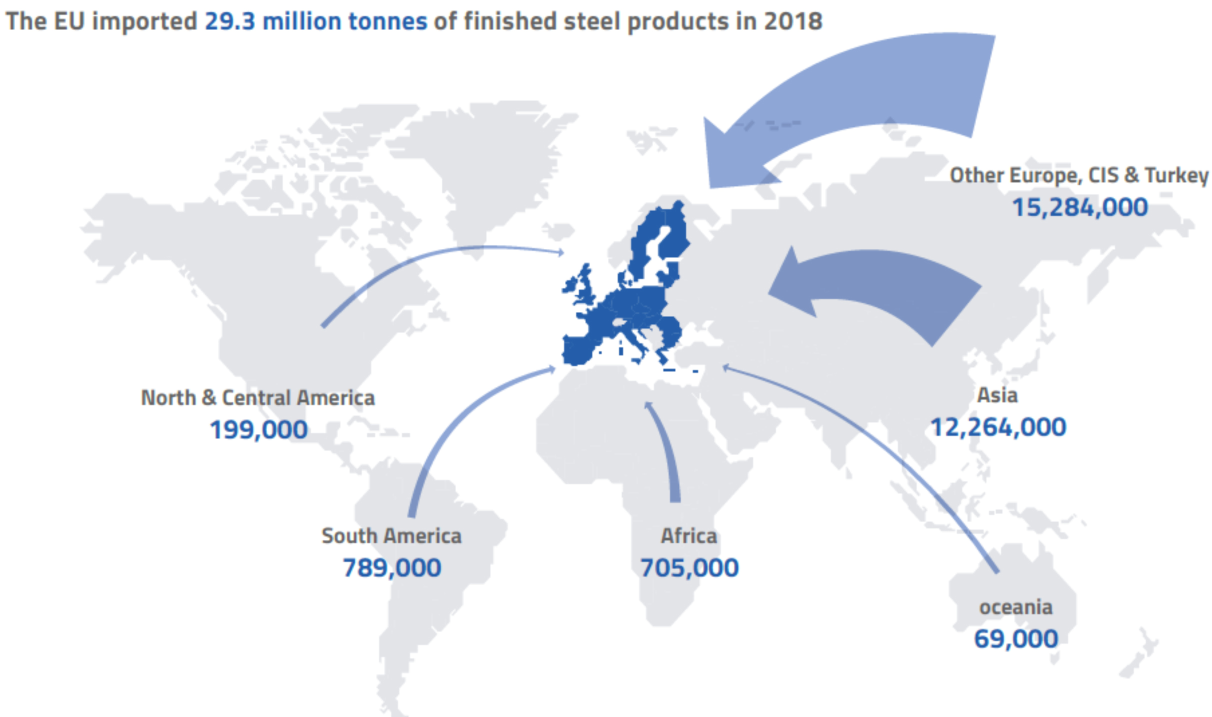

Figure 3.1: Total Imports into the EU, source: EUROFER, 2019

As it can been seen in Figure 3.3, the balance between the steel exports and the steel imports in the European Union has changed the last years and the EU has become a net importer of steel. Excluding semi-finished products, import levels remained level at an all-time record high in 2018, but steel exports from the European Union have been declining since 2014. According to the EUROFER (2019) "the net trade balance continued to reverse in favour of imports, with the EU a net importer of steel". That indicates that there is a dependency of the steel European market on imports.

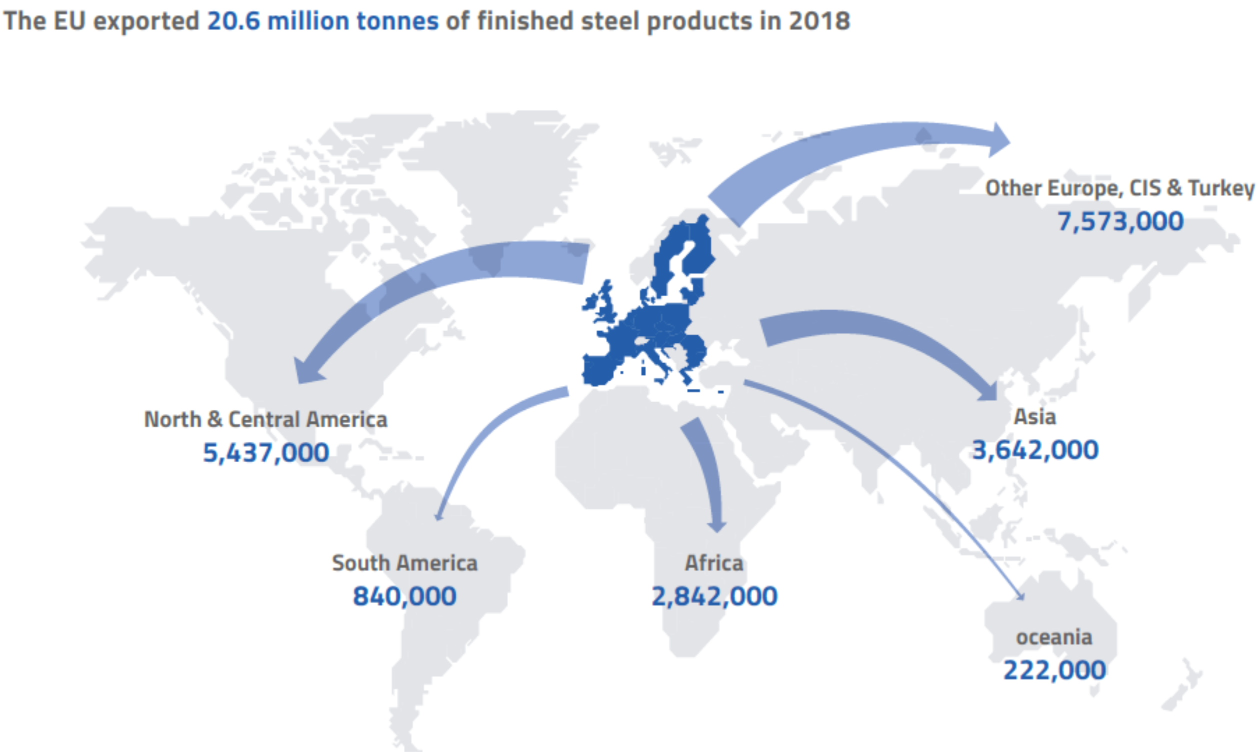

Figure 3.2: Total Exports into the EU, source: EUROFER, 2019

3.2.2.2 | Challenges faced by the steel industry

The main issues that the steel sector is facing have to do with the availability and the cost of necessary commodity prices such as raw materials and energy prices. The impact of energy cost amount to 40% of the total OPEX (operational costs) of steel making within the European Union, and the industries within EU are acquiring energy in higher prices compared to their international competitors (European Commission, 2020c). Moreover, before the COVID-19 crisis occurred, the European steel industry was already experiencing a hard year (2019). With the pandemic arriving in the quarter 1 of 2020 the steel industry is negatively affected. According to Reuters, the European steel sector faced the worst hit with 9 blast furnace that amount to 19 million tonnes steel per year been temporarily stopped (Onstad, 2020). The reason why Europe suffers the most currently, is that the

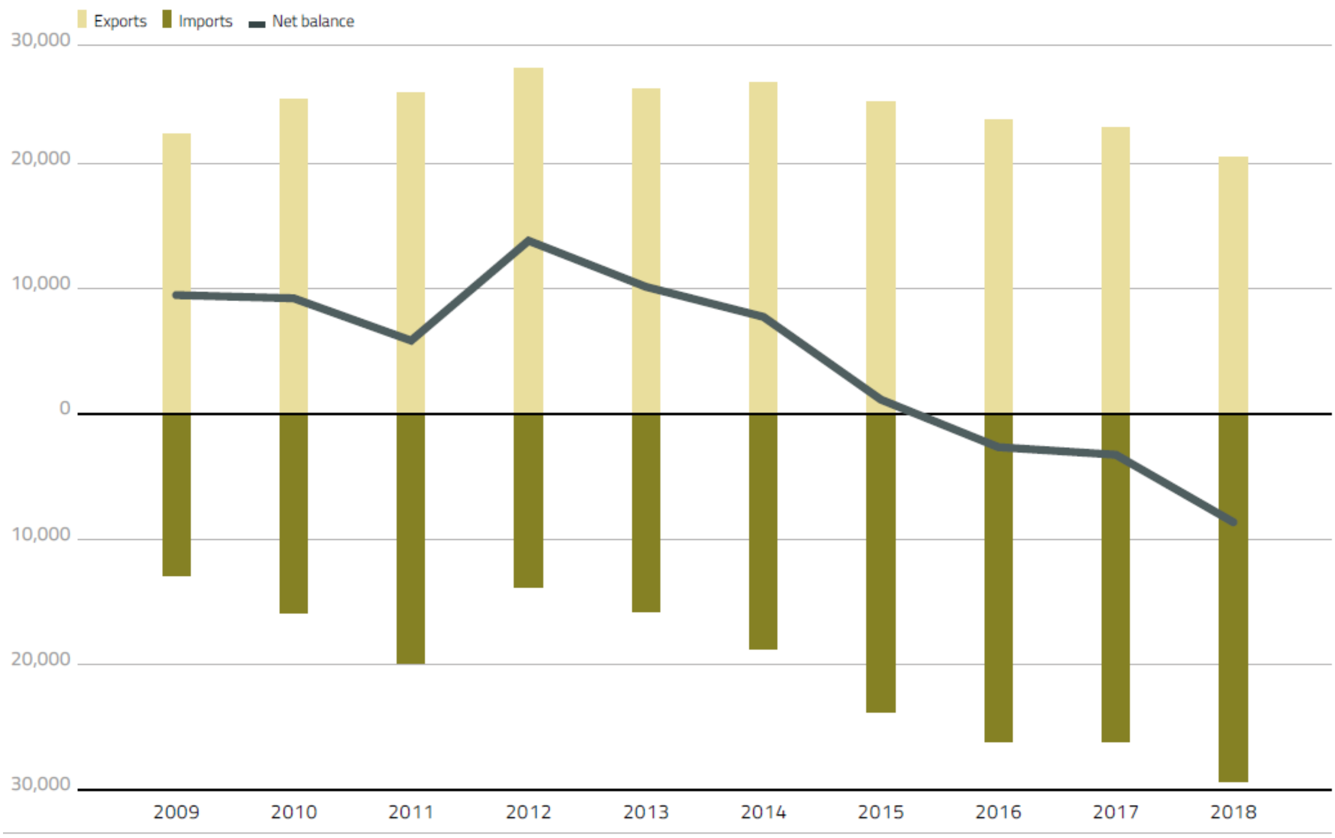

Figure 3.3: EU trade balance (finished products) by volume, source: EUROFER, 2019

majority of the European steel production is made with the technology of BOF (Blast Furnace) that is hard to shut down and restart later. Thus, comparing to other competitors like USA face the drop of the demand by shutting temporarily their EAF furnace to reduce their production capacity, Europe does not have this option (Onstad, 2020).

3.2.2.3 | Transition towards circularity

The industry is pushed due to the European strategy to move towards circularity as well as achieving the Paris COP21 Agreement goals to become greener (The European Commission, 2020). The European Union tries to implement different policies that try to assign responsibility to actors along the product life cycle to manage environmental impacts and optimize resource recovery and recycling. The steel sector by nature of the product has an advantage in the circular economy as it is explained in the section 2.4.1, especially in mature markets such as Europe – because as steel stocks saturate, it is quite possible to increase steel recycling and minimise primary production (Material Economics, 2018). The European countries as well as the majority of the developed countries have more stocks of steel products to recycle. In the future a big part of the demand for steel in Europe can be met by steel produced by recycling that part of the existing steel stocks[2] that is being discarded or scrapped. Primary production of new steel (from ore) can be reduced and minimized. In Figure 3.4 the global steel production and the availability of scrap can be seen.

For the industry it is beneficial both from economical and for environmental view to be proactive with this opportunity and prioritize practices that required to enable future recycling from the collection at end of life point (Material Economics, 2018), to transition to practices that are helping on separating the steel stocks easier from contaminants. It is a challenge to maintaining the steel scrap pure by separating other materials such as copper before the steel scrap is reused for production.[3]

$$S_{t+1} = S_t + NS_t - SCRAP_t$$

Where S_t= the existing stock of steel at time t NS_t = new steel added to the stock (for example, steel in a newly produced car in year t) and $SCRAP_t$= steel that is discarded or scrapped (for example a very old car which is dumped in a car dump). Now NS_t= the demand for newly produced steel (either primary or recycled). $SCRAP_t$= a proportion ∂ of the existing steel stock which is described; Let us write: $SCRAP_t$=∂*S_t. The steel stock will grow ($S_t + 1 > S_t$) if $NS_t >$ $SCRAP_t$, i.e. the demand for new steel is larger than the availability of scrapped

[2]With steel stocks we describe the existing steel that is already produced and is part of infrastructure (buildings,railways,bridges), automotive etc.

[3]Copper in steel can create metallurgical problems and can not be separated after the steel is reused as scrap (Daehn, Cabrera Serrenho, & Allwood, 2017). According to Daehn et al. (2017) "estimates show that quantities of copper arising from conventional scrap preparation can be managed in the global steel system until 2050" thus policies to help on closing product loops are needed.

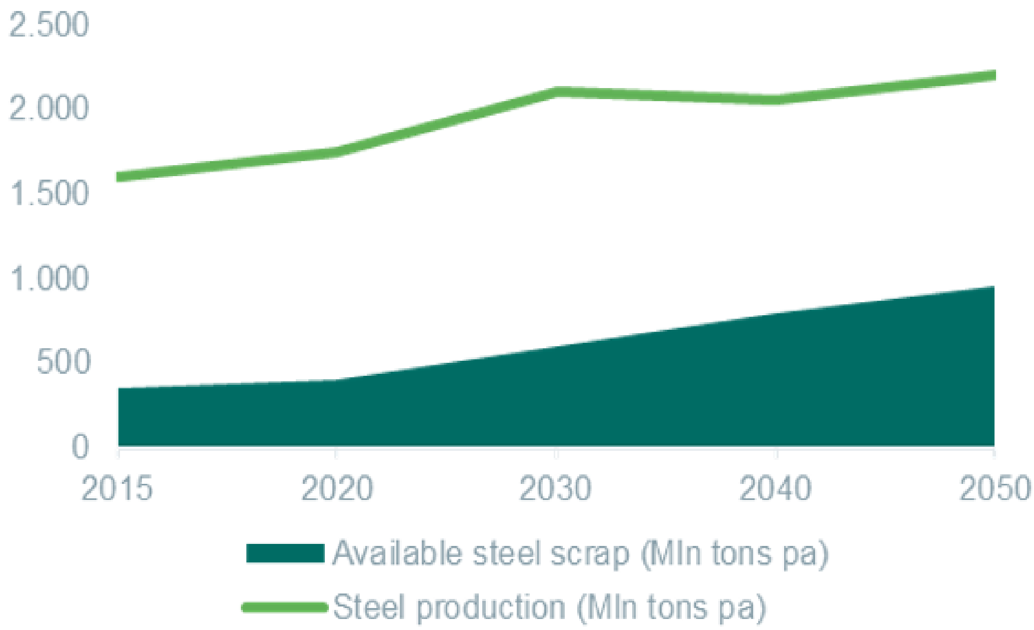

Figure 3.4: Global Steel production and scrap availability

steel. Now if the steel stock is large (relative to the economy), then the amount of scrapped steel (which can be recycled) will be high. Hence, in a "stationary" state, we would have: NS_t= $SCRAP$=∂*S_t - the new demand for steel can be met by the discarded (scrapped) steel. This in turn means that the steel stock is constant (and not growing). All new demand for steel can be met by recycled steel; there is no need for primary steel production anymore (no need to extract new resources etc). The steel stock is constant. And if the secondary steel production is made carbon-neutral etc., then this constitutes a significant move in the direction of the CE model.

To be able to transition, the industry will face different financial, technological uncertainties and barriers. Important actors to this transition except from the local governments and the European Union will be also the downstream producers that are using products and by-products[4] such slag that is a by-product of the development of iron to steel using a BOF or the melting of scrap steel using an EAF and is mainly used in the construction and cement industry (Shi, 2004). Moreover the banking sector plays an important role since they can help on overcoming the financial challenges from this transition to a more circular production.

3.2.3 | Downstream Producers

Steel products and its by products are necessary for a number of industries. By implementing circular theories (as it shown above) in the production of steel we could manage to reduce the total steel stocks (per capita) and this way reduce the primary steel production with satisfying delivered products (Energy Transition Commission, 2018)[5].

A big change could come from more circular models in the industries that are direct users of steel products such as the automotive and construction sector. Currently those sectors account for two thirds of the steel demand (Energy Transition Commission, 2018). These industries also receive pressure from national and European policy makers as well from the consumers for sustainable products that are more environmental friendly (or less environmental unfriendly) .

According to Milev and Al-Habaibeh (2020) if all UK would change to electrical cars the carbon emissions would drop by 12%. This estimation includes the fact that there will be increased demand of electricity (green and conventional) that cost 2% of carbon emissions rise (Milev & Al-Habaibeh, 2020). This is a significant

[4] During the steel production, different by-products are produced. The main ones are the slags, sludges, scales and dusts. These by-products can be directly reused in the production of steel or they can be separated, stored and sold to secondary external industries (Matino, Colla, Branca, & Romaniello, 2017)

[5] According to the Material Economics (2018): "Current EU steel production is more than 60% based on primary production, i.e.produced from iron ore. However, a detailed analysis of steel stock evolution and scrap flows suggests that, in decades to come, the EU will approach the point where the need to maintain a near-constant stock of steel can be served to a large extent by recirculating steel that has already been produced. Doing so will require reducing losses of steel, changing how steel scrap is handled and traded, and avoiding contamination of the steel stock with copper.

drop (12%) but is still not enough to achieve the goal of the country to be zero carbon by 2050. The example of electrical vehicles is important because it can show that changing from a product to an other is not enough.

In a commercial non-electric car in use, around 77 % of the CO2 emissions come from the usage of the car while the rest of the emissions is due to the production of the vehicle (Material Economics, 2018). This is different in case of electrical vehicles. Emissions from usage are estimated to decline to 10% of the total C02 emissions (Material Economics, 2018). The majority of carbon emissions from electrical vehicles comes from the production (Haustfather, 2019). For that a big part plays the battery that is used. Big brands (such as Tesla) import their batteries from China where a big part of the electricity for their production is provided by plants that use coal (Haustfather, 2019).

Just by changing the product, without focusing in the end of life cycle total emission we can not reach big changes in the carbon emissions. There might be a need for the industry and the society to embrace the a more circular model such as the shared mobility system. Similarly, the construction industry accounts for about 50% of all steel demand (Material Economics, 2018). This sector except from the reduction of construction waste could also mitigate their emissions from the acquiring of steel that is better designed.

3.2.4 | Banking Sector

With the change in strategy and attitudes in their client companies and the Paris COP21 Agreement commitment, traditional banking is a facing new challenges. Circularity will be part of our lives and most traditional supply chains that are supported by the banking system are at the beginning of a transition period. For the banking industry, this could be an opportunity for a new market and a moment to support strong sustainable future scenarios for their clients.

At the same time, circular business models can bring challenges as well. With the companies adopting circular models, the traditional cash flows of companies also change. To transition and adopt new technologies the companies will have increased capital needs and legal issues will arise regarding collateral and its value. Moving from tradition models to circular business models it is only excepted that the traditional way of viewing collateral will also change. In a circular supply chain were ownership of a product translates to responsibility for the way the product will be handle at the end of its life, the ownership of a product is changing. That might create a challenge for the banking institutions since the sense of the ownership and thus the collateral assets. The property rights and how they will be described and put on a contract will play a role.

Companies could be involved in the transition to circular economy with different roles. The road to the transition is not trivial. For large, capital-intensive and energy intensive companies such as those operating in the steel industries there is funding aimed for innovation that would lead to technologies that promote circularity and mitigate the CO2 emissions since they have budgets dedicated to R&D. However, to be able to scale up the new technologies, the "bankability[6]" of these companies is a critical factor (Van der Stel et al., 2018).

A reason for a slower transition can be the unwillingness to make changes when there is an absence of immediate economic imperatives due to new circular innovation, regulation or consumer demand for "greener" products. To push companies towards this direction the institutional investors can create initiatives on how the companies they are involved are going to transition so they can a ensure a long term sustainable business. An other way the banks can support business to move towards circularity is by creating multi-stakeholder dialogue and bringing different parties involved in a supply chain together.

In 2018, three major Dutch banks (ABN AMRO, ING, Rabobank) created the Circular Economy Finance Guidelines with the goal to be proactive and create a framework to help them define the notion of Circular Economy and its place within finance and banking (ABN AMRO, ING, RABOBANK, 2018). These guidelines aimed to create a common understanding with the purpose to promote the financing and investing in circular business models. The guidelines are useful for the banking sector according to ABN AMRO, ING, RABOBANK (2018), since there is lack of guidance on how to "uniformly define and apply circular economy thinking". The

[6]We define bankability as the willingesss of the banking institutions to finance the projects from an industry and provide a interest rate that is beneficial. According to the European Investment Bank (2010) "Bankability of transactions in the Corporate Finance Model primarily depends on the creditworthiness of the promoter, typically also being the borrower"

definition that is given for the Circular Economy Finance from ABN AMRO, ING, RABOBANK (2018) is:

Any type of instrument where the investments will be exclusively applied to finance or re-finance, in part or in full, new and/or existing eligible companies or projects in the circular economy

The guidelines have four core components:

- Use of investments
- Process for Project Evaluation and Selection
- Management of Investments
- Reporting

Using the example of ABN AMRO, an other measurement that illustrates the new approach regarding the transition of different industries is the GSRI (Global Sustainability Risk Indicator). This is an internal tool of the company based on the Global Sustainability Risk Indicator model, to asses the overall sustainability and performance of a client that. For example, a GSRI for a client of the steel sector aims to look is the client follows the bank sustainability policies and at the same time give a clear message to the client that there are specific criteria set internally be the bank regarding sustainability. The GSRI showcases if the steel industry is complying to the environmental and social regulations, what is their commitment, their current capacity (steps and measurements taken) and their track record (environmental and social issues that have occurred) (ABN AMRO, 2016). This way the sustainability risk of the client is identified before lending. With the GSRI reports, there is a relationship created between sustainability and financial performance (ABN AMRO, 2016). Thus, the estimation of the ability of the client to repay their loans, involves their sustainability performance as part of the risk. This tool aims to provide knowledge to the bank on what should change in the production process of client but also check an entire portfolio of the client to see if there is a shift to a more sustainable way of operation. Using tools such as the GSRI, the banking sector shows that they aspire to be part of the transition of their clients.

3.3 | Actors Map

To be able to understand the characteristics of the actors involved, a map is developed to underline their relations. These formal relations that can be seen in the following map Figure 3.5, describe the formal positions of actors (Enserink et al., 2010). The colour coding in the map helps to identify the different group relations. In the map, the European Union is connected with the steel industry only. This choice is made because the focus of the institutions and regulations that are discussed in this report is mainly for the steel industry. Moreover, the map can include this way other industries such as downstream producers that are not based in EU, thus they sdo not have to follow the EU directives. As it is shown the arrow (relationship) that connects the Banking Sector and the Steel Industry is thicker to denote the focus of this research, that is how the banking sector can help the European steel industry to become greener.

As it is seen in the Figure 3.5, the banking sector interacts and has formal relations with the majority of the actors. That illustrates that they can be influential regarding the transitioning towards circularity. Moreover, they are connected with all the industries since a European banking sector can have clients and connections from all over the world, which is the case with ABN AMRO as well. That increases the complexity of having the banks pushing towards sustainability.

This figure can help us understand the fact that the change towards sustainability in one industry will affect more parts of the supply chain. With Figure 3.5 the crucial actors that can affect this transition (positive or negatively) can be identified. Since a complicated issue like this involves multiple actors, the map can help us identify the ones that we can focus on more in the analysis. In this case, the actors that are involved in more relationships is the Steel Industry, the banking sector, the European Union and the downstream producers. Thus, these actors were selected to be further analysed in the previous sections of the chapter.

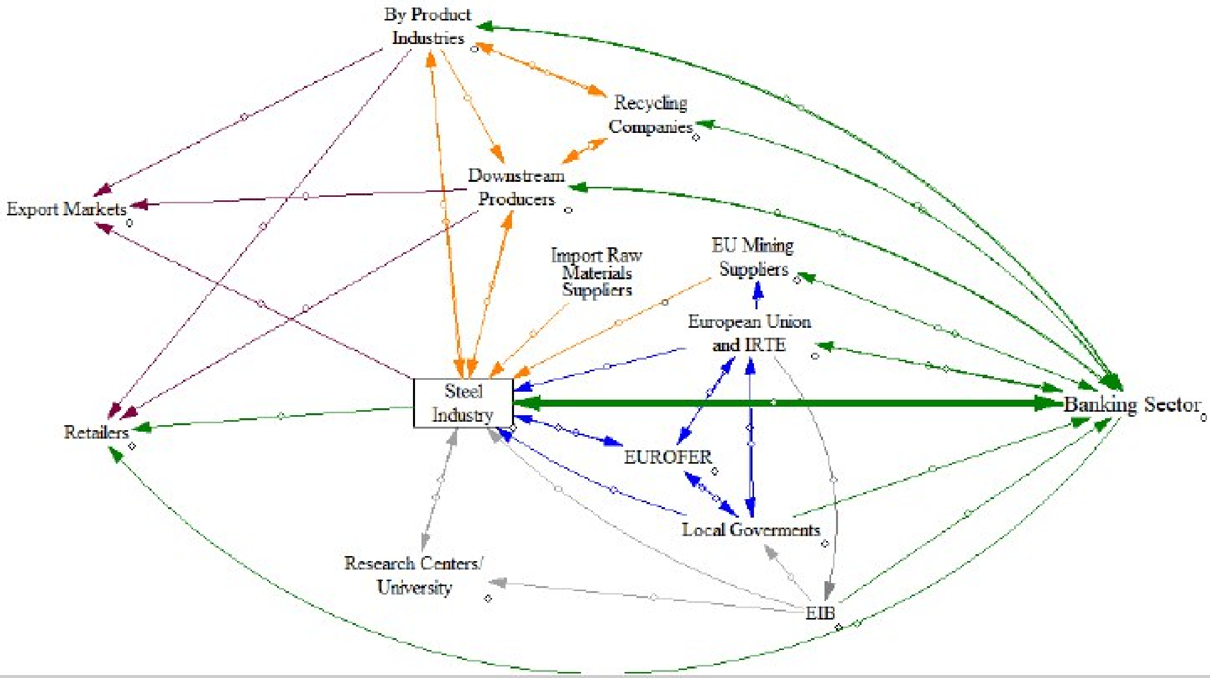

Figure 3.5: Map of formal relations

3.4 | Influence of the Actors for the circular transition

In Figure 3.6 we can see the dependency of the steel industry in two different levels. When it comes to transitioning to circularity, the European Union and the directives coming from the committees of the union play a central role and have a direct influence for the transition of the sector. Moreover, the European Directives are nudging the downstream producers such as the automotive industries that use the products of the steel industry, to demand greener products from their suppliers. This way they can mitigate the CO2 emission in total of their production as well (PWC, 2020).

For the European Union to effectively help the energy-intensive industries such as the steel industry to completely the circular economy values, there is need for clear institutional, regulatory and fiscal frameworks. So far, the frameworks regarding circularity are not yet efficient, because these are focused mostly on recycling.

By focusing mostly in the end life of the products and not also in the resources that were used as well as the production of the products important leakages are ignored. By addressing the whole life circle of a product, problems such as the resource scarcity can be mitigated throw circularity (European Commission, 2020e).

The economics view of the current linear system is that resource scarcity will be solved by the market processes and price (profit) incentives (Aage, 1984). As a consequence of the increased scarcity of the raw materials that are needed, there will arise excess demands in the markets for raw materials and natural resources, which will lead to increases of their prices. The higher prices for raw materials and natural resources will next induce (profit maximising) firms in industries, such as the steel sector, to become more resource efficient using methods such as recycling. That is a practice that can been seen in the steel sector. According to PWC (2020) the main difficulty with this hypothesis is that market processes by themselves generate higher prices for raw materials and natural resources, is that these price increases will be too slow, and hence the induced innovation and structural change toward a more circular economy will be to slow to prevent negative environmental impacts (such as global warming). Therefore, the European Union has to create strong policy frameworks that will help to avoid negative (climate) externalities by strengthening the transition process toward a more circular economy.

The current crisis that is created in the steel sector due to the pandemic of COVID-19 shows that the steel industries are already really dependent on their suppliers as well as the downstream companies that buy their products. The fact the the automotive sector was severely affected with a 12%–15% dip in market in 2020 was a big hit for the steel industry as well (GlobeNewswire, 2020). Moreover, a similar example of the dependency of the industry in the other actors involved in the supply chain, can be seen by the crisis that hit the sector when the basic materials (iron ore) coming from Brazil decreased (Ker, 2020). In both cases the financial institutions played a big role on how the steel industry will effectively get out of these crisis and survive. These examples showcase that the steel industry is already deep interconnected with other actors. Thus, a positive change towards circularity in one of them will cause a positive impact to the steel industry.

One of the direct influences to the steel industry (to move towards circularity) comes from the banking sector. To be able to transform the existing production infrastructure (including global commodity chains) and to capitalize on the existing green technology as well put in motion pilot innovative projects that could lead to green industrial processes, capital investments are essential. Using the example of ABN AMRO, it is an opportunity for banks to become the mediator that brings together firms in the steel industry to provide knowledge on how to proceed financially towards a circular economy. To achieve circularity, there will be institutional changes that need to be taken into account, thus a mediator to help navigate the investments that need to happen between the industry is important.

3.5 | Summary

This chapter provides a better understanding of the actors involved in this complex issue and provides an actors inventory. The European Union, the European Steel Industry, the downstream producers (construction and automotive industries) as well as the banking sector, are selected as the main focus and are further analysed. In the analysis the different challenges that the steel instr is facing (such as cyclicality of the sector, the dependency on the Basic Oxygen Furnace (BOF)), the fact that Europe is becoming a net importer of steel as well as their interest regarding circularity) are discussed. Furthermore the downstream producers and the banking sector are analysed further and their relationship and interest in the transition of the steel sector is explained. In this chapter an actor map is developed as well as a circle of influence of the actors for a better understanding of their influence in the issue. In the actor map we see that there are lot of connections and dependencies, thus the change in one sector will be important for the whole chain. Also, it is shown that the bank plays a role in this transition since the need of capital is big. Having this information, in the next chapter the leakages in the current system will be identified with the purpose to understand the possible bottlenecks and uncertainties of this transition.

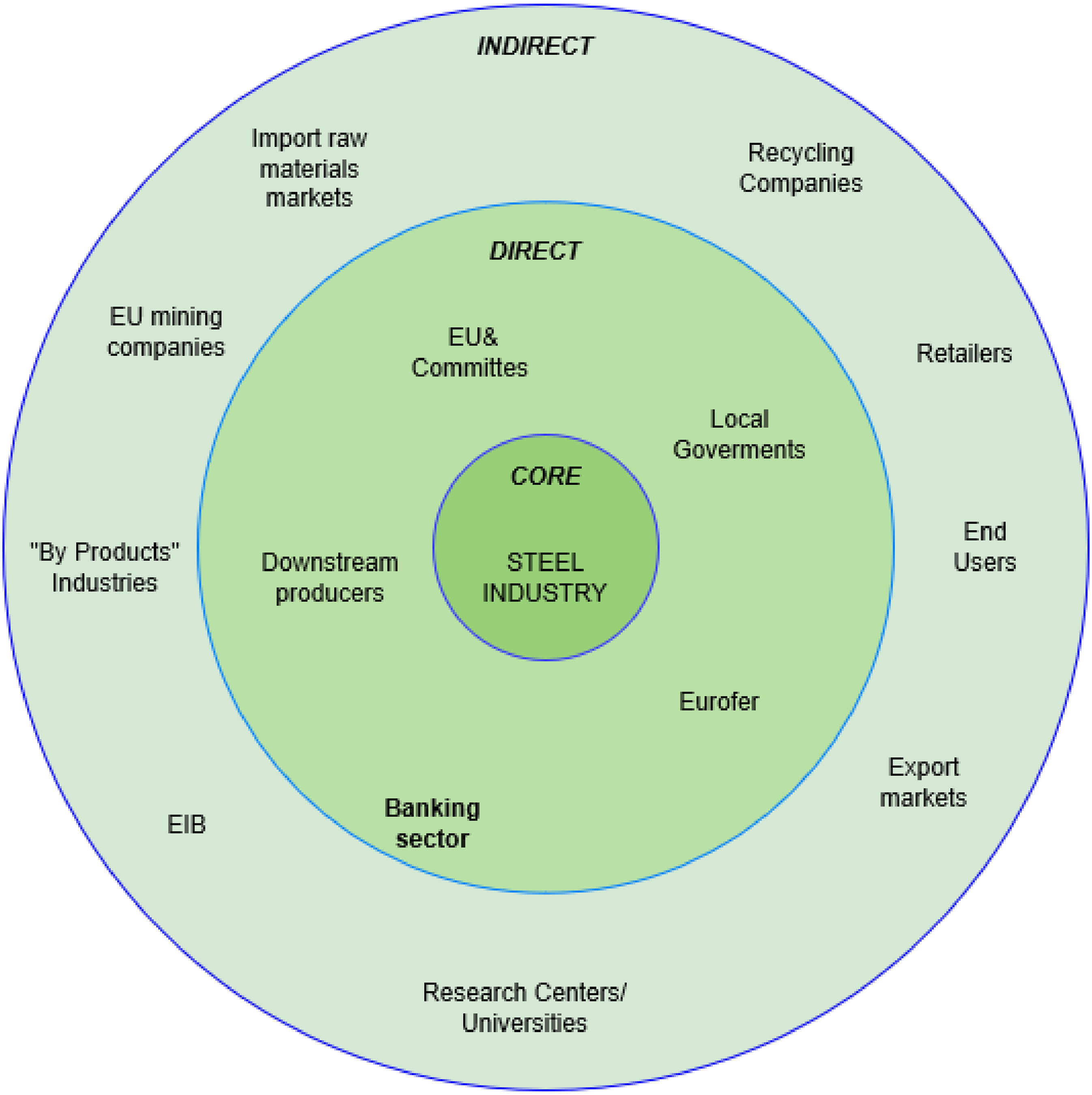

Figure 3.6: Circle Influence

4

A circular base case scenario of steel production

4.1 | Introduction

The key goal of this chapter is to identify not just the technical-physical material balances (of inputs and output flows) of the steel industry, but more specifically to identify the costs (and financial implications) of transforming existing linear steel-production practices into more circular ones. The intention is to identify points (or levers) where the a steel industry would need help from banks – either credit, or financial expertise, or bankers' knowledge of the larger global (steel) market. To be able to identify these points we will first consider linear steel production (as our base scenario) as well as the "leakages" from this system. Different technological solutions that can assist towards a "greener" industry are identified as well as the possible cost of implementing them.

From these alternative processes of steel making HIsarna, a technology that is developed by Tata Steel IJmuiden (TSIJ), is selected as an example of a more circular approach to steel production which can help identify the costs and trade-offs of this transition. The HIsarna technology could potentially be quite circular, since it allows use of biomass and bigger scrap input. A "linear" base scenario that depicts the cost of the conventional steel production is shown and two more circular-economy scenarios of the HISarna implementation are developed. The comparison of these scenarios and the information gathered in this chapter, lead to the development of a table that categorises the bottlenecks and uncertainties arising from this transition. These findings will be a tool to derive questions from for the interviews with specialists from the banking sector as well as from the steel industry that will follow in Chapter 5.

To be able to shift towards sustainability, the steel corporations in Europe have to become more circular and move towards decarbonization by:

- Utilizing the Best Available Techniques (BAT) and try to implement efficiency improvements
- Put in operation the circular economy values of Recycle and Reuse
- Achieve material efficiency[1]
- Use green electricity and renewable energy sources (wind, solar, biomass)

There are several reasons why it is hard to fully decarbonize and close the loops in this industry. For example, 45% of the CO2 emitted by steel production can not be altered by using green fuels but there is need for change in the industrial processes as well to eliminate the effects such as the smelting in the convention steel making (Material Economics, 2018). In general steel industries are capital intensive with their major facilities having a 20 years life span and complex and large installations. To change the industrial processes of steel production is not trivial since existing processes are closely integrated (Keys et al., 2019). Moreover, there is a need for increase of renewable energy capacity to be able to feed a green steel industry. Thus, all in all, there is an evident need for institutional planning and investments (public and private) to achieve a closed loop green industry.

To be able to identify the possible bottlenecks and consider different scenarios based on the HIsarna technology , the first steps is to understand the most common practices of steel production and how the supply chain of steel works currently. We

[1] According to Allwood, Ashby, Gutowski, and Worrell (2013) material efficiency is defined "the pursuit of the technical strategies, business models, consumer preferences and policy instruments that would lead to a substantial reduction in the production of high-volume energy-intensive materials". Specifically, in the case of the steel industry the emissions from the steel production can be mitigated the amount of the materials used and by improving the energy efficiency in the industrial process. Thus, making same quality products but using less material (Skelton & Allwood, 2013)

will do this by using the existing literature, and we will at the same time identify important "leakages".

4.2 | Convensional steel production

4.2.1 | Methods to produce steel

To produce steel, the industry needs iron, ore, coal, limestone and steel scrap. Scrap steel is in small supply due to the long life of steel as a product. As we mentioned above, currently there threet main methods that are used worldwide to produce steel:

- Blast Furnace method (BF): With the help of the basic oxygen furnace (BOF). This is the main route to produce steel currently, with about 70% of steel production coming this way. The main inputs of this production route are iron ore and coal. The majority of these raw materials are further processed to sinter, pellets and coke. These material are entering as inputs the BF and are processed to crude steel with the use of oxygen furnace (BOF) (Keys et al., 2019). To make sure that their recycling rates are high, industries in the process of BOF can also utilise a small quantity of recycled steel. The quantity that will be used is highly affected from the availability and the price of recycled (scrap) steel[2]. Moreover, there is also a technical limit on how much scrap steel can the BOF take depending on the utilization.

- The Electric Arc Furnace method (EAF): The main input for this process of making steel scrap, direct reduced iron (DRI), the combination of the two or hot metal and electricity. The method of EAF can be used with the utilization of only scrap (100%) as a primary raw material. Around 30% of the global steel production is developed with this method.

[2]It is important to mention that the scrap steel does not have a price of its own. It is highly affected by the commodity prices. For example when the price of CO2 is increased then scrap price increase as well. When electricity price increase that decreases the price of scrap.

- The Open Hearth Furnace (OHF), is an other method to process for steel making that can be used. Currently is the less used one globally, due to the heave environmental impact that creates. Thus, nowadays less of 1% of the steel is produced using OHF.

CO_2

4.2.2 | Why the steel industry has a good potential for circularity

The steel industry can potentially move to circularity, since the material (steel) by nature can be almost fully recycled and the steel production process generate usable by-products. The industry has capitalized that characteristic by trying to create markets for the by-products of the steel industry. A useful example for this is the use of slag, that is a by product of steel making, in the cement production. This way a "circularity" is created because it enables with result the mitigation of CO2 emissions for the industries that will use these by-products. The use of by-products as the main inputs for a new industry is consistent with the notion of Cradle to Cradle (TATA STEEL, 2020). Following this model, the "waste" produced from one industry constitute the new feed stocks for another one (TATA STEEL, 2020).

Moreover, in the value chain of steel, the circular notions of recycling, reuse and reduce can be found already. Metal is recycled and turned into scrap, and can be again an input in the process of steel making. The reason why it is a useful opportunity for the steel industry to furthermore expand its recycling and innovate is that steel scrap has the ability to be upgraded during the process of recycling into (relatively) high value new steel.

In addition to recycling, there is effort made within the industry for innovation with the creation of new types of steel that are stronger, but lighter. That translates in reduction of emissions due especially in the downstream production (cars e.g.) Furthermore it affects the transportation costs that becomes lower since the steel is lighter. Regarding the reuse of steel products, the construction industry has capitalized the opportunity of reusing elements of steel since less quality steel products are required[3]. To reuse already existing steel products is less intensive in terms of energy-use than having new products produced. Due to the durability that characterises steel, the circular value of reuse could be increased.

4.3 | Leakages in the current system

Even though the steel industry has considerable potential to be circular, currently it is not. The industry is energy intensive and responsible for a great amount of the CO2 emissions within EU (Hight-level Group on Energy-intensive Industries, 2019). Thus it is evident that there is need for change, but the best route that should be followed is not clear yet. In this section, the term "leakages" is referring to the losses on the energy and materials that are not completing a closed loop and maximize an opportunity for reuse and recycle.

4.3.1 | Production process

The main production processes currently are the main reason behind the heavy C02 emissions of the industry (Material Economics, 2018).To be able to mitigate this emissions, the European steel industries trying to put in place the Best Available Techniques (BAT) (European Commission, Industrial Emissions Directive 2010/75/EU , 2013). These techniques are helping on waste management, monitoring and maintenance, and help the reduction of the emissions. To implement the techniques it needs an investment from the industry and the implementation of these techniques can lead to a competitive advantage (European Commission, Industrial Emissions Directive 2010/75/EU , 2013).

Even with the use of the Best Available Techniques it is clear from the chart 4.1 that there is need for new processes that can lead to the actual decarbonization and closure of the material loops. There are emerging technologies such as the use of biomass as a feedstock or Carbon Capture Storage and/or Use (CCS/CCU) that the industry is considering as the future of decarbonization of steel .

[3] lower scrap steel quality has higher copper and tin concentrations. Scrap is used more often for lower quality steel grades, such as reinforcement bars (Haupt, Vadenbo, Zeltner, & Hellweg, 2017)

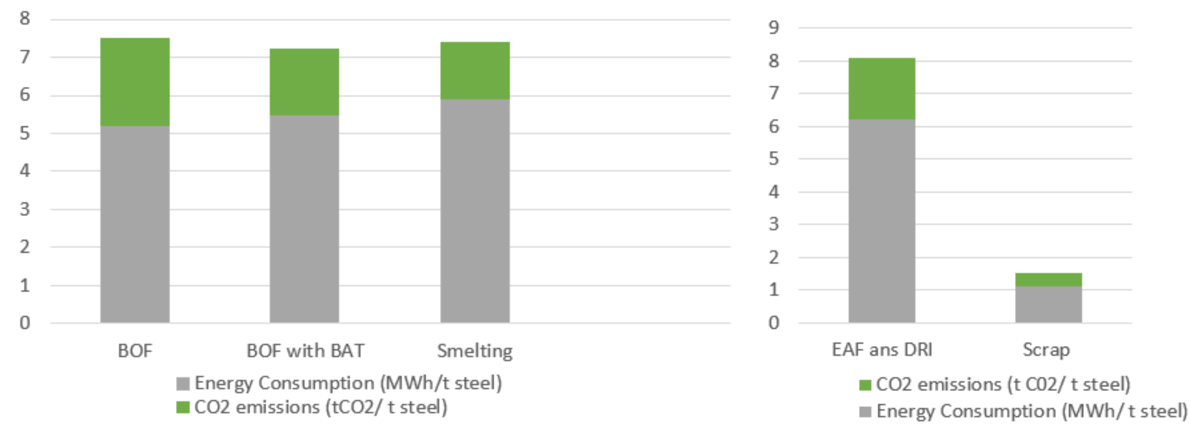

Figure 4.1: General impact of the steelmaking processes .(Commission, n.d.)

4.3.2 | Recycling and scrap steel

The steel industry is in a competitive position regarding the other basic material industries of Europe due to the characteristics of steel and the mature market (European Commission, 2020c). Currently there is not enough steel to cover the demand of the Union, so primary production is steel needed to cover the demand. Even though the European market is promoting the recycling of steel and the use of scrap for new steel making, a considerable quantity of scrap steel that could stay within the union is exported to the developing countries where demand is growing due to urbanization (de Miranda Pinto, 2019). Moreover, scrap steel is exported to third countries such as Turkey and USA where there are more Electric Arc Furnace (EAF) mills that can utilize bigger quantity of scrap. There is need for monitoring and measuring of the input to the recycling process.

Currently, in a world without boarders, the product modulation has increased as well as the economic arbitrage of materials and production costs. The products or components of different industries "travel" in a bigger value chain, with the result of an open loop since this products will not return back to be recycled in the end of their life time. It is important to be able to cover this geographic dispersion and to improve the traceability capacity across the value chain. This way we can monitor the full life circle of a product and collect reliable data regarding the waste and recycling in the sector.

It is vital for the steel industry within the European Union that steel producers take advantage of the opportunity to adopt practices that are closing the loops and increase the stock of recycled steel. There are leakages within the value chain regarding where are the products exported end up at the end of their life. To actively close the loop and move to a circular economy, it is important the the all the products are retrieved at the end of their life cycle. Moreover their is a leakage on how to keep the steel that is collected from contaminants and avoid the downgrading of our stocks in the future[4]. There is lack of incentive for the steel makers to feel that they could earn profit focusing on resource ownership (de Miranda Pinto, 2019).

4.3.3 | Life circle of steel

Even though there is effort both from the steel industry and the European Union to reinforce recycling and the development of products that are long lasting (European Commission, 2020c; EUROFER, 2020) there is still need for better implementation of circular thinking during the development process of steel.

4.3.4 | The EU ETS system leakage

As we explained above, the EU ETS system is characterised as a "cornerstone" policy to tackle climate change within the European Policy (European Commission, 2016b). However, despite the lofty intentions of this system, free carbon emission permits are allocated to resource and energy intensive industries such as steel. Due to this practice more than 90% of industrial carbon emission from these sectors has zero cost for these companies (Carbon Market Watch, 2019).

By allowing the use of free permits instead of having the companies acquire them through official auctions, the national governments and the European Union are losing money that could have been directed towards further investment to cope

[4]An issue with the current way of sorting at the end of life, is the copper contamination. Due to the fact that the demand for secondary steel was lower in the past, this issue was faced by putting new primary scrap in the market. In the future, that the demand of steel will be increased we will have to find ways to avoid this. The sorting of copper demands labour work and is costly thus there is need for clear planning to mitigate the issue (Material Economics, 2018)

with climate change. If emission rights are free, big emitters such as the steel industry do not have to face the cost of CO2 emissions – and this compromises their motivation to reduce emissions. According to the published report of Carbon Market Watch (2019), an environmental NGO, in the recent EU ETS revision, the "free" pollution permits that will be given amount up to 6.5 billion between 2021 and 2030. That translates in an absence of impactful price incentives in the coming years, for the energy intensive industries such steel to reduce their emissions.

One reason for the current situation is the fact that there is fear from the European Commission of Carbon Leakage. That translates according to European Commission (2020a), to the notion that: "for reasons of costs related to climate policies, businesses were to transfer production to other countries with laxer emission constraints. This could lead to an increase in their total emissions". What is though noticed is that the measure of the EU ETS system is loosing its value since the energy intensive industries including the steel sector are utilizing this situation to make substantial profits. Out the fear of carbon leakage, they get subsidies from the European governments (Carbon Market Watch, 2019). While at the same time they let their customers pay for the permit through their products price, even though this permit was free(Carbon Market Watch, 2019). Moreover, in several occasions steel industries have been accused for selling the "remaining" permits they did not use to other industries for additional windfall profit (BBC News, 2016).

In energy intensive sectors large investment in infrastructure happen every few decades (Carbon Market Watch, 2019). By having the EU ETS carbon price signal as low as EUR 10 per tonne of CO2 (between 2012 and 2018) (Carbon Market Watch, 2019) as well as allowing the miss-manage of the system, is hard to give clear incentive to the steel industry to move towards substantial green investments. According to (Ramstein et al., 2019), indicates that despite the fact that globally the number of carbon pricing schemes is increasing, there prices (including EU) is below USD 40-80/t price. In the report (Stiglitz et al., 2017) it is stated that " Efficient carbon-price trajectories begin with a strong price signal" otherwise the purpose of the tax (to incentive change) is lost.

4.4 | Key points of transformation

4.4.1 | Steel Production, implementation of alternative routes

The climate goals of the European Union are forcing the industry to make changes in the current processes to make sure that the CO2 emissions are mitigated. A lever to reduce the emissions could be through reduction of the demand while there is focus on material efficiency following the circular values. We can illustrate this using our equation for the steel stock:

$$S_t + 1 = St + NS_t - SCRAP_t$$

NS_t is the demand for new steel (products) and the more we can reduce NS_T - by increasing material efficiency (i.e. using less steel in products such as cars and buildings), the lower can be steel production and the lower will be emissions. A second strategy is to focus on the recycling of old (scrapped) steel, that is by using $SCRAP_t$ to produce NS_t, we can reduce resource use and CO2 emissions as well. This way there is focus on recycling and a sustainable design that leads to lighter steel products (David G, Frank W, & Simon, n.d.). But according to the literature, the most important way to effectively manage the goals of Paris COP_{21} Agreement comes through the decarbonization of primary steel production (Commission, n.d.). Furthermore, the European Industry does not plan for demand reduction since there are no incentives to do so nor are there specific reduction programmes (David G et al., n.d.; Hight-level Group on Energy-intensive Industries, 2019). Thus to look into a circular scenario for the European steel industry, we must look at key factors that could accelerate circularity and consider, the process that will lead to the Paris COP_{21} Agreement through primary steel making.

To be able to realise process changes, major investment decisions need to be taken. According to (Keys et al., 2019) the choices regarding available technology implementations, the investment in the further research of the ones that are not still fully developed and their implementation will have a big effect on the future of the European steel industry. The different decarbonization options are demanding infrastructure change at many levels. Some of the available options, do not require pre-processing units and some other options need a complete infrastructural change (hydrogen and electricity focused alternatives) (Keys et al., 2019).

The prices of the materials that are used as an input in the steel making process (raw materials) and the emission and energy costs that the industry will be called to pay, are key points to offset the cost advantage of current processes of Blast Furnace (BF) and BOF technology in favor of more circular production methods. The methods that will be chosen by every industry have to do with the geographical location of the industry and the electricity prices, the amount of scrap steel that is available but also the social acceptability of different alternative routes. The following are some of the prominent technically routes that can be followed:

The following are some of the prominent technically routes that can be followed:

- Carbon Capture Storage and Usage (CCS & CCU)
  This process can be an add on the existing steel making process. This addition can help to reduce the C02 emissions of the steel making. It is regarded as technically feasible and cost efficient in comparison with other process alternatives. The C02 emissions are separated from the process and should be compressed (even cooled in some cases) and then transported with the use of pipelines or shipping tankers to storage (Keys et al., 2019). The CO_2 that is stored can be also utilized for new products generating profit and create a circular economy model around the process. A good example for the utilization of the stored CO_2 is the project of Nouryon, The Port of Amsterdam and Tata Steel, together invested in a feasibility study regarding the hydrogen cluster in the Amsterdam region. These actors believe that hydrogen with the combined with CO_2 (developed due to CCS) can be useful for the production of chemicals (Port of Amsterdam, 2018).

- Hydrogen based iron making
  Different emissions due to the consumption of fossil fuel for the necessary heat and from certain feedstocks can be resolved by moving to zero-carbon hydrogen. Hydrogen can be generated by using zero-carbon electricity for the electrolysis of water. Existing DRI facilities could move to hydrogen. An example is the German steel producer Salzgitter which has prepared a

plan on how to achieve 80% emissions reductions by 2050 (Energy Transition Commission, 2018). At the same time the development of new hydrogen-based Direct reduced iron (DRI) is needed. This solution offers a promising great low emission pathway but to be implemented a big investment is needed since the industry will have to "start anew". Even though it is not commercial yet, the technology is promising since it is quite effective regarding the decarbonization of the industry. This process is selected because by investing in it and in the future implementing it, the European steel industry may be gaining competitive advantage.

- Use of circular carbon
  Plastic and bio-based municipal wastes, industrial and also agricultural waste can be used to fragment C02 and make ethanol that can be used in by products such as new plastic and fuels. To do so a catalyst technology can be used.

- Electrolysis
  Another option is to decrease the iron ore via direct electrolysis. This process is already used in the aluminum industry[5]. According to (Energy Transition Commission, 2018) : "Processes being researched include ones where iron ore is dissolved in a mixture of calcium oxide, aluminium oxide and magnesium oxide at temperatures of around 1600 Celsius degrees, and an electric current then passed through". The issue is that the technology is immature and in a lab phase.

[5]"During the reduction process, the oxygen content in the iron ore is bound to the carbon. The reaction produces raw iron and CO2. A commercially available alternative is the direct reduction process. Its product is direct reduced iron (DRI), which is characterized by its carbon content and a small amount of residual iron oxides. Existing commercial plants are predominantly fueled by natural gas. In a so-called reforming step, this feedstock is converted into hydrogen and carbon monoxide, which are both available as reducing agents for the reduction of iron ore. As a by-product besides CO2, water is formed. The partial reduction with hydrogen results in a significant decrease in CO2 emissions compared to the blast furnace route, because the oxygen is partially bound and emitted in the form of water. A potential pathway for a further reduction of emissions, and perhaps in future for the complete abandonment of fossil fuel sources, is the generation of the relevant reducing agents hydrogen and carbon monoxide via electrolysis from water" (IKTS, 2020)

- Biomass
  In the current production when there is use of BF and BOF, the process of iron ore reduction is dependent on carbon. The main resources used to provide this carbon are coal and coke (Mandova et al., 2018). That contributes greatly in the emissions of the steel making process. It is proposed that a more natural, circular alternative would be the use of bioenergy provided by biomass (through the use of municipal waste for example) (Mandova et al., 2018). On the other hand this method is criticised because it might be a circular way of thinking but it is not sure that will achieve the goal of mitigating $C0_2$. According to (PFPI Driven Data, 2020) " biomass burning power plants emit 150% the CO2 of coal, and 300 – 400% the CO2 of natural gas, per unit energy produced".

These alternative processes can be used to assist the transition to circularity in a European steel industry. The best route to move to decarbonization will be a mix that may vary within the sector and will be highly determined by the different local factors (De Pee et al., 2018). The solution of CCS and CCU is quite circular since the carbon emissions from one industrial process have the ability with this method to be used again for an other process. Even though the use of biomass as a replacement of coal is a more cost effective choice (De Pee et al., 2018), the limited biomass supply can result in bigger future cost for the industry.

Currently, due to the commodity prices(energy, scrap), the most cost - efficient choice is Carbon Capture Storage (CCS) combined with Carbon Capture Usage (CCU) where carbon storage sites are available (De Pee et al., 2018). In the future the use of hydrogen can be quite prominent and fully decarbonize the sector, but that will be highly dependent on what will happen to electricity prices. According to De Pee et al. (2018), if the steel sector switches to the use of green electricity (zero carbon) to produce hydrogen instead of the solution of CCS, the price of the electricity must not exceed USD 50 per MWh. Moreover, in the same analysis it is stated that the the cost of the decarbonization of sectors such as the steel industry will amount from USD 11 trillion to USD 21 trillion trough 2050[6]

[6]This result comes after an analysis of three levels of electricity prices. According to this research this translates to almost 0.4-0.8 percent of the global GDP per year (De Pee et al., 2018).

With data that are collected by the Basic Materials department of ABN AMRO, De Pee et al. (2018); Ghenda and Lungen (2013) the following model is created to showcase how different prominent technologies and solutions on current technologies could help the mitigation of emissions. In this display different research reports are consulted and their cases are used (De Pee et al., 2018; Keys et al., 2019; Energy Transition Commission, 2018). In the table the energy consumption and the CO2 emissions of the different options are shown. To enrich the examples with the understanding of the role and the uncertainties that different needed commodities can bring, the paper of De Pee et al. (2018) is used.

In this research a model was build to indicate the different cost of decarbonization options using the electricity price as main commodity in three different scenarios. These three scenarios are tested for a greenfield as well as as a brownfield. A greenfield site refers to the development of a new industrial location without any infrastructure and other facilities and utilities. A brownfield is an existing industrial location thus the OPEX and cost of alternation of existing infrastructure is considered (De Pee et al., 2018). In a greenfield location indirect investments to set basic utilities must be added to the costs. So to estimate the cost of decarbonisation of a specific technological choice, both the OPEX and CAPEX should be considered. For the scenarios in the paper a weighted average cost (WACC) of 8.5% is implemented. The WACC represents in one part of the rate of interest paid to banks (on loans) and the other part is the desired rate of return which shareholders wish to receive on their shares (the equity of the project). For this model the Capex estimates are annualized with an annuity formula with the use of real terms discount rate of 8.5% (De Pee et al., 2018).

Moreover Ghenda and Lungen (2013) computed the annualised capital (CAPEX) and operational costs (OPEX) of different technologies for a greenfield infrastructure. In the table, it is shown that commodity prices (specifically the electricity price) have an impact on the cost for different technologies. The table is developed using the models of De Pee et al. (2018) and (Ghenda & Lungen, 2013) as well as information provided by (Hight-level Group on Energy-intensive Industries, 2019) to give an insight on different methods that are welcomed from the industry.

	Driver	Unit	BOF (Basic Oxygen Furnace) - Blast furnace	BOF w BAT	BOF with Smelting reduction	BOF w Biofuels	BOF + CCS (Carbon Capture and Storage)	DRI (Direct Iron Reduction) - Feedstock Natural Gas	EAF (Electric Arc Furnace) - SCRAP ~100%	DRI - Feedstock Hydrogen	EAF with Zero Carbon Electricity
1	Alternative steel making technologies - Environmental footprint										
	CO2 Emission	CO2 Tons/ Steel Ton	2,3	1,7	1,5	1,1	0,9	1,1	0,4	0,1	0,1
	Energy Consumption	GJ / Steel Ton	18,7	19,8	21,4	12,5	n.a.	22,4	6,7	n.a.	6,7
2	Alternative steel making technologies - Cost of decarbonization options										
2	Greenfield @ WACC 8.5%										
	Low Electricity price @ USD 20/MWh	USD/Ton CO2	n.a.	n.a.	n.a.	15,2	60,9	n.a.	n.a.	17,4	17,4
	Reference Electricity price @ USD 40/MWh	USD/Ton CO2	n.a.	n.a.	n.a.	23,9	84,8	n.a.	n.a.	80,4	80,4
	Current Electricity price @ USD 65/MWh	USD/Ton CO2	n.a.	n.a.	n.a.	32,6	110,9	n.a.	n.a.	158,7	158,7
2	Brownfield @ WACC 8.5%										
	Low Electricity price @ USD 20/MWh	USD/Ton CO2	n.a.	n.a.	n.a.	56,5	65,2	n.a.	n.a.	60,9	60,9
	Reference Electricity price @ USD 40/MWh	USD/Ton CO2	n.a.	n.a.	n.a.	65,2	87	n.a.	n.a.	132,9	132,9
	Current Electricity price @ USD 65/MWh	USD/Ton CO2	n.a.	n.a.	n.a.	73,9	113	n.a.	n.a.	197,8	197,8
3	Alternative steel making technologies - Comparison of Capex/Opex										
	Capex	Euro/ton Crude Steel	170	n.a.	392,7	n.a.	n.a.	413,1	183,6	n.a.	n.a.
	Opex	Euro/ton Crude Steel	429	n.a.	441,87	n.a.	n.a.	570,57	489,06	n.a.	n.a.
4	Technology status										
			Conventional	Conventional	Convetional	Diverse-part of other pilot technologies	Towards demostration plants and commercialisation	In use	Smaller scale mills	Towards pilot-demostration plant	Conventional
5	Infrastractual needs in a brownfield										
						High	High	Medium/high (depedent on the application)		Hight (it can be lower if the H2 is produced inhouse)	

Figure 4.2: Different technologies and cost comparison (De Pee et al., 2018; Ghenda & Lungen, 2013)

4.4.1.1 | Costs and trade offs

According to the Energy Transition Commission (2018), the route of Biomass is harder due to the fact that not all the locations can supply the necessary demand for biomass. The paper, as well as the De Pee et al. (2018) indicates the following three parameters as key points for achieving deep decarbonisation of the steel industry:

- The costs of capturing carbon from BF-BOF furnaces (in the current infrastructure)
- The social acceptability and cost of carbon transportation and storage
- The cost of renewable electricity to produce hydrogen via electrolysis.

According to De Pee et al. (2018) the cost of the carbon capture & storage will be in the range of USD 50 to USD 100 per tonne of CO2. With the current electricity prices this solution from a cost point is more effective. For the technology of the Hydrogen reduction to become more attractive regarding the costs, the prices of electricity should not exceed USD 50/MWh in a greenfield plant. For greenfield plants that use biomass it should be below USD 20/MWh (Energy Transition Commission, 2018; De Pee et al., 2018). The break-even point between the application of these two new technologies in the existing BF- BOF furnaces (brownfield plants) is around USD 25/MWh and USD 20/MWh for plants using biomass (De Pee et al., 2018; Energy Transition Commission, 2018).

Of course, the cost of research and development of new technologies as well as the new infrastructure are included in the consumer prices. As is shown in the table, if we choose the average of the costs of the different decarbonization methods (in a greenfield of the reference case) it is around USD 60 per tonne of CO2. These data are derived from the research of De Pee et al. (2018), which estimates that this translates to an increase of USD 115 per tonne of steel. Comment: explain using your table that the carbon intensity is around 2 tonnes of CO2 per tonne of steel.

To meet this cost it is assumed that steel producers will have access to low electricity prices. According to Carbon Market Watch (2019) EU predicts that the future investments in energy systems and green energy need to raise and reach the level of EUR 520-575 billion annually. By investing in energy systems there will be a bigger availability of green energy in the future within EU. This way the total cost estimated by the paper is a cumulative USD 3 trillion over the next 30 years or USD 100 billion per year during 2020-2050 (De Pee et al., 2018; Energy Transition Commission, 2018). This is quite a large burden for the global steel industry. The annual value added (or GDP) created by the global steel industry is USD 500 billion (or 0.625% of global GDP, which is estimated to be around USD 80 trillion). The cost of decarbonization (of USD 100 billion per year) amounts to around 0,125% of global GDP, but to 20% of the annual value added generated by the global steel industry (Askerov, 2019).

It is important to notice the impact of the assumed WACC of 8.5% on the cost of the decarbonization choices (De Pee et al., 2018). The minimum rate of return for the investors will play a big role in what will be the "best" choice, since investments are needed from the companies to be able to transition. A higher WACC translates to increase in the costs and thus makes the implementation of a new technology less attractive. In the paper of De Pee et al. (2018) a very optimistic WACC of 8.5% is used but the WACC may become lower in the current financial situation and with the effect of Covid – 19.

4.4.1.2 | Bottlenecks in decarbonisation through new technological routes

The cost of decarbonization through alternative routes is not large for the global economy, but it is very substantial for the steel industry (equaling 20% of value added generated by the steel industry), in a way that can stop the industry from moving towards zero C02 carbon emissions. The prices and availability of the different needed commodities such as scrap still, energy cost and biomass will be an indicator for what technology is most fitted. Especially the prices of green-renewable electricity could be an issue. Some locations in Europe are better suited t for solar and wind production and that can create a difference between the electricity and steel prices in different locations. That concern can be put also in a global context, since in some parts of the world, the renewable electricity will be priced below USD 20/MWh even while prices are substantially quite higher in different locations (Energy Transition Commission, 2018).

In addition to the (variation in) commodity prices and the availability of scrap, biomass and other inputs, the social and political acceptance of the carbon capture and storage makes the feasibility of this solution harder in some cases. Also, from technical perspective not every location in Europe has available underground CO_2 storage capacity or is able to support a system like that (Energy Transition Commission, 2018). Moreover, many of these technical solutions are currently still in an immature (development) phase.

To be able to create the necessary environment for collaboration, and a regulatory system that support investments there is need for institutional collaboration between different actors in and around the steel industry to enable the transition to a circular production model, while ensuring the competitiveness of the steel industry at the commodity price level (Energy Transition Commission, 2018). Due to the important role of the location for the best route towards decarbonization, it is possible that there will a difference in the production cost per tonne of steel due to the difference in carbon prices in different countries. Thus, there is need for appropriate policies to offset unavoidable differences in costs.

4.4.2 | Circularity

The decarbonization of the sector is a process that is costly and needs time to be realised. Circularity and the mitigation of the demand for primary production can be an effective side measure that will lead to fast results (De Pee et al., 2018). Circularity is a key to achieve fast reduction on the emissions and mitigate the cost of transitioning for the economy (Energy Transition Commission, 2018). To be able to manage the Paris COP_{21} Agreement goals it is important to reduce the total demand of steel and/or to try to meet the current demand through scrap steel. In the literature it is found that the global annual carbon emissions from the steel industry could be mitigated (from to 37% to 52%) relative to the current way of running, if the industry would take the opportunity for more quality recyclable steel with scrap having a bigger share in the demand and try to innovate by delivering more efficient type of steel (Commission, n.d.; Material Economics, 2018). By changing the current common reductant agent (carbon) to scrap steel the industry avoids the CO_2 emissions during the production.

4.4.3 | Recycling, Reducing and life cycle

Recycling is an essential part of the transition to a CE model. To increase the extent of recycling in the steel industry, it will be important to implement the notion of Eco-design in the production of steel. By doing so, steel products will last longer as they become re-usable and circular. With the creation of eco-friendly design, lighter and stronger steel will reduce the amount of the waste. This might reduce the availability of scrap steel initially, but it will be balanced due to the Cradle to Cradle notion that proposes that no steel is ending up as a waste (TATA STEEL, 2020).

Every product has a life cycle. In the Figure 4.3 there is a simple graphic demonstration of the steel life cycle. Applying this way of design the goal is to create products from the beginning of their life cycle until the end[7], that can be

[7]According to (PWC, 2020) the " The end-of life of a product represents value leakage as important by-products are not collected for productive use. Instead of leaking value by discarding products and materials after use, the circular economy stops this value leakage in order to yield more value."

recycled completely and with an easy way. To implement both the Eco-design and Cradle to Cradle notions fully, there is need for capital that is directed to R&D. To achieve a design that is targeting the treatment of the products in the end of life, investment only from the steel industry is not enough. There is need for collaboration with the rest of the industries involved in the supply chain, since the steel products will be used by them. So, the design that is used in the steel production is quite connected with the need of the downstream producers.

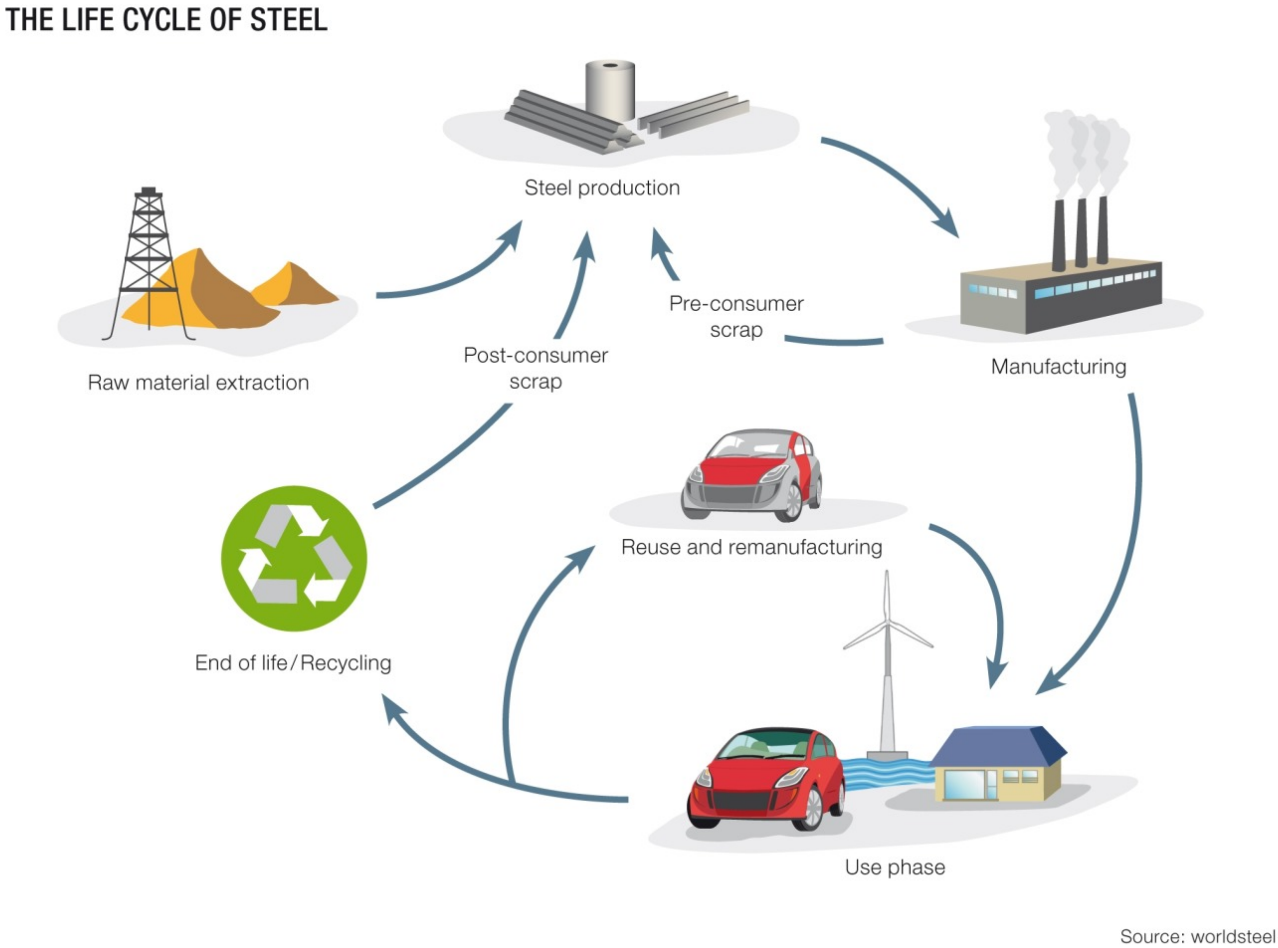

Figure 4.3: The life cycle of steel, source: worldsteel

By managing the demand with more intense use of steel based products, with better and more quality scrap products and redesigned products for material circularity, the future steel industry will be able to contribute on the C02 emissions reduction (Commission, n.d.). In the Figure 4.4 there is a comparison between three different scenarios for steel (with global focus) that shows that the impact of measurements that introduce circularity and help in the control of the demand, have a positive impact. The "Current Scenario" depicts use of the conventional methods with the combination of BAT while the "Circular" scenario is based on the assumption that there is increase in recycling as well as in material efficiency (with reduction of steel across the supply chain) (Energy Transition Commission, 2018).

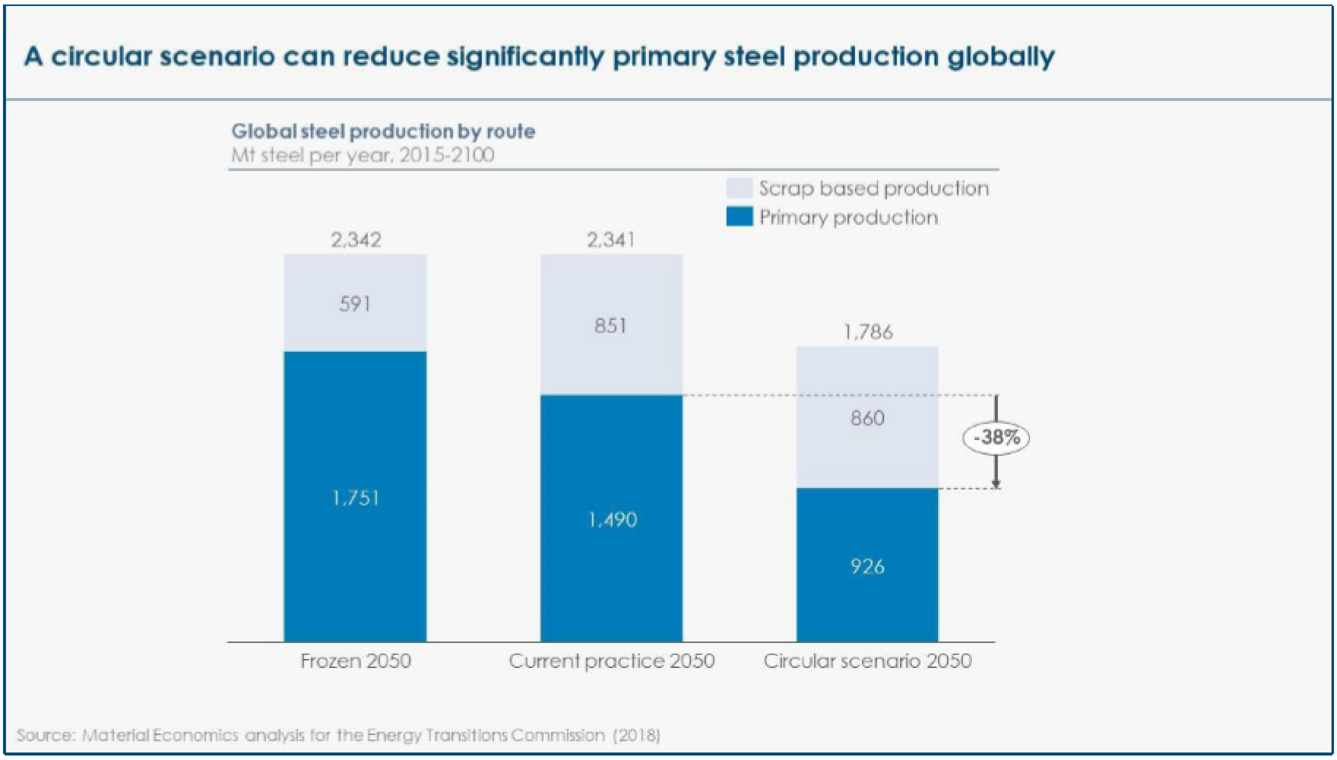

Figure 4.4: Impact of circularity to the global primary steel production,(Energy Transition Commission, 2018)

4.4.4 | Recycling and traceability

As it is mentioned in the above section, to increase circularity of materials, we have to be able to have an overview and access to the whole life cycle of a product. Currently in EU even though the rates of the recycling steel are quite high (around 70%), we do not manage to keep it within Eu and that means that the industries are not in control of the end of life of this products (de Miranda Pinto, 2019). The traceability of the steel could be optimized and help to solve this issue. To achieve that, different technologies such as the implementation of IoT (Internet of Things), Blockchain Technology and current collection of Big Data could be used. This way, the ownership of the steel producer [8] is increased and the leakages due to products that end up in the lad field in countries with less developed waste system are mitigated. Moreover, the collection of materials is easier due to the implementation of digitalization and the reverse cycle infrastructure and logistics. In an linear economy model, the collection of recovered steel and virgin materials, would happen only locally with small ability to collect and separate materials in a way that the quality and the purity of the material is safe- guarded. With implementing digital technologies in the production this scenario of a circular steel industry is mitigating the following issues:

- Leakages of steel that are not recycled. According to Material Economics these losses amount approximately to 150 Mt of steel in Europe currently, with primary production unnecessarily increasing to fill this gap(see the equation chapter 2).
- The downcycling of steel[9] Recycled steel is typically lower quality and value than the primary one. This downcycling is happening due to "tramp elements" in the recycled steel (Energy Transition Commission, 2018). An example is the steel that comes from old cars that can contain contaminates.

[8]With the notion of ownership, we describe the idea that the steel industry has access to the whole life cycle of the product and responsibly to what happens at the end of this cycle.

[9]In this point is helpful to introduce the difference between upcycling of steel and downcycling. The upcycling of products happens when leftover excess material is reused for an other product, increasing the value of a product (excess steel pipes transformed to art). With upcycling we prolong the life of materials. Downcycling can happen we we process again materials that contain contaminants due to prior use.

> Currently the natural downcycling is not an issue since there is sufficient demand for basic steel products, it might be a barrier in the future if we aim for 100% recycling (Energy Transition Commission, 2018).

Thus, to create circular steel industry the investment is required to make sure that there is a reverse cycle flow (products come back to life either with recycling). This way the industry will develop better collection systems of end life material (improved separation), improved alloy shorting and mitigation of remelting leakages (Commission, n.d.).

4.4.5 | A circular scenario for the European steel industry

So far different points that need to be addressed have been collected. To be able to identify the bottlenecks of transitioning into a greener steel industry and how the banking sector can assist this change, the case of Tata Steel IJmuiden (TSIJ) is used. The reason for this selection is that this industry is based in Netherlands, is a current client of ABN AMRO and is a participant of the ULCOS (Ultra Low Steel Making) programme with the technology of HIsarna. Moreover, since this head office company of Tata Steel is located in India, there is a fear for "carbon leakage" – if EU regulation become too costly, the company may relocate to another – non-EU- location or if a new circular technology (such as HIsarna) is fully developed, the company may use that technology in its non-EU production facilities.

The specific steel producer is using a blast furnace production process for production with coal as the primary energy source (Keys et al., 2019). The European plant of the company currently is producing approximately around 7 million tonnes of steel per year. The product portfolio of the company consists from Strip Products (HR, CR, Galvanised, Coated, Plated & Precision), Tubes and Electrical steel.

4.4.5.1 | Linear model

Using the data from the financial report Tata Steel NL BV (2017) and sustainability report of Tata Steel NL BV (2018) for the fiscal year 2017, assuming a linear environment, the Table 4.1 was developed. Tata Steel IJmuiden is required to change the way they produce steel, so they can achieve to meet the goals of the climate agreement for 2030 and 2050. The issue for the company is the need for significant reduction of CO2 emissions, which is a change that according to Keys et al. (2019) is requiring more investments than ever.

To be able to calculate the current investment capital the operating approach is used:Net working Capital + PPE (Property & Equipment Plant) + Goodwill + Intangibles

The Net working Capital is calculated as the difference between the Current Operating Assets and Non Interest Bearing Current liabilities

The capital expenditures (Capex) for the fiscal year of 2017 were EUR 323 millions. According to Tata Steel NL BV (2017) a part of this amount was given to the Asset Roadmap Programme STAR with the aim of strategic growth of differentiated, high value products in the automotive, lifting and excavating, and energy and power market sectors.

4.4.5.2 | HIsarna Project

In 2004 Tata steel joint a group of European steel companies and researchers that are working for the project Ultra Low CO2 Steelmaking (ULCOS). The project translates to Ultra Low Carbon Dioxide Steelmaking and tries to identify how the steel industry can innovate and develop technologies that will half the CO2 emissions by 2050 (Tata Steel, 2020). The group is developing in their premise the technology called HIsarna. This technology is quite promising and comparing to the rest of the ULCOS project is close to realisation in large scale. In the Appendix A more details are given on the cost and CO2 emissions of the different technologies developed in the programme. There it is shown that the technology is quite resilient regarding the changes is electricity prices.

HIsarna optimizes the steel making process by eliminating the pre process of coking and agglomeration. This way, it effectively mitigates the CO2 emissions

Table 4.1: Linear Production, course: Financial report Tata Steel IJmuiden (TSIJ) BV (2017)

Indicators	Units	FY 2017
Total Assets	EUR m	1514
Net Assets	EUR m	2604
Raw materials cost	EUR m	2140
Labour cost	EUR m	964
Equity	EUR m	2604
Operating Cost (OPEX)	EUR m	4285
Capital Expenditures (CAPEX)	EUR m	323
Investment Capital	EUR m	3479
Total crude steel production	million tonnes	7
Production cost	EUR m	3104
Production cost per (crude) steel unit	EUR/tonnes	443,42
Emissions rights deficit	EUR m	11
Steel recycled	1000 tonnes	1,1192
Waste generated	1000 tonnes	228
Waste re-used through internal process (excluding scrap steel)	1000 tonnes	1,142
Waste-material reused, recycled by third parties	1000 tonnes	187
Energy intensity per tonne crude steel	GJ/tcs	20
Carbon intensity in tonnes of CO2 per tonne of crude steel	tonnes/ tonne	1,86

from steelmaking. The technology is quite circular since it aims to use 50% scrap steel (Keys et al., 2019) which is twice the current theoretical maximum of a Blast Furnace. Moreover, it has the potential of zinc recovery from coated steel scrap.

Moreover, combined with the technology of Carbon Capture Storage and Carbon Capture Usage could lead to a total CO2 saving of 80% (Tata Steel, 2020). So the different scenarios according to TATA Steel and their environmental contribution are the following

- At least 20% reduction of CO2 emissions without CCS/CCU
- At least 50% reduction of CO2 emissions with scrap & biomass
- At least 80% reduction of CO2 with CCS/CCU

The HIsarna technology is the scenario and future plan of Tata Steel to become more circular and reach a significant CO2 emissions reduction. According to Keys et al. (2019), except from energy and carbon savings, that lead to cost reduction,the technology helps in the elimination of 90% of the process phosphorous to slag. This is cost beneficial because it allows the usage of cheaper, high-phosphorous iron ore that currently in the conventional processes can not be used.

4.4.5.3 | CO2 emissions and circularity in different scenarios of HIS-arna

In the diagram 4.5 different scenarios of the use of HIsarna and the CO2 emissions are depicted. The first case we see, is the base case for the ULCOS programme, that depicts the CO_2 emissions from a convectional BOF. The second case is the result of the calculations of the 2010 pilot plant that was constructed at Tata Steel IJmuiden. The rest of the scenarios show different future outcomes when we increase the circular characterised of the technology (with usage of scrap and biomass). As it is shown, the more circular the use of the technology is by using a bigger amount of biomass and scrap steel, the bigger the CO2 emission reduction.

4.4.5.4 | The capital expenditures on HIsarna

HIsarna will require lower capital investment costs (CAPEX) and will produce semi-finished products (referring to pig iron) compared to other developing technologies of the ULCOS program with small operational costs (OPEX), with lower energy consumption (Croezen & Korteland, 2010). Furthermore,the technology is capable to use lower quality thus cheaper feedstocks that is cost beneficial compared to other break through technologies (Croezen & Korteland, 2010).

The technology is not yet in industrial scale and so far with the current plant of HIsarna producing 60,000 tons of pig iron per year. By 2017 that is the year of focus, over EUR 60 Million have been invested in this technology (Tata Steel, 2020).

The paper of (Keys et al., 2019) is used to indicate a possible range of the overnight investment for the infrastructure of the project with and without Carbon Capture

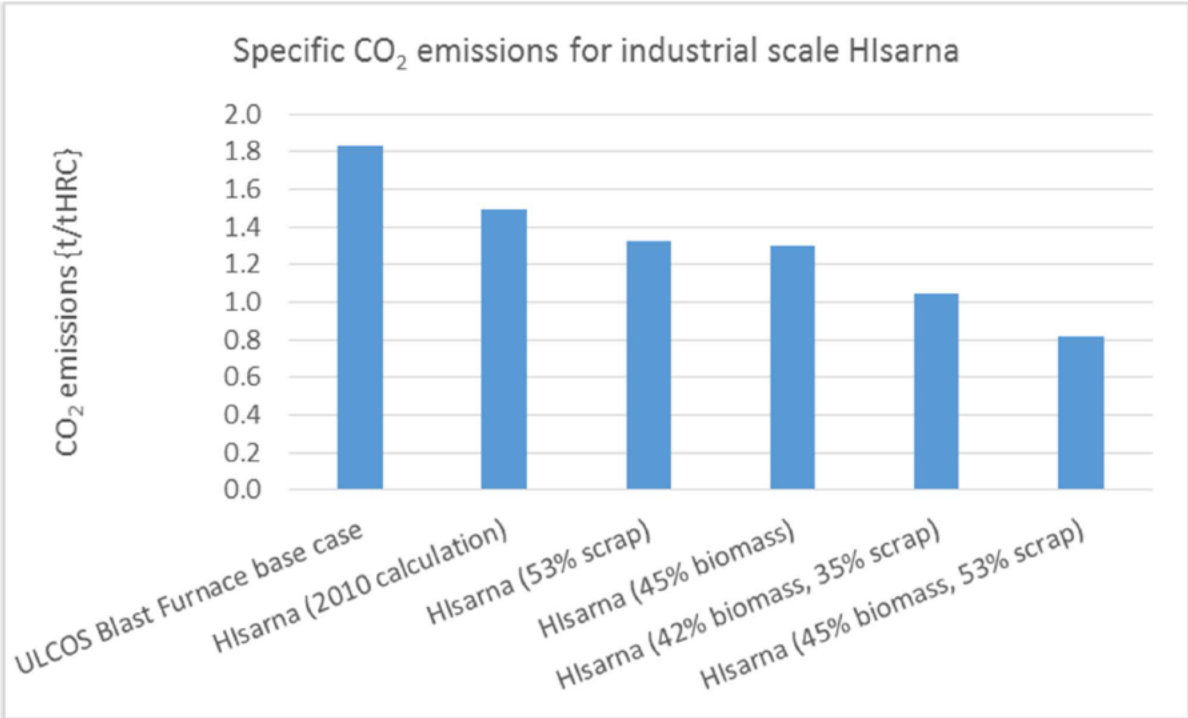

Figure 4.5: HIsarna CO2 benchmark calculations .(Van der Stel et al., 2018)

and Storage as well as the conventional Blast Furnace. In this case the emphasis is in circularity, thus the technology of Carbon Capture and Storage that can lead in utilization of the carbon is important. To calculate the ranges of total overnight investment costs[10] the paper is using a discount rate of 5% - 10% and a universal equipment lifespan of 10 - 15 years are inputted. Due to the fact that these technologies are in a premature state it is hard to predict the absolute cost ranges(Keys et al., 2019).

As it can be observed by the model this circular solution compared with the traditional Blast Furnace is offering a reduced OPEX (operating expenditure) and CAPEX (capital expenditure). Moreover, in this technology the costs could be

[10]The overnight investment costs is a way of comparison of the costs of building new plants. According to (Keys et al., 2019) "the European Commission (2016) provides the annualised investment capital costs and is absent of the associated discount rate or equipment lifetimes assumed to convert this to an overnight investment capital cost." It is important to mention that this is a more simplistic way of calculation and it does not depict the actual prediction of construction cost (Rocky Mountain Institute, 2012)

mitigated by the application of low grade iron ore (ores with P, Zn, S, Ti or alkali) (Croezen & Korteland, 2010). Furthermore, the use of industrial waste such as plant oxides or mining reverts can be used lowers the costs and closes the loop.

In general the fixed costs in greenfield plants with a new technology that will produce in the future cheaper steel initially can be higher. Thus, it is important in the early stages that there is organised effort for funding technologies such as HIsarna so they can transition to a mature level. The success of demonstration project of the technology is involving substantial risks depending on the cooperation and support from industrial partners (such as ULCOS) as well as adequate public funding (Van der Stel et al., 2018).

Indicators	Units	Linear BF	HIsarna	HIsarna &CCS
total crude steel production	million tonnes	7		
Recycled steel	1000 tonnes	1,1192	30% to 53%	30% to 53%
Total CO2 emissions		12,97	20,00%	80,00%
Investment Capital	million euros	3479		
Capex (Brownfield)	million euros	323	65,00%	
Capex (Greenfield)	%	100%	75,00%	
Opex (excl depreciation cost) including energy	million euros	4285	90,00%	90,00%
Annual Operating Costs range (excluding energy)	EUR(2017)/tonHRC	255	290	300
Raw Materials annual operating costs range	EUR(2017)/tonHRC	200	220	220
Overnight Investment costs (ranges)	EUR(2017)/tonHRC	750-1150	700-1100	750-1150
Needed aditional Investment for demostration plant	million euros		300-350	320-375

Figure 4.6: Indicators of the current linear process, HIsarna and HIsarna with CCS implementation scenarios

4.4.6 | Bottlenecks to circular transition based on the Tata Steel case

Using the points gathered in this chapter and the case of Tata Steel and the HIsarna technology the Table 4.2 was developed. There the main bottlenecks that were identified are classified in the following three categories:

- Technological
- Economical
- Institutional

Table 4.2: Hypothesis: Identified bottlenecks to a circular production of steel industry using the case of Tata Steel IJmuiden (TSIJ)

Technical Challenges	**Economic Challenges**	**Institutional Challenges**
Availability of commodities (scrap, green energy, biomass)	Rate for return for investment	Property Rights Between Investors (risk allocation)
Availability of CCS locations within EU	Commodity Prices within Competition	Carbon Leakage Fear
Slow rate of infrastructural change in steel industries	Required investment for scale up of pilot the Technology (EUR 300-350 m)	Linear supply chain
	Investments in R&D for implementation of Circular production models (Eco design, Traceability)	Social Feasibility of CCS

4.4.6.1 | Economic Bottlenecks

To be able to achieve the rise in the recycling they industry needs to undergo significant changes in industry practices. These changes need to be supported by changes in regulation (Energy Transition Commission, 2018). To adopt a more circular approach there is need for improved systems regarding the collection of end-of-life materials. There is need for investment in technologies like IoT that could improve the traceability.

Regarding the processes there should be redaction of primary steel creation by implementing Eco- design principles and better product design, with methods such enabled 3D printing and powder metallurgy. According to (Energy Transition Commission, 2018) currently the product designs are not focused on end-of-life recycling processes which make it easier to separate copper from steel. Moreover, the current technologies as well as the regulatory system do not help in an optimal the separation of different alloys.

Moreover, there is need for more circular technologies that eliminate the harmful pre stages of iron making. Having the case scenarion of Tata Steel IJmuiden, the cost of implementing a technology like HIsarna in the future when it will be in a mature state are not out of consideration since they are similar with a new Blast Furnace in a greenfield. The possible barrier is that in this stage the investment that is needed for the technology to be scaled up is between EUR 300-350 million. This is an substantial investment that is requiring a better funding mechanism that involves also public funds (Dutch Government and EU) to support a large scale demonstration. The support of the banking system in this effort is crucial. According to Van der Stel et al. (2018) "Bankability is an important keyword".

4.4.6.2 | Technological Bottlenecks

Scrap and biomass availability will be a big factor in the scale up of the HIsarna steel making. In USA there is a bigger availability of scrap and that means that they can achieve the Paris CO_2 Agreement, based on scrap availability and the usage of EAF with scrap. Due to high production and low scrap availability, the EU will struggle to reduce their primary demand. Biomass availability will also play a role in how much biomass will be used from HIsarna and thus how circular this technology can be. Moreover, the prices of these commodities will affect the choice of which technology can be established in a specific location.

A potential bottleneck of the adaptation of technology like HIsarna that has circular positive impacts (increase of scrap steel and biomass usage, Zinc recovery) is that is not trivial to penetrate the European steel sector. According to Energy Transition Commission (2018) the expected increase of steel consumption within the European Union is marginal. Thus, current production is covering it. Furthermore, steel industries are usually maintain the Blast Furnace to increase the life spam of their plant. The cost of maintenance is around 50% less than the investment needed for a new furnace. That leads to slow rate of replacement of the current facilities and opportunities for new plants and thus HIsarna will be focused mostly on substitution of old plants. There is need for strong legislation to achieve a faster rate of replacement and thus penetration in the market of more circular technologies.

4.4.6.3 | Institutional Bottlenecks

In the development of the HIsarna technology as well as in all the technologies under the umbrella of the ULCOS programme, different industries and the European Union co-sponsor the development of these innovative technologies. More specifically in this case, until 2017 EUR 75 million have been invested in developing HIsarna (Tata Steel, 2020). The partner companies have invested 60% and the rest is covered by the European Union. This co sharing of a breakthrough technology is a new R&D innovation model that creates different interdependencies regarding the property rights on the new technology. Moreover, it is important to clarify the allocation of possible risks from this co- sponsorship.

An other challenge is to make sure that the institutions and incentives put in place to push the industry towards a greener production will not lead to "carbon leakage". In the case of Tata steel, there is a risk that after the HIsarna technology is in the phase of industrial scale, it can be established in India. The European Union is dependent on the steel industry and thus having a leakage of innovative technology to countries outside of the EU with less strict environment regulation is a valid fear (European Commission, 2020a). So it is a question how to navigate between institutions that help the industry transition and how to make sure that there financial incentives for them to stay within the European Union.

4.5 | Summary

In this chapter a description of the steel making production is given, to provide a deeper understanding of the available methods as well as where the steel industry already applies already values coming from the circular economy. The "leakages" in the current system are identified and the key points of transformation that could lead to a circular industry are provide. This work helped in the development of a circular base case scenario for steel production. To create this case the existing example of Tata Steel Ijmuiden (TSIJ) is used. An estimation of the financial linear financial environment is given, as well as an estimation for the required financial cost for Tata to adopt a more circular production by scaling up a pilot circular technology. This case provided a better view on the technical and financial points of transformation and led to the development of a hypothesis that includes the possible bottlenecks that a European steel industry will face during their transition to circularity. With the use of the institutional economics mindset, these bottlenecks are separated in three categories: Technical, Financial and Institutional. This bottlenecks will be used in the following chapters to create a conversation with main actors from the policy, steel and banking sector.

5

Interviews

5.1 | Introduction

In the previous chapter with the use literature and the example of HIsarna, different possible bottlenecks that can affect the transition of the steel industry into a greener more circular production were identified. Using these bottlenecks and the example of Tata Steel Ijmuiden (TSIJ), with the development of HIsarna technology as a hypothesis, a set of semi structure interviews was conducted. This chapter gives an understanding on the way the interviews are structured and the limitations of the method are explained.

5.2 | Semi Structure Interviews

As it was discussed in Chapter 2, the method that the topic is approached is inspired from the theories of the Institutional Economics. The transition of a traditional industry such as steel, to a greener more circular production is "born" from the change in the regulation and the available technology. This change is perceived different from the actors that play a role in the system. Even within the same organisation, different perspectives co exist and the different specialist view the issue from a variety of angles. Currently we are in the age of information and it is important to gather the necessary knowledge to understand the opening of an industry to a new market (a greener more circular one) (Glachant, 2012). In chapter 3, a hypothesis is developed using the case of HIsarna (Tata Steel NL) to set 2 scenarios of a different more green steel production and help identify possible bottlenecks from institutional, technical and economical view.

Having an constructivism approach, the bottlenecks that are identified in Chapter 3 should be validated and discussed with the aim to improve them and create knowledge through the insights of different actors. Thus, semi structured interviews are conducted with one or two responders per time (same organisation), using a mix of closed and open ended questions to enrich, discuss and valuate this hypothesis. During the interviews if there is a need for extra clarification, follow up questions are made. The interviewees come from the Banking sector (ABN AMRO), steel industry (TATA Steel NL) and the Rocky Mountain Institute (RMI)[1]. The majority of the respondents comes from the banking industry. This is due to the fact that that the "problem owner", the focus of interest is the banking sector and how they can be part the transition of their clients. The respondents include the directors of the following departments as well as a specialised coverage banker of the steel industry:

- Basic Material Department (client coverage)
- Sustainable Banking
- Green Bond Desk
- Central Sustainability Risk

The first participant of the steel industry comes from the Financial department (treasury) and the second on from the team that works on the green transition of the sector. The results of their interview are presented in one table. This choice is made due to the fact that the information provided by the two participants is represented in a more complete way if it is combined since their knowledge is sector

[1] "RMI is an independent, nonpartisan nonprofit co founded in 1982 by Amory Lovins, RMI's chairman emeritus and chief scientist. RMI engages businesses, communities, institutions, and entrepreneurs to accelerate the adoption of market-based solutions that cost-effectively shift from fossil fuels to efficiency and renewables. They employ rigorous research, analysis, and whole-systems expertise to develop breakthrough insights. Then convene and collaborate with diverse partners—business, government, academic, nonprofit, philanthropic, and military to accelerate and scale solutions (Rocky Mountain Institute, 2020) ".

specific. The same structure is followed with the two participants from the Rocky Mountain Institute. This actor was chosen due to their deep knowledge of the global steel industry and the policies that push towards sustainability. The fist participant is from the RMI Global Finance Group and the second one is leading the RMI Industries Program that is a global programme to engage with industries to find ways to accelerate their decarbonisation technologies. This programme is part of the Energy Transitions Commission, which is working on mobilising steel industries to understand the challenge and committee in a solution pathway (as well engage with heavy industry assets to help them in the transition).

5.3 | Analysis

The interviews were transcribed and analysed. The main questions and the flow of the interviews were mostly same for all the participants but different follow up questions were made in responose to and line in with the interest of the participant. The interviews aim to collect qualitative empirical data with a focus on getting insights on the different identified bottlenecks. The interviews are separated in two parts. In the first part of the interview there is a set of questions that aim to gradually bring the contestant to the topic and to identify some of following points:

- "bankability" of the steel industry
- understanding of the main products (current relationship) that the steel sector is provided by the bank
- perception of the participant regarding the transition of the steel sector
- The impact of the prominent transition of the steel sector to the industry of the participant

The second part of the interview is introduced with the explanation of the Tata Steel NL case and the technology of HISarna, our table with the different scenarios (Figure 4.5) is shown and explained. With this figure an introduction is made to the specifics of the case regarding the impacts of changing production using a more circular and greener technology on the CO2 emissions levels as well as the financial costs involved. After this introduction the Table 4.2 is used as the center of the conversation. The participants are asked a number of questions that arise from this table. It should be noted that the case of HIsarna is used as an example to make the conversation and the questions more specific and thus easier for the participant to answer.

5.4 | limitations

There are a number of limitations regarding the interviews. The biggest challenge was due to the COVID-19 crisis. It was hard to find participants who had available time for an interview. The European steel industry unfortunately is one of the sectors with major damage due to the lock-downs that took place globally that destructed the normality of the supply and demand. This thesis made use of the case of the Tata Steel NL due to the fact that is an international company with presence within Netherlands. Thus, during the current climate two employees of Tata Steel NL (a specialist in finance and a specialist on the transition of the company) were interviewed. In a future research it would be important to include participants from more European steel industries Moreover, due the situation, the appointment for an interview with one Dutch policy maker with focus on circular economy was cancelled. To better analyse the political and institutional dimensions of the bottlenecks it is important in future research to address politicians from EU member countries .

Moreover, the choices of the participants were made with the aim to talk with strategically positioned people who play a role in the European steel industry and the EU banking system. The decision was made after consultation with ABN AMRO. There are without a doubt, more players who could have been interviewed to get more insights, but due to the lockdown and the time limitation of the thesis the choice is made to focus on the banking sector. Moreover, due to the fact that each participant answers with his/her own knowledge and perspective there might be some bias in there answers. For example, the participants from the banking sector belong to the same company and departments that have an understanding of the value of a more circular steel industry. It is possible that in other banks within Europe this understanding is less.

Furthermore, due to the guidelines for data protection, after considering the wish of the respondents to remain anonymous, the participants description of specialisation is given in this chapter, but in the results (Chapter 6) the interviews are presented with random order and without any data regarding the participants.

6

Results

In Chapter 3 different categories of bottlenecks of the steel transition have been identified based on a case-analysis of Tata Steel IJmuiden (TSIJ). The hypotheses concerning the proposed bottlenecks are based on the transition of the company from a linear production model (as seen in Table 4.1) to a circular production model (as illustrated Table 4.6). The identified bottlenecks are validated through semi-structured interviews. The results of these interviews will be presented in this chapter and further discussed and analysed in the following (Chapter 7). The findings of the interviews represent missing information, feedback on the identified points and additional interesting information that give a better understanding of the case. Based on the findings of these interviews adaptions have been made to our final classification of constraints on the transition of the EU steel industry to circularity. At the end of the chapter some common terms identified in the interviews are discussed and a deeper analysis of the is provided in Chapter 7.

[1] For a bank is hard to be part of an investments in the scale up of a pivotal technology since it is not certain that the scale up will be successful. Thus, in this cases public sector could play a role, by providing subsities or playing a de-risking role. By doing so the public sector through Export Credit Agencies covers the CAPEX of a project like that while the bank participates by covering the project. This is a safe way for the banks to be part of these investments. From the other side, it is more beneficial for the banks since the avoid the risks but still have profits

[2] In the literature this statement could not be validated. This is a quite big increase in OPEX

Table 6.1: Results of the first interview (Banking Sector) regarding the Hypothesis: Identified bottlenecks to a circular production of steel industry using the case of Tata Steel IJmuiden (TSIJ).

Category	Findings
Missing information (bottlenecks)	Cost of recycling (it is more cost beneficial to produce primary steel) The Credit Rating of the company(see section 6.1) It is an important factor for the investors; thus companies that have a low rating or are new to the bond the market will have difficulties to access "green" finance The size of financing Small companies with breakthrough technologies can not attract institutional investors
Points on the identified bottlenecks & Feedback	The involvement of public funding might be beneficial to make the sustainable financing more accessible. Moreover, the initial cost of investment to scale up HIsarna is an issue since the bank would not get involved in a project like that. The cost would have to be covered from the cash flows of the company.
Steel industries are riskier to include within the green products. Additional interesting information	A Green Bond might not apply for the steel industry but a Transition bond is more feasible. The rate of return would be similar to a green bond (see section 6.1).

Table 6.2: Results of the second interview (Banking Sector) regarding the Hypothesis: Identified bottlenecks to a circular production of steel industry using the case of Tata Steel IJmuiden (TSIJ).

Category	Findings
Missing information (bottlenecks)	Lack of a clean long term umbrella policy as well as a taxation on the imports of steel from outside the EU Credit worthiness
Points on the identified bottlenecks & Feedback	The availability of CCS space is not the main issue since there are ex oil and gas stations offshore in the North Sea (close to Tata Steel) that could be utilised to store carbon. The issue there is the social acceptance-feasibility for on-shore storage. The reason why there is need for on-shore storage is that this way more steel industries that are located in EU will have access on them. The commodities availability and pricing will play a role in the transition of the sector. Scrap availability is the "key" to achieve a green zero carbon production. Currently the scrap availability in EU is more than the scrap is use, but steel it will take around 20 to 30 years to achieve this (see chapter 7, section 7.1.1.1). Thus there is need for a transition period, with transition technologies (Carbon Storage). The Carbon Leakage fear is characterized as feasible and with the current climate due the will of EU to move towards sustainability(see section 6.1).
Additional interesting information	The European Industry currently is under-investment and not modernized compared with the competition from US. By modernizing the technology that is used in production and adopting cleaner solutions the number of necessary employees will be reduced. That is negative trade off. The industries within EU tend to play the "blame game" and try to require cheap capital from the European Union, but they should prioritize sustainability and invest on greener actions In principal the bank could be part of these type of projects. De-risking with the participation of ECAs is important (see section 6.1), so the bank can participate in the finance of a new technology[1]

Table 6.3: Results of the third interview regarding the Hypothesis: Identified bottlenecks to a circular production of steel industry using the case of Tata Steel IJmuiden (TSIJ).

Category	Findings
Missing information (bottlenecks)	Credit Rating of the company
	Lack of an umbrella policy (that gives specific criteria and sustainability indicators) that pushes the banking sector within the whole EU for sustainable client list
Points on the identified bottlenecks & Feedback	The investment required for the scale up of the technology and for implementation of CE values within the production has to come from funding within the cash flows of the company. It is risky for the bank to invest on providing products when there is no quarantine profit of the scale up of a new technology (that it might not work)
	The commodities availability and pricing will play a role in the transition of the sector, especially the price of scrap and the of the green electricity
	The Carbon Leakage fear is characterized as feasible and with the current financial climate. In case a company such as Tata Steel will leave EU, the bank would have to assess the reason this choice is made. If it is shown that within the European Union the company would not be able to survive the bank would continue to cooperate with the company (to avoid the loss of jobs) if according to their own (banks) taxonomy the client follows the criteria(see section 6.1).
Additional interesting information	A Transition bond could be possible. Though currently after the COVID-19 the industry is suffering. That will make the transition towards a greener production a smaller priority because European steel companies are having a hard time to survive now. The priority should be the survival in a first step

Table 6.4: Results of the fourth interview (Banking Sector) regarding the Hypothesis: Identified bottlenecks to a circular production of steel industry using the case of Tata Steel IJmuiden (TSIJ).

Category	Findings
Missing information (bottlenecks)	Credit Rating of the company
	Lack of an umbrella long term policy making (slow decision making)
	Global Industry- but there no global standards
Points on the identified bottlenecks	Feedback
	The investment required for the scale up of the technology has to come from the cash flows of the company. It is risky for the bank to invest when there is no profit right now due to the covid19 recession. There the EU has to play a factor ECAs
	The commodities availability and pricing will play a role in the transition of the sector, especially the price of scrap and the of the green electricity
	The Carbon Leakage fear is feasible. Clients have expressed this fear and prepare strategies in case the institutional environment does not help steel production within the with EU
	The CCS solution is technically feasible but social there is acceptance issue(see section 6.1)
	The Rate for return on investment for the steel industry is quite low. The bank from their side is willing to support sustainable projects with lower returns if is important for the transition
Additional interesting information	The steel sector bankability is under pressure. Banks "move away" from these industries. In the banking sector there is competition over the sustainability leaders (such as HSBC Holdings and Triodos Bank in NL) and ABN AMRO feels the pressure

Table 6.5: Results of the fifth interview (Banking Sector) regarding the Hypothesis: Identified bottlenecks to a circular production of steel industry using the case of Tata Steel IJmuiden (TSIJ).

Category	Findings
Missing information (bottlenecks)	Lack a strong long term assessment (The hope is that the EU Taxonomy will be a "game changer")
Points on the identified bottlenecks	Feedback
	The Carbon Leakage fear will not be the main issue especially if is there is a specific policy to tax the imports. That will create a more equal and fair competition markets for the European Firms. The access in capital markets for funding will be harder for companies that do not comply with the sustainability criteria of the EU Taxonomy
Additional interesting information	The steel sector is not perceived as the leaders of the energy intensive industries regarding their transition to more sustainable production (aluminium sector is lending much more). There are some steps towards circularity and sustainability but the industry is not vocal. Even within the sector the respondent believes that there is not a "big pool" of leadership on the transition to a CE model There is a lot of hope regarding the EU taxonomy(see section 6.1). The bank has already a framework for sustainability and that is a common practice within the EU banking leaders. A common framework could be helpful for the banking. Moreover, it will act as a natural incentive for the steel industry. It is important that is clear that what is not sustainable is not bad and there should be inclusion for companies that try to become more sustainable.

Table 6.6: Results of the sixth interview regarding the Hypothesis: Identified bottlenecks to a circular production of steel industry using the case of Tata Steel IJmuiden (TSIJ). This interview includes two participants from the steel industry.

Category	Findings
Missing information (bottlenecks)	Lack of carbon border adjustment tax
	Getting access to a carbon transport and storage system
Points on the identified bottlenecks	Feedback
	The Carbon Leakage fear is real. If the steel industry reduces the C02 emissions then the cost of production will rise. If the steel industry manage to half the cost of production the cost increase of the product will be 20%-25% (due to OPEX increase)[2]. So there must be a carbon leakage instrument(measure) in Europe in place, before the steel industry moves to carbon reduction
	The CCS technology is a pre-condition for the HIsarna technology to work. The locations within the EU are close to the North Sea(see section 6.1). If we want actively reduce C02 emissions, the CCS is the only method right now that can work effectively and give fast results. It is an essential part for the transition, thus it is expected that the social acceptability should change with education of the public regarding the benefits of the method.
	For a project such as HIsarna, funds from the EU under the green deal would be welcomed(see section 6.1). Steel industries look for possible ways to finance these projects. EU could be part of this, with the requirement that they provide a loan or a subside so they will be not profit from the technology for the EU
	The availability of affordable, green energy is crucial
Additional interesting information	A Transition bond should have the same characteristics with the Green Bond. This title might attract easier investors
	There should be collaboration between the different industries regarding the infrastructure of carbon transport and storage systems. This transport and storage system should be open access system, open to all potential users.

Table 6.7: Results of the seventh interview regarding the Hypothesis: Identified bottlenecks to a circular production of steel industry using the case of Tata Steel IJmuiden (TSIJ). This interview includes two participants of the Rocky Mountain Institute (RMI).

Category	Findings
Missing information (bottlenecks)	Overcapacity of production. This global problem that has accumulated through the years and it will create financial issues for the industry, slowing down the transition efforts Points on the identified bottlenecks Feedback The term "rate for return of investment" should be rephrased as cost of capital The Carbon Leakage is not so realistic due to the fact that the EU is really protective towards the sector. As a result, the EU will provide counter measures in suppose of European steel producers (will be marginal)(see section 6.1) The CCS technology is a solution for a transition period. This technology will bring fast results, but it does not solve the problem. Long term there is need for change in infrastructure The commodity availability will play a role and is a realistic bottleneck. The use of biomass in an extensive manner (like in the HIsarna case) seems quite hard to achieve The cost of capital will not be the biggest bottleneck because of the support the industry receives from EU
Additional interesting information	The EU is very protective over the steel industry A big issue faced by the banking industry is the lack of know how on the transition to a CE model. The acceleration of this transition (to circularity) will be a big opportunity for the banking sector. Finance will be a catalyst in the change The EU steel industry and the steel industry of China are quite protected by the public sector and do not act in terms of pure market conditions

6.1 | Explanation of commonly used terms in the interviews

In the tables that depict the data gathered from the interviews, there some terms that need to be further explained. In this section these terms are identified and discussed. A further more in depth analysis is provided in the following chapter (Chapter 7) where the points that are gathered from the interviews are analysed.

6.1.1 | Green bonds and Transition bonds

We could say that every bond is a promise to pay an amount that consist of the value of the bond combined with the interest. Green Bonds, are giving this promise with the additional claim to support sustainability and climate related projects. The first green bonds were issued within EU from the European Development Bank in 2007 and since then this product the segment has a significant growth. This product combines the investment goals we meet in the traditional bond market with the importance of the impact of the product. The negative site of this sector is that is hard to define what is green and what kind of criteria should the industries that issue follow to be applicable. Thus in a lot of cases green bonds are used to refinance projects that do not have an actual green impact. For industries like steel where institutional investors see far from what we define as green, to issue this type of bond is not a quarantine success.

Carbon intensive sectors like steel, are not the main focus of green finance since due to the barriers and bottlenecks that are discussed during the research is harder to achieve the European goals. Thus these types of industries could be also characterised as transition industries. Thus, there is the emerging idea of transition bonds as an important instrument to finance transition of these industries towards circularity and zero carbon production. This types of bonds are further discussed in Chapter 7, section 7.1.5.

6.1.2 | Credit Worthiness

According to (Brock, 2020) Creditworthiness is "how a lender determines that you will default on your debt obligations, or how worthy you are to receive new credit". Capital markets and institutional investors need information regarding the ability of a bond issuer (or other obligor) to repay their dept. This evaluation is done primarily from credit rating agencies through credit ratings. A a credit rating shows the agency's view, as of a specific date, of the creditworthiness of a steel industry (in this case), security, or obligation (Securities, Commission, et al., 2003). The credit worthiness of steel industries is coupled with the bankability of the "bankability" of the sector. The credit rating of steel industry is low due to the cyclically of the sector making the accessability of steel industry to green/transition bonds harder (see chapter 7, section 7.1.2.3).

6.1.3 | EU Taxonomy

According to the European Commission (2018b), the taxonomy is providing "rules for low-carbon benchmarks and improved disclosure requirements for investment products". This framework issued by the EU will provide specific criteria on what qualifies as a green activity and thus a framework on sustainable economic activities and is the backbone of the Europeans Union strategy for green finance (see chapter 2, section 2.3.3.2). This taxonomy aims to address the fears for "greenwashing" with the use of products such as green bonds. Both in institutional and industry level, the valuation that will be based on this taxonomy will show important risk insights. The investors will have a clear idea what is the current position of an industry regarding the sustainability criteria and what are the future steps the will take to get to a zero carbon production.

The draft taxonomy that was released this year by the European Union, still needs to address in more depth industries such as steel that is harder to manage in their current state(early transition stage) high sustainability standards. It is important that the criteria that are set in the final form are realistic and sector specific so heavy industries such as steel industry can have access to green finance and move to circular investments. Due to the absence so far of a similar policy, some of the European banks (including ABN AMRO), the recent years have developed their own system with criteria to be able to access their clients. This is a great first step, but the need for a specific policy such as the Taxonomy is evident since now different firms can define "sustainability" with a lot of ways, enabling the green washing.

6.1.4 | De-risking

To be able to achieve the Sustainable Development Goals (SDGs) the common consensus is that the private banking sector should be involved[3] (Gabor, 2013). The focus of de-risking is to create opportunities for institutional investors by providing securitization. By playing a security role in green investments, the belief is that organisations like privet banks will be incentivised to investments such as the scale up of a new technology (like HIsarna), or the development of infrastructure for circular production (CCS). On the other side is important to note that de-risking can be problematic if it is only established in a way that is beneficial only for the banks (Gabor, 2013). In a success the bank has profit, but in case of a failure of the project then the bank is secured and the public sector will have to face the downfall. To battle this fear, a framework like the Taxonomy might provide the solution since it will be easier to identify real green projects and monitor the client choices of banks. This topic is further discussed in the following chapter as well as in the reflection in chapter 8.

6.1.5 | Carbon Leakage Fear

As it also explained in Chapter 4, section 4.3.4, the "carbon leakage fear" translates to the exit of industries from EU due to reasons of costs related to climate policies This could lead to an increase in their total emissions (European Commission,

[3] In a letter (2017), Jin Yong Kim, former president of the World Bank Group (from 2012 to 2019) said : "we need to create markets and bring more private sector rigor and innovation to our client countries, especially the poorest and most fragile ones. We have to start by asking routinely whether private capital, rather than government funding or donor aid, can finance a project. If the conditions are not right for private investment, we need to work with our partners to de-risk projects, sectors, and entire countries" giving the signal for the public sector to start acting as a de-risking force.

2020a) since they will move in a country with less restrictions and it will lead to massive loss of employment within EU (Clements, 2020). The issue is further analysed in the following chapter, in section 7.1.4.1.

6.1.6 | Social Acceptability of CCS infrastructure

Currently the acceptability of the development of Carbon Capture Storage facilities for utilization of the carbon is low due to low engagement and communication with the public communities regarding the necessity of these locations and their benefits (Shackley et al., 2009). There is the view that the a storage space like that can be dangerous to the local communities. By start utilizing former oil and gas off-shore facilities, the public will be come more familiar with the process. Moreover, the needed infrastructure for the storage of the carbon and the transportation is a new opportunity for employment in the local areas. It is important to mention that this should not be a permanent measure but a way to facilitate a transition period until cleaner, more circular technologies for steel production are available. Also, before the construction there should be a social and environmental assessment that makes sure that are grievance mechanisms and a plan for the decommissioning of the infrastructure after the end of this period. This way the acceptance of the measure will be increased.

7

Discussion

In this chapter the insights gathered from the interviews will be discussed and analysed. It should be mentioned that the focus of this research is the banking sector and how a European bank perceives the transition of the steel industry and how they can help them with this grand challenge. Thus, the respondents are mainly from crucial departments of ABN AMRO. Moreover, two experts of Tata Steel IJmuiden (TSIJ) and two consultants specialised on the topic were interviewed. It is possible that if the focus was more in the technical part of the transition or the participants belonged to a bank that gives less priority to sustainability, that the insights gained from the interviews would be different.

7.1 | Discussion of the pre-identified bottlenecks

7.1.1 | Technical Challenges

7.1.1.1 | Commodity availability

Regarding the availability of commodities such as biomass, scrap and green electricity, from the interviews it is evident that the adequate supply of steel scrap is of essential importance to a more circular model of steel production. According to the insights of interviews with the basic material sector of ABN AMRO it was found that even though currently within EU we have more scrap than the quantity we use, it will still take around 20 to 30 years more globally[1], to have available scrap that can be used for production and cover the demand. That is a bottleneck regarding the fast adoption of new technologies that can be more circular such as HIsarna. As it was stated in one of the interviews, there are technologies that could also create zero carbon steel through iron ore, but these technologies are still hard to implement and are quite expensive. Thus, it was proposed that in this transition period, “transition” technologies could be used. A cost-effective way to do so which was proposed by a respondent, is to use the current technologies with the Best Available Techniques (BAT) combined with Carbon Capture Storage (CCS).

It is stated in two of the interviews that CCS technology is a feasible solution to a fast mitigation of the carbon emissions. The respondent of the steel industry (transition team) stated that the availability of green energy is one of the main bottlenecks for adopting more circular technologies like the HIsarna. Moreover, two interviewees respondent that their hopes for biomass to be a change factor in CO_2 mitigation are low. They agreed that theoretically (renewable) biomass is a circular way of thinking, but in the reality it will be damaging for the environment. The opinion that this method has an environmental impact is also supported in the literature (Dart & Milman, 2018). Regarding this case, that the HIsarna Technology is aiming to use biomass along side scrap, they stated that they do believe that the availability will be an issue for the scale up of the technology. Moreover, they stated that the biomass industry is a very complicated commodity market. The established market of biomass as a fuel is small due to the fact that this is a marginal fuel compared with coal (Ortiz, Curtright, Samaras, Litovitz, & Burger, 2011). According to the respondents when carbon price increased around 2005, the biomass price also increased accordingly creating a ripple effect. The increase in the carbon price led the energy users to turn towards biomass resulting in the increase in the price of it.

It is important to state here, that in the research it is found that the results of

[1]A lot of big ticket items (like buildings) where steel products are used have a lifetime of 20 years on average. Currently (in a global scale) we recycle products that were produced and released in the market 20 years ago. At that point in Europe but mostly in the emerging markets (particularly China) the steel products were significantly less and lower quality and that will be reflected in the current scrap we collect as well as as on how fast we can have enough

extensive use of biomass as an alternative to the coke are not positive towards the end goal that is the CO_2 reduction. Though in the rest of the interviews there was a positive attitude towards this method and it was mentioned that many industries that consider the biomass option as feasible. So since in this case (HIsarna) is in need of a fuel commodity, this research will still include it as an option.

7.1.1.2 | Availability of CCS locations within EU

In the interviews it was stated that currently there are not a lot of available CCS locations within EU. Though, in this specific case, there are off-shore locations of ex oil and gas storage infrastructure (Norbic Sea), that can be altered and used for carbon storage.

7.1.1.3 | Slow rate of infrastructural change in the steel industry

The retrofit possibilities for physical infrastructural change are more limited in steel manufacturing than in comparison to other industries. This due to the fact that steel facilities last for a long time and at the same time new infrastructures, such as changing a steel mill from BOF to EAF that uses more steel scrap, are capital intense. In the interviews it came up that the EU taxonomy might help identifying the current situation of the steel infrastructure and point out (possibilities) that infrastructure changes can happen. At the same time it was stated that the fact the EU steel industry operates with BOF instead of EAF gives a competitive advantage on the quality steel that can be used in downstream productions such as the automotive industry, which need high-quality steel.

It was also stated in the interviews that by adopting modernization of the current facilities or by implementing a new technology that is more sustainable might be the cause for lay offs. It is important to state that this is an actual issue, that is also found through the literature an has an impact on the policy makers decisions making them more reluctant towards stricter measurements. An example of this issue is the case of Tata Steel that wanted to terminate the production of its two blast furnaces at the Port Talbot (in South Wales) plant and replace them with EAF, which would means the end of primary steel making(Clements, 2020).

A structural change like this could lead to more circular sustainable steel making (since with the use of EAF there is use of scrap steel), but the community might by hurt by a big wave of unemployment.

7.1.2 | Economic Challenges

7.1.2.1 | Commodity prices within competition

Future commodity prices, especially the price of green electricity, are viewed as being deeply uncertain. The energy costs are one of the main points that create competitiveness for the European steel sector. With the current production around 40% of the fixed costs come from the energy consumption of the furnaces. The cost of energy within the European Union for the steel industries (as well as the other energy intense industries) is higher than the global market. That is an issue that can determine the choice of technology. Thus, a technology such as HIsarna that does not require so much energy might develop easier in this environment. According to the interviews, these prices are the reason that in Europe the main type of technology is BOF which is less dependent on electricity than the EAF. In one of the interviews with the department of the Basic Materials it was stated that in the future the green energy prices will also drop within EU but this will take time. At the same time, a non common policy for pricing commodities within EU is a factor that can create unfair competition within the Union on how fast an industry can transition and thus comply on future stricter regulations.

Moreover, it was stated that the biggest issue with the current institutions is that there are plans that change constantly which brings a lot of uncertainty. A good example to justify this statement was given from the interviewers from the Basic Material Department of the bank regarding the ETS system. Currently, the industries are given ETS licences to produce steel. If there is demand to produce extra tonnes of steel they have to buy more licences. That is not cost effective, thus the industries decide to not produce these extra quantities. To be able to cover the demand this marginal tonne of steel is imported from competitive markets such as Turkey and Russia. The issue is that there are no restrictions or taxes imposed on the imported steel. Thus, as a result of bad management on the ETS system and lack of an import tax, steel that is produced in non sustainable ways is used in the EU. From the interview with the respondents from the steel industry it became clear that a lack of an established Carbon Border Adjustment tax is damaging to the European Industries.

One of the issues that has been identified which is dictated throughout the interviews is that currently the cost of recycling scrap steel is more expensive than actually producing primary steel. Moreover, the whole steel commodity chain is built in such a way that is less cost efficient to make new steel from recycled steel than from primary production. It was proposed that a better structure of the carbon taxes within the European Union could make circularity more accessible. To effectively make a change, the current ETS system has to become more effective as well as there should be a carbon tax imposed to the incoming steel. It was proposed by the responders of the basic material department that this tax should be in the same level with the tax imposed within EU to create a balanced fair market for the local industries. By taking a measurement like that and assuming that the structure of ETS system remains the same, then the local producers will have an added advantage since they still get a number of a carbon credit for free.

7.1.2.2 | Required Investment for scale up and R&D

A common point in the interviews is that the required investment for the scale up of the new technology is an issue that can challenge an industry such as Tata Steel. There are different ways to finance the activities of a company. The investments in R&D and in new technologies that are in an initial phase of development are financed from the cash flow of the company. To increase the liquidity of the company there are financial products and services such as loans that the company can acquire from the banking sector.

A result from the interviews is that the risk–return trade off, for financing projects of new technologies, is not in favor of the bank. That means that even if the rate of return is beneficial, the risk (which accompanies the expected return) is considered too high. For a financial institution to invest in a product there must be profit generated directly from it, which is commensurate with the risk exposure of the bank. That is why often banks jump in these phases (scale up of a technology) that a technology works and can be commercialised. At this point it was stated by three interviews that public funding and incentives can play a crucial role since it can give the initial push.

It was pointed out that to invest in a greener new technology a steel company has to prioritize this investment activity so it can finance it in the initial phase. With the current climate in the market due to COVID-19, the steel industries including Tata Steel IJmuiden (TSIJ) are suffering a substantial hit. In this current situation it is argued in two interviews that it might be harder now for companies that struggle to finance their fixed cost to allocate funds to the further development of a pilot technology. However, it is pointed out that the leaders in the industry will still give priority to the sustainability factor. Moreover, it is also suggested by a banking sector respondent that to always try to subsidise these developments (greener technologies) is not healthy and necessary. The example of USA was given, where the industry has implemented changes towards sustainability in response to the free market forces. From the research it is shown that in the past the steel industry within EU, realised a big infrastructural change, moving to the technology of BOF due to the fear of becoming less competitive. That reinforces the example about the steel industry in USA and at the same time proves that the industry is willing to make big changes when it is profitable for them.

7.1.2.3 | Rate of Return for investment

As we mentioned earlier in section 7.1.2.2 even if the return of investment for a new technology is substantial, the risk might be more important for a financial institution. Especially at the point that the technology does not produce income. It was stated in the interviews with the Basic Material Department, that in general the steel industry is characterised by big assets and low rates of returns in their investments. The interesting information in this case is that one respondent stated that the bank would be willing to accept lower rate of return for an investment of them, if it would support the transition to circular, greener production. Moreover, it was suggested from to participants to rephrase this bottleneck as "cost of capital" which in this case is more fitted description as it is a more inclusive term that can describe the opportunity cost of making a specific investment. It was mentioned from two respondents that currently the steel industry in the world has in the majority a BBB credit rating making the " bankability" of the sector harder. In the reality this rate is even lower. Due to the fact that some steel players from China are government owned, thus their rating is similar to the government of China creating this average. But if you look at the independent companies especially within EU, there is only a small amount that has this (high for the industry) rate. The low rates are due to the fact that it is a cyclical industry and that the industry has been unprofitable for times in the past. The current situation with the COVID-19 has also played a role. Thus, the only way to get an investment credit rating is to be geographically big and diverse.

The last years in Europe the industry is struggling with structural overcapacity, with production moving to China, the environment is not beneficial for investments in new assets, so investments that have happened have been improvement capital in existing assets primarily. Now, the China's outlook is also not good (with the volumes going down) thus all the competitive markets are facing structural overcapacity.

7.1.3 | Institutional Challenges

7.1.3.1 | CCS Feasibility

According to the interviews the social acceptance of the carbon capture storage is currently low and that creates a possible bottleneck in the adoption of greener technologies. As it was mentioned above in the section 7.1.1.2 a proposed way to reduce effectively and cost efficient the carbon emissions would be to adopt carbon storage, until technologies that do not require it are ready for a scale up (and cheaper). Currently there are off shore locations that could be used for carbon storage in a first action towards accepting this method. A responded stated that if the results on CO_2 reduction due to the usage off shore carbon storage will get public, that it is highly to alter the negative view of the society towards this method. Thus, on shore locations will be also more accepted. It was also mentioned that there is lack of political will to implement a measure like that due to the low social acceptance that causes a political debate.

7.1.4 | Property rights

The result of the interviews regarding the possible issue of property rights case of the investments in new technologies from the EU, is that in this stage the steel industry is more interested in funding that comes in the form of subsidies or loans. This way the industry has more freedom regarding the way and the where, they want to scale and their technology. Where this "bottleneck" might be more relevant in the current stage, is in the carbon storage and transportation infrastructure. To manage to scale up the CCS, there is infrastructure that is needed. The steel industry sees a collaboration with other companies that want access to this storage. That would decrease the cost of operation of these facilities. The way that this infrastructure will be developed potentially raises issues regarding the property rights. Will this infrastructure be developed by the public sector but operated by the private (industries)? Would the infrastructure and operation belong to a third party? Questions like this are interesting in this case.

7.1.4.1 | Carbon Leakage Fear

In the majority of the interviews it was stated that the Carbon Leakage Fear is an issue. From the interviews with the respondents from the department of the Basic Materials it was stated that the current institutions are not following long-term strategies and that creates uncertainties to the steel industry. Additional to that, the failing ETS system in combination with the lack of an import tax for steel that comes from outside of the EU makes it harder for the industries to plan for a long-term strategy within Europe. In one of the interviews with a banking respondent, it was mentioned that some firms are afraid that they will not be able to produce steel in the future from Europe. A relevant result from the interviews is that if the industry mitigates the emissions from production to half, the OPEX is increased and that results in the increase of price (20% to 25%) per tonne of steel. With an increase like that the steel industry will not be able to survive. Thus, before it is asked from them to decrease their emissions, there has to be measurements to avoid the carbon leakage. An interesting note from a respondent is that now the EU faces the issue from the part of the consumer, thus by not imposing an import tax they try to provide cheaper steel to them, but in long term this is harmful for the European industries and for the transition to a zero carbon economy. The majority of the interviewers believes that the end consumer will not be adversely affected by a tax on steel imports.

There were 3 (out of 9) respondents who believe this fear is not realistic. In the EU there is a strong acknowledgement of having a sustainable and strong steel industry. The downstream manufacturing industries within Europe are deeply dependent on the steel industry. As it was stated by a respondent, the industry has a strong lobby in EU and is a big contributor to the economy. The EU wants to maintain this position of the steel industry and the high ambitious will of the Union to move to circularity will also push the industry to take measurements. It was stated by two respondents that the EU will keep a balance to keep the industry satisfied. This transition can give the industry a competitive advantage against the rest of the markets. In the literature research there was not clear evidence found that showcase actual cases of industries that moved out of EU, due to the current strong mandate of the European Commission to create a more circular, green economy.

7.1.4.2 | Linear environment

The steel industry has to make changes to become more circular within a linear economy. That can be a challenge, since in a linear environment growth is a priority. As it was stated in the interviews, for a company to invest part of their cash flow in circular technology, it has to be a priority for them to become more sustainable. In one of the interviews it was stated that the current linear environment should not be an excuse for the companies to not act. As it was also mention above, the example of U.S. steel industries, which follow the linear model, but nevertheless make steps towards sustainability, by investing in the modernization of their processes.

7.1.5 | Interesting information derived from the interviews

According to the majority of the interviews, the steel industries, even the ones in the premises of Europe such as Tata Steel are not easily associated with sustainable and circular production. It is pointed out that this perception that for a big part is realistic, is quite discouraging for investors. Thus, to issue a green bond that could also cover the financial cost of targeted R&D for circular implementations, or the scale up of a new technology would not be the most feasible solution for Tata Steel. Due to this negative view of the investors for the steel industry, some financial products such as the Green bonds that could help in financing the transition, are not easy to use in this case. The Green bonds are targeted for industries that are substantial more sustainable already. What is considered from the banking sector as a possible product that would fit better with energy intense industries is a Transition Bond.

According to the participants of the interviews that are coming from the banking sector, there have been some initial talks with investors about the launch of this new type of bonds (transition bonds) and there was an appetite from the investors side. The issuer of this bond (companies such as Tata Steel) will benefit from attracting a bigger group of investors than the issuing a traditional bond. By having more demand for their bond, the flexibility and the diversification increases for the company. Especially after situations that the markets have been hit hard such as the current climate, it is important to know that there is a wider range of parties that the company can address than of one big systemic bank or a small group of banks.

Another interesting insight from the interviews is the fact that the European steel industry is not modernized enough (though it still provides high quality steel) comparing with other competitive industries (Japan e.g.). Having less modern technologies implemented in the steel production translates to more CO_2 emissions in comparison with "younger" production systems. By modernizing the industry and optimizing processes there will be a loss of jobs since less employees are needed (Clements, 2020). That is a hard debate for an industry to face. This insight is valuable because it connects with the fear of EU loosing industries.

Against the claims of the industry that a transition will be hard, historical data showcases different. The industry implies that is impossible to move from the current asset base to a greener future asset base because is hard to support such a big costly change, but they have done it successfully in the past. Within two decades (1965-1985) the industry managed to transform their production from the Open Hearth Furnace (OHF) to BOF. . This transformation happened because the BOF is a way more competitive technology. In this case (nowdays) if the new pivotal technologies like HIsarna are more competitive, they will accelerate the transition. If the industry loses the competitiveness edge the competition will be hard to face (China, Japan, USA).

7.2 | Newly identified bottlenecks from the interviews

7.2.1 | Credit Quality

A main bottleneck that has been identified in the interviews so is the credit quality of the client. A Transition bond might be the most promising product for a company to raise capital that can be directed towards investments such as the development and the scale up of a new technology. To be able to to access a product like that the credit quality of the issuer and might be a possible challenge. The majority of the bonds that the banks are selling are investment grade so that could limit the scope of the potential issuer base.

The problem is that if you are a non-rated high yield company it can be harder to enter the market. It was mentioned in one of the interviews that there are companies that developing interesting technologies and ideas that could accelerate the transition towards to sustainability but due to there size not big enough to enter the bond market. The bond market is in the size of 300-500 millions while for them to scale up there idea less than 10 millions of funding would be enough. But for institutional investors that is too small and is hard to follow so many entities.

There, a gap is observed on how this companies could be financed. A solution to issues like this might come from the public sector that could act as a de-risking force. In the interviews it was stated that there examples of smaller companies in India (where the issue is more the currency price difference) that the companies issue green bonds that are bought from a public entity and then this public entity will issue a bond from there part using there risk and credit rating.This way they obtain cheap funding and they push it on through the green bond they bought. According to the responder that specialised on green bonds that is not the most optimal solution but a way to make sustainable finance more available

7.2.2 | Institutional environment

According to the interview of the participant that is specialised on the Green Bonds, there could be tools to help the investors identify if a company is aligned with the sustainability values. A recent tool that is provided by the European Union is the Taxonomy (see Chapter 2, section 2.3.3.2). This report could potentially be helpful for the investors because it provides some specific criteria. Though the report was issued this spring and it is not final yet. So far the banking sector is not sure if it will be actually used from the investors. An issue rising with this report is that it makes it harder for companies, especially in grey areas such as steel industries to be able to be placed within the proposed criteria of the taxonomy. Thus, incentives that are born from the steel industries will not be encouraged since the criteria are quite hard to target.

An example given in the interviews to explain this issue is that one of this benchmark criteria that belong to the Taxonomy is that the iron cast should be between 0.3-0.5 tn C02. If for the greyer industries is higher, even if there was a targeted, substantial effort to reach the target with new designs and better practices, still this industry can not be included among the green (or sustainable ones) and have accessibility to green finance. According to some producers it might be hard to reach the Taxonomy criteria in practice without technology available that makes possible. So the risk is that policies like this might make the "green" finance harder to obtain.

In the majority of the interviews as an issue-bottleneck is stated that the current institutions are ambiguous, not universal (among the EU member countries) and short term. To better understand this statement, the example of the ETS system that is failing to deliver the results that were promised will be used. This system does not work because it allows big companies to profit with selling excess licences, and at the same time as a respondent stated it discourage further production that is not covered by the free licences that are distributed from EU. That encourages imports from other markets were the environmental standards are really low. In addition to that, for these imports there is no tax that is impose for introducing to the EU steel this "grey produced" steel. In the interviews it was stated, that that behaviour creates hurtle to the industries, and the counter measurements of EU are " too little and too late".

7.2.3 | Hard access to carbon transport and storage system

The technology of CCS and CCU is characterised as essential for the fast mitigation of the CO2 emissions from heavy polluting industries such as the steel industry. As a result from the interviews is that a main issue for adopting this technology that can lead to "closing the carbon loop" is the hard access to carbon transport and storage systems. There is need for local transport infrastructure to transport the captured CO2 to different sites for utilization or for further storage.

7.2.4 | Structural overcapacity of the sector

An outcome of the interviews is that the steel industry in Europe is facing structural overcapacity. This is situation is observed in more markets currently (China, US). What happens is that the industrial capacity of a steel company is not utilized by the production (Brun, 2016). In capital intensive industries like steel it is normal over the period of time due to the cyclically of the sector to face this issue. Though, now this phenomenon is more lasting and shows an over investment in infrastructure. The overcapacity is a problem that affects the profitability of the sector since the mills are not able to produce at a cost effective and financially sustainable way (Brun, 2016). The reduce profitability of the sector might hurt the incentives of the industry to engage in investments that would lead to more circular production. That is a big issue since in the future this will make the sector less competitive. As it was expressed in one of the interviews, in the near future the banking industry expects that the less sustainable business will have a hard time to access the capital markets and thus capital sources to support their production.

The overcapacity will be a danger in the future that is hard to fight due to increase of unemployment in case of capacity reduction. This aspect makes the politicians reluctant in taking measurements. A big part is that the European Union is a union that can implement policies but not a a common market where local political influence do not play a role. An example is the case of ArcelorMittal (a leader in the steel production in Europe and a frontier in sustainability) plans on reducing their closing some of their plants in France. The job loss would be so important for the region that the government played a mediator role to keep the furnaces open.

7.3 | Common and different views

It is common view from all the respondents that the institutional environment is not currently ready to facilitate the transition to a more circular steel industry. The respondents that specialise in the sustainability are more optimistic and positive regarding the new actions of the EU, and specific with the introduction of the Taxonomy. There hope is that this plan will act as a natural incentive towards the steel industry to make changes and it will help at the same time the institutional investors to fund them. It was stated in the interviews that the European steel industry is always getting a good, protective treatment from the EU. That means that their lobbies are quite strong and that they can affect the policy making.

From the other side, the people that specialise in the financial part of this transition are more skeptical. They believe that the EU has to make sure that there is a stable, clear, long term strategy to facilitate this transition period. There is the thought that an ambiguous institutional environment makes less attractive the "sustainable" investment in this sector. Moreover, a common perspective from the majority of the respondents is that this ambiguity causes the fact that the steel industries do not feel secure for their future within EU.

An important finding is that even though the specialists of the banking sector that focus more on the financial aspect of the transition (Basic Material Department, Risk Management) call for a clear, long term legislation, when it comes to the issue of a common Taxonomy system they are not so interested. They propose that that banks can create their individual systems (some Banks like ABN AMRO already have done so) and that in this phase the public sector should be mainly playing the role of the de-risking factor in green investments of steel industries. The problem with this view is that it contradicts the sustainability bankers view creating a knowledge gap. Moreover, it allows space for questions such as: if the public sector role is only as de-risking force why not use public investment banks directly rather commercial banks for green investment and if by having the public sector as a de-risking factor then there is space for the private banks to make profit. In the majority (8 out of 9) of the responders believe that the adoption of circularity and the move towards a greener production will be unavoidable for the steel industries that want to remain within EU and have access to finance. That is a positive insight since it shows that there is will from both the banking and the steel industry to start implementing changes.

Most respondents do not believe that the steel industry is a leading example when it comes to circular production. From the literature, it is clear that the European steel industry already has take actions and steps to include the circular economy values in their production. Moreover, they already started to prepare for the "day after" when there will be need for green technologies by investing in the development of technologies such as the HIsarna. This difference between the common view regarding the sector, and the current state of the sector shows that there is a "knowledge gap". Combining the knowledge required by the literature with the outcomes of the interviews, it is proposed that this "knowledge gap" might be a factor that slows down the rate of change.

7.4 | Final classification of challenges and bottlenecks

The data that are gathered from the interviews are used to create the following table that answers the 4th research sub-question. Due to the feedback from the interviews the bottleneck "Rate for return for investment" is rephrased to "Cost of Capital[2]". Moreover, the new identified bottlenecks are added. The required investment for the scale up of a new more sustainable technology and the required investment for R& that will be need for the implementation of circular processes within the production are categorised together. That was a result of the interviews, that showcased that in an initial stage both of these actions will be funded in the same way.

Table 7.1: Final classification of bottlenecks to a circular production of steel industry in the EU

Technical Challenges	**Economic Challenges**	**Institutional Challenges**
Availability of commodities (scrap, green energy, biomass)	Cost of Capital	Property Rights Between Investors (risk allocation)
Availability of CCS locations within EU	Commodity Prices within Competition	Carbon Leakage Fear
Slow rate of infrastructural change in steel industries	Required investment for scale up of pilot the Technology (EUR 300-350 m) & investment in R&D for circular processes	Linear supply chain
Access to carbon transport & storage infrastructure	Credit Quality	Social Feasibility of CCS

[2]The required return to make a capital budgeting project (Investopedia, 2020)

7.5 | Coping mechanisms & policies

7.5.1 | EU Green Classification System-"Taxonomy" and sectorial assessment

Currently there are different directives but not concrete long term institutions in place. The EU Green Classification System-"Taxonomy" could be a good point to create specific criteria for the assessment of each sector that provide information on the carbon risk of a company. There is need for an inclusive classification as is understood from the interviews, thus it is important that the steel industries are involved in the conversation for the finalisation of the system to cope with this bottleneck. To avoid having a similar situation with the ETS system that is failing to perform as it is expected, steel companies should be obliged to disclosures that include detail descriptions of their current way of production, their expected economic and physical retrofit[3] of their facilities as well as their internal targets for aligning with the European Union targets for net zero carbon emissions (Bataille, 2020). This will help the institutional investors to have better idea of the actions of the steel industry to become greener and it will change the "negative" perspective of the industry. Thus, access to green finance will be easier since more investors will find the transition of the sector more feasible Currently some banks including ABN AMRO have set in place their own system to check the compliance of a company with the banks criteria.

As is it mentioned in the section 7.3, there is a contradiction between the bankers regarding the implementation of a public Taxonomy system. The responders from the sustainability sector of the bank are quite welcoming of a messurmenat like that and feel that it will help them establish clearer, long term criteria. In the other side the rest of the bankers are more sceptical of a common system. In this report it is argued that this is not an effective way to follow and there is a need for a common system due to the following three reasons:

[3]With economic retrofit we describe the time that the capital that is invested is amortised. With physical retrofit, we describe the physical time that is expected that the facilities of a steel industry are lasting until a big maintenance project.

- A common taxonomy eliminates political interfering from the local governments. Using the Carbon Leakage Fear, some countries putting the sustainability agenda lower than others within EU. That creates and unfair market within the EU and makes it easier for banks to adopt lighter criteria

- It is ensured that all the banks within EU have common and effective sustainability criteria for lending their clients

- The strenght of a common policy should not be overlooked. R&D and innovation should be driven by the industry as well, but a common taxonomy system can provide a powerful market and price signal regarding a change towards sustainability and the need in green investment

7.5.2 | The public sector as a de-risking force

It is clear from the interviews that for the banking sector to be an active financing force of this transition there is need for subsidies and guaranties provided from the public sector. EU has to play an active role as Export Credit Agencies, so that the private banks can participate as lenders in a project such as CCS infrastructure. By doing so, the public sector covers the CAPEX of a project like that, while the bank participates by covering the project. It is important that the public sector participates actively as a de-risking force, to ensure that "green" financing is accessible for smaller companies as well. In the current funding that comes from public investment banks like EIB(European Investment Bank). In the current funding that comes from public investment banks EIB, there is a specific capacity of funding that allows a number of companies to apply, thus smaller companies that may provide pivotal technologies and methods might be excluded. Moreover, from the interviews the feeling is that the presence of the public sector will also give a political message and a strong signal to the market, there is a specific capacity of funding that allows a number of companies to apply, thus smaller companies that may provide pivotal technologies and methods might be excluded.

According to the recent report of (Robins, Tickell, Irwin, & Sudmant, 2020), the role of the banking system in a greener transition is essential to accelerate the change and at the same time is beneficial for the banks as well[4] In this report is recommended that the banks are needed as a source of green finance and thus in this initial stage that the transition towards circularity and zero carbon production should be supported by the public sector. At the same time it is strongly adviced that the role and the sustainability mandate of public investment banks becomes stronger, so they can support SMEs and bigger industries in the transition.

7.5.3 | Research on the identification and mapping of possible routes for CCS and CCU infrastructure

There is need for collaborative research on how and where to create infrastructure that will facilitate the carbon storage and transportation within the EU. It is important that this research is inclusive and that the results will facilitate a large number of industries.

7.5.4 | Policies to close the loops of the linear production

7.5.4.1 | Policies that support the increase of recycling in the steel sector

The stock of the scrap steel is growing and that should be utilised as a way to meet the demand for steel in the future. An issue (bottleneck) that was identified in the interviews is that currently recycling is expensive and less cost efficient than the primary production. By increasing the recycling of steel there will be need for better sorting facilities that can accommodate the quantities as well as

[4]It would reinforce the trust of the society towards the banks after the financial crisis within EU (in the report the example of the UK is the main focus); it would show leadership and will to be a positive force; the banks will mitigate their exposure to material climate risks; and it would expand their customer base due to the development of demand for new services and products (Robins et al., 2020). Of course it is important to mention that this research is partially funded from HSBC. That showcases that there is an understanding from the banks that been part of the green finance movement is a financial opportunity for them.

the separation from copper that is an important factor[5]. That will add up on the existing cost of recycling and will make the primary production a more cost effective solution. As it was stated in one of the interviews with a respondent from the banking sector, for the banking institutions a big priority is that the steel industries are "surviving" (in the COVID-19 crisis) so they can repay their loans. Thus, a cheaper solution would be easier accepted when it comes to the survival of the steel sector.

To cope with this issue there is need for policies that aim directly at improving recycling. It is essential that the European Union invests in a dialogue with the involvement of the stakeholders of the chain to increase the possibilities for cooperation and co-design of products. This way the steel production can coordinate with the downstream producers and create products that are easier to recycle at the end of their life. Moreover, there is need for an assessment and understanding of the "leakages" in the current recycling system. There, the member states should act and map the issues in the recycling of steel, so that there is an understanding of the correction steps that should take place (Bataille, 2020). Bataille (2020) proposes that a way to effectively aim to recycle is to put in place Advanced Disposal Feed that would translate in a small cost for the consumer (this cost will show the cost of collection and treatment). According to Shinkuma (2007) an "ADF policy can be second-best either if net disposal cost is relatively low or if repair cost is relatively high". Thus, we propose that the first step is to assess the current recycling process and engage in dialogue with the parties involved to gain understanding.

7.5.4.2 | Actions that introduce product ownership and producer responsibility along the steel commodity chain

The current Eco-Design Directive 2009/125/EC is mainly focusing on the consumer and the domestic appliances (Bataille, 2020). It is important that the Directive would include in the future specific and long term actions that promote the product ownership increasing this way the responsibility of steel producers for the end of life treatment of their products. For example the steel used in automotive industry

[5]If copper is not separated completely from the steel scrap, in the smelting process the levels of steel can increase resulting to a product that can be used to less applications (Bataille, 2020)

should be designed in a way that the collection of vehicles at is easy (ensuring a treatment operation) and it can happen it suitable treatment facilities supported by both the steel producers and the downstream industries like the automotive in this case. To be able to implement policies that target this issue there is need for engagement and cooperation with the downstream industries involved in the supply chain such as the construction and automotive sectors. By doing so, they can co-design and create innovative circular products and services that could focus on track and trace systems and cooperation on the process for scrap recovery and reuse. By working together with the different part of the supply chain, they can extend the life of the capital equipment from real time monitoring and data predictive models and share the ownership of heavy equipment.

7.5.5 | Clear Transition Strategies

In the interviews it was proposed that it will take time for the new green technologies that are more circular (HIsarna e.g.) to reach maturity, but it will take even more time to raise the supply of steel scrap enough to cover the demand and replace the primary steel production. To cope with this rather lengthy "transition period" the EU needs to create clear "transition period" strategies that help the steel industry mitigate their emissions. These strategies should aim to create clear institutions regarding the CCS facilities using the example of gas storage infrastructure. By having specific and clear regulation, the social feasibility of these projects can increase. There is a need for a fair, cost effective legislation regarding the liability and insurance for infrastructure of CCS and CCU. With the creation of strong, clear and transparent long term legislation in this area, the banking sector as well the institutional investors will be more assured to participate in the financing of a project like that.

7.5.6 | Creation of strong European market

In the interviews it was mentioned by a respondent of the basic material sector (banking industry) that an issue that creates further fear for carbon leakage is the unfair competition that EU industries face. This statement was repeated in more interviews and was accepted by the respondents of the steel industry. One contributing factor to this is the ETS System without the introduction of an effective and high enough import tax. This is an example that shows that there is a lack of well functioning secondary products market. Thus, to strengthen this market withing Europe, and lead the demand it is proposed that:

- A "sustainable" import tax is proposed to steel imports from third countries
- There is investment in initiatives for circular public procurement. By having the public sector selecting "circular" steel products for their infrastructures (Bataille, 2020), or subsidising products with circular produced components (vehicles) the whole supply chain around steel is incentive to invest in adopting circular values.

7.5.7 | Make credit/subsidies conditional on certain green performance criteria including reduction of overcapacity

To fight the intractable issue of the over capacity, EU could follow the example of China that requires reduction of capacity from the steel industries. This way the achieve a marginal reduce instead of a collapse in the sector. It is proposed that EU will give priority to green subsidies and credit to companies that present a strategy that aims to follow a strategy according certain green performance criteria including plans to reduce the capacity of “grey” not sustainable infrastructure.

7.6 | Summary

To reduce the emissions from the primary production there a lot of uncertainties arising as shown in the table 8.1. The technologies that could make a change (HIsarna) are in a pilot stage and from the interviews it is clear that with the current uncertain environment (financially and institutionally) there will be a transition period until they scale up and as it is explained it will be necessary to take advantage of every physical retrofit opportunity to replace existing facilities (even before they are obsolete) which will be a costly procedure. Thus, the banking sector there can play a role with providing know how to their clients and help them have access to the capital markets. A great example for this, is the proposal of the Transition Bond. In this "transition" period, controlling the demand with circular measures can make a difference. The chapter provides a set of proposals- policies that could help.

8

Conclusions

This chapter answer the research question *How can the European banking industry be incentivised to assist their basic material clients and specifically the steel industry to move towards CE?*.

We will provide an answer to this question through the formulated sub-questions.

What are the current institutions blocking and enabling the adoption of CE in the European steel industry? The European Green Deal, is one of the pivotal institutions accelerating the circular economy transition. Part of the European Green Deal, is the European Circular Economy Action Plan. From this plan, Article 5 (1) of the Extractive Waste Directive 2006/21/EC (EWD), Directive 2009/125/EC for the Eco-design requirements are the most interesting for the steel sector. In the European Green Deal the steel industry played an active role, with the High Level Group that created a policy framework which gives recommendations to energy intensive industries. The European Union, views the accessibility to sustainable finance as part of the transition towards circularity. Main frameworks that the EU created to help there, is the EU Green Classification System-"Taxonomy" (starting at 2020), the Sustainability Related Disclosures (starting from 2021) and the Climate Benchmarks Disclosures. Last but not least, the "Raw Materials Initiative" and the "Exchange of Best Practices" initiative are interesting for the steel industry as well as the supply chain involving the steel industry.

To what extent is the existing regulatory regime (at a European

Level) helpful to transition to CE? The most helpful part of the European Circular Economy Action Plan is the product policy for the creation of life cycle assessment of products and thus the creation of secondary raw materials market within EU. By focusing on establishing the importance of life circle of products, this policy helps the companies to design products that are providing a clear way to be recycled in the end of their life. Moreover, this focus gives a signal that public procurement will be implementing a life cycle assessment in the products that will be acquired. The plan though is focusing mostly on the recycling and less on the design of circular products. This plan should be seen as a starting point for the transition and less as a concrete policy framework. On similar note, the EU Green Classification System-"Taxonomy" eventually could help as a framework to facilitate sustainable investment, but in the current phase it is not clear if less green industries such as steel can be included. Currently the institutions within EU are ambiguous and not applied by all member states.

It is concluded that there is lack of effective, long term institutions to establish a strong secondary market within the EU. It came up in the interviews, that a policy that is missing and that affects the European market and the local producers is a sustainability import tax for the steel products entering the EU. The responders in their majority believe that a taxation similar to the ETS system (same price) that would apply also to imported products would give an advantage to the local industries that will create incentive for investment in circular, greener production. In this research it is supported that a tax like this should come alongside with measurements that protect the consumer for price increases and also with clear policies that give the message that the public procurement within EU will be focusing on products that implement circular values. Otherwise, a measurement like this will only provide a financial advantage in the local industries but will not translate to an actual step towards a more circular supply chain.

Who are the main stakeholders involved in the steel commodity chain? What are the stakeholders' interests when it comes to the transition to a CE? Specifically, what is the role of banks in the steel industry and how do banks perceive the necessity and feasibility of the transition to a CE? The steel commodity chain involves a number of different actors. The main stakeholders involved in steel production are (first and foremost) the steel producers themselves, then the downstream producers and by-product industries, the mining industry (within and outside of EU), the retailers and the end users, and finally the European Union, the national governments and banks. From Figure 3.5 the main actors that have an interest in the transition to a more circular supply chain and can affect more the European steel industry are the downstream producers (like the car manufacturers), the European Union and the banking sector. Specifically the banking industry aims to be part of the transition to greener, circular economy something that is depicted from initiatives such as the adoption of the Global Sustainability Risk Indicator (GSRI) assessment before lending to their clients and the the "Circular Economy Finance Guidelines" collaboration. The banking sector perceives the steel industry as one of the heaviest polluters making it harder to include them to green finance. However, the banking industry recognises the need for change in this sector and aims with products such as the transition bonds to help the steel industry move towards circularity.

What are the main bottlenecks, challenges and uncertainties that will arise on the transition of the steel industry from a linear to a circular economy? There are three categories of bottlenecks identified: Technical, Economic and Institutional challenges as it is seen in the table 8.1. In the 8.1 we can fine the main bottlenecks identified in this research:

How to cope with these bottlenecks, challenges and uncertainties created by the shift to a new circular business models and markets? The coping mechanisms that are needed to overcome the bottlenecks created by the shift to a new circular business models and markets are

- An ongoing dialogue between the main stakeholders involved in the steel supply chain. This way the policies that are developed are better targeted, more inclusive and can provide results.
- Cooperation between the steel industry and the down-steam producers for co-design of products and their end of life strategy can mitigate the cost of recycling
- Long term, clear and sector specific policies that are followed from all member states

Table 8.1: Final classification of bottlenecks to a circular production of steel industry in the EU

Technical Challenges	Economic Challenges	Institutional Challenges
Availability of commodities (scrap, green energy, biomass)	Cost of Capital	Property Rights Between Investors (risk allocation)
Availability of CCS locations within EU	Commodity Prices within Competition	Carbon Leakage Fear
Slow rate of infrastructural change in steel industries	Required investment for scale up of pilot the Technology (EUR 300-350 m) & investment in R&D for circular processes	Linear supply chain
Access to carbon transport & storage infrastructure	Credit Quality	Social Feasibility of CCS

- For the banking sector it is vital to build internal knowledge on the issue and try to align perspectives within the organisation. This way they will be ahead and will be able to support the leaders of the industry to make the steps towards a zero-carbon circular production.

What new institutions and policies could (should) be introduced in order to assist the steel industry companies to transit to CE production and business models? Which coalitions between stakeholders can be built in order to support the shift to a CE?
There is a need for:

- Inclusive EU Classification System-“Taxonomy” that comes as a result of conversation with the main stakeholders. The system should require specific disclosures from the steel sector that provide information about their targets, current facilities and production methods. To finalise the document the banking sector and the steel industry can work together to propose fair, sector specific sustainability criteria that are feasible for the steel industries.

- Specific policies and actions to close the loops in the current supply chain such as: Policies to accelerate recycling and make it more cost effective, actions that support product ownership. To do so, the steel industry has to work closely with the downstream producers and co-design products that can easily be recycled.
- The public sector to actively play a de-risking factor and provide guaranties for projects such as HIsarna, to attract institutional investors
- Clear "transition period" strategies that help the industry mitigate their emissions in this period between the maturity of new green technologies and the time that the scrap stock will be enough to cover the demand. These strategies should aim to create clear institutions regarding the CCS facilities using the example of gas storage infrastructure. By having specific and clear regulation, the social feasibility of these projects can increase.
- Strength the European market, by imposing an import tax as well as invest in "circular" public procurement to provide incentive for the whole supply chain to adopt circular values.
- Research on the possibilities on the infrastructure for storage and transportation of Carbon
- Make credit/subsidies conditional on certain green performance criteria including reduction of overcapacity

To be able to support the change towards a more circular production it is important that there is coordination and cooperation between the actors involved in the supply chain. For all the above proposed policies there is need for a coalition between the steel industry, the downstream producers and the banking sector, so that fair and effective targets and policies can be introduced. Moreover, a collaboration will be needed between the industries in Europe that produce a lot of carbon and the ones who can utilise it. There is need for infrastructure planning and development to facilitate a big amount of industries, so that we can have fast results on the CO_2 emissions and manage the set targets. Thus, it is important that there is cooperation on this topic. Here, it might be an opportunity for the banking sector to bring interested clients from different sectors (steel, cement e.g.) together.

What can banks (like ABN AMRO) do in order to support and enable the transition of the steel industry to a CE model? How feasible and cost efficient is it for banks like ABN AMRO to actually choose to lend to industries that adopt CE?

It is evident from the literature and from the results provided from the interviews with bankers, that the European banking industry understands the need for the steel industry to adopt the CE values. The banking industry understands that the "sustainability" risks of the steel industry in the future will be connected with the overall performance of the company and thus the bankability of the sector. From the research, it is shown that currently it is not feasible for a bank to choose actively to finance only industries that adopt CE. To scale up a plant of a circular low carbon technology like HIsarna, requires a large investment while at the same time involves a big technology risk. That makes it harder for the steel industries to devote this amount of their cash flow by their own and at the same time discourages the banking sector to engage actively in this type of investment. To be able to introduce (in a bigger scale) these technologies in the coming future, it is necessary that the public sector supports this effort with subsidies or by de-risking the investment. By playing the de-risking role, the public sector supports the private banks to be part of investments in circular projects that normally would be risky to be part of. This way the banks will be able to still be part of promiscuous projects like the development of a new circular technology without having the risk, in case this project fails.

There is need for a transition period that the bank to work alongside the steel sector with products such as the proposed "Transition Bond" to help the sector implement circular economy production methods. It is important that in the current state the bank builds know-how regarding the sector. From the interviews it was evident that there is a will from all the departments of ABN AMRO for assisting the steel into the circular economy adoption, but the perception regarding the current state and activities of the sector was different per department. Thus, the first step the bank can take to help the steel sector, is internally build a common understanding. That can be achieved with assessments such as the GSRI to identify the current practices and consult their clients on setting targets that will help them have access to finance. The bank needs to explain the importance that the "sustainability" risks will have in the future for the credit quality of a company, and help their steel client to set feasible targets. Moreover, the banks should play the role of the mediator of their clients from the steel industry and downstream producers and create dialogue. Also, it is important that the EU considers the banking sector and their views regarding the EU Classification System-"Taxonomy". Since some European banks like ABN AMRO have already developed an in-house set of sustainability criteria that they use to asses their clients, the policy makers could use the knowledge and insights they gathered so far. Moreover, in the case of the Taxonomy that will become a reference point, it is important that the policy makers are inclusive and engage stakeholders such as the banking sector to establish a cooperation during the development of the system, since the banks will have to work with this policy on daily bases. Last but not least, the Banks should be considered in the development of the Taxonomy so they can be held accountable as well.

How can the European banking industry be incentivised to assist their basic material clients and specifically the steel industry to move towards CE?. As it was found in the interviews, so far the European banking sector has implemented different sustainability frameworks (criteria) and assessments (such as the GSRI) from their own initiative to make sure that in the future that the "sustainability" risk that that their clients bare is not problematic for the bank. That showcases that the sector understands the future implications of associating with clients that do not plan for a greener production (limited access in the capital markets). Though, the fact that there is not a specific umbrella policy (or assessment criteria) provided to the sector by the EU, slows down the industry. By implementing a coherent framework, which the banks can follow uniformly, it will help them surpass this initial stage of having to build know-how, on how to identify the suitability risks and performance of their clients and pass to the next one where they can act as the mediator in a inter sector dialogue of heavy emitting industries including the steel industry. The EU Classification System- "Taxonomy" can be a first step of a useful tool when is finalised, under the condition that provides an inclusive framework that comes after the consideration of the involved actors. To be a helpful tool the framework should be robust enough to look at the current portfolio and the investments over time and look if the industries are actively contributing in the transformation of the economy to circular. Currently the benchmark (that is used to identify if an industry qualifies for green investment supported by EIB) is not enough to hit the 2050 target.

8.1 | Achieved Aims and Objectives

This research managed to create an initial background on what are the possible uncertainties and bottlenecks that arise in the case of the adoption of values that come from the circular economy theory, in the European steel industry. In the research the interdependence between actors and the possible needed collaborations are identified. The conclusions of the research manage to achieve the final aim of this research, by showcasing that a complex, multi actor problem like this, needs an approach the examines different angles and provide a deeper understanding of the involved actors perspective and interest on the issue. The result of the research indicate the need for collaboration within the steel supply chain (steel & downstream producers) as well as for vivid cooperation and dialogue with other sectors such as the banking industry and other "heavy emitters". Last but not least, the research manages to give a clear understanding on how the involved actors perceive the bottlenecks for this transition and provides some proposals that could help in the acceleration of the process.

8.2 | Limitations and Future Work

Additionally to the limitations that are described in section 5.4, it is important to state that the hypothesis of the circular base case scenario of steel production and the identified bottlenecks that was developed in the chapter 4 was based purely in the literature regarding the European steel industry and the available information in the case study of Tata Steel IJmuiden (TSIJ) with the development of HIsarna. This research was validated and enriched with the data gathered from the interviews, but still represents a small part of the EU steel industry as well as the banking sector.

In the future to further improve this research and give a more complete understanding of the issue, it would be important to include interviews with more steel industries and banks of Europe. Both ABN AMRO and Tata Steel are located in The Netherlands which is amongst the leaders in the EU regarding the initiatives to adopt circular economy. Though, the EU does include countries that are still behind in this effort and the industries located there have different priorities. By including them in the conversation, a future research can present a more inclusive result. Moreover, it would be important to include EUROFER (European Steel Association) in the conversation. EUROFER was contacted multiple times, but unfortunately there was not an answer from there side. Also, a public investment bank (InvestNL) was conducted to give a view on how a public bank could assist the steel industry with there transition, but there was not reply from their side.

The technology of CCS is a necessity for managing fast results in the mitigation of carbon as well as is an integral part of new green technologies such as HIsarna. In the results of the research it is mentioned that there is need for collaboration of different industries in the development and use of the CCS infrastructure. A collaboration brings a lot of positive aspects but also raises questions on how this system will operate (property rights, transaction costs[1]). Due to the time limitation, this aspect is not further introduced or examined.

This is a very interesting finding since in the future there will be need for different industries (steel, aluminium e.g.) to collaborate. A CCS location and the transportation system would be used as a common-pool resource (CPR) that all industries have assess to. It will be interesting scientifically to explore the "bottlenecks" arising in this case, as well as an infrastructure like this will operate as public, private of a communal property.

Moreover, in this research the emphasis was placed on the European Institutions

[1]In a case that of a collaboration between different industries questions such as the following arise: Who holds the ownership of the infrastructure?; Is it a project funded by the government allowing the a collation of industries to use it; How monitors the infrastructure after during the usage period; Are there transaction costs between the different involved; There will be a specific capacity in the CCS, how will be divided to ensure fair access

and not on the national laws and directives in the different member countries in EU. To provide a more complete answer regarding the enabling and blocking institutions regarding the CE, in the future research the countries could be clustered in bigger groups regarding the regulations on the topic. Last but not least, in this research one of the main results is that there is need for collaboration in the co-design of products between the steel industry and the downstream producers with the aim to improve the recycling rates. However, that might bring legal accession issues that should be identified and better understand in future research.

8.3 | Reflections

Before this research my belief was that the banking industry would not be strongly interested in sustainable investment that would help in core changes in heavy polluting industries. During the development of this research, I had the opportunity to do an internship in the Basic Material department of ABN AMRO. There I had the chance to actually get real experience of the current framework used by the bank to asses the sustainability performance of their clients as well as to develop GSRI assessments for steel companies. That gave me a better understanding of the issues that the banking sector is facing by having to find their own framework as well as having to compete with other banks that prioritize the sustainability performance of their clients lower. Finishing this research, I am optimistic that the topic of circularity and sustainability is gaining momentum and becomes more central.

During the development of my thesis I wanted to be unbiased thus I tried to not ask extensive feedback in the formulation of the topic from my colleagues. If I would approach the topic now, I would be more open in their suggestions and I would ask more often for feedback, especially in the initial stage of my research. That would help me identify their "pains" from the current system they use faster. Moreover, at the middle of my research when I was developing the base case scenario I believe that it would be interesting to contact at that stage Tata Steel IJmuiden (TSIJ) for an initial understanding of their development.

In the progress of this research there several questions that are raised and showcase the complexity of the a multi-actor issue like this. One issue that is also part of the limitations of the research, is how representative is ABN AMRO to indicate the current position of the European banking sector in the topic. The Netherlands is a country that comparing with the rest of Europe is ahead in the implementation of policies and incentives that aim towards sustainability. ABN AMRO is not the leader in the Dutch banking sector regarding the topic, but in the last years there are serious efforts from the bank to create a culture around the topic of circularity and the sustainability risk of existing and new clients. This affirmation move from a traditional bank to one that sees sustainability as a priority, makes it a great environment to investigate the internal gaps and the processes in place to achieve this organizational change. As it was found from the research, there is currently a gap in the views of the bankers from the different departments, but it is evident that there are efforts to mitigate it. Thus, I believe this firm is a good starting point for this research, but represents the banking leaders within EU. Still there are countries where they prioritize less the transition to a more circular economy and thus the banking system there is less incentivised to focus on this part of their client risk.

To bridge this difference between the countries within EU it is argued in this research that it is important that the European Commission provides the private banking sector with a standardised official European Taxonomy. During the period of the research, the question if we should allow self-regulation by allowing banks to use their own taxonomy came up during interviews. While all respondents feel that there is lack of effective regulation, some proposed that the banks can have their own private taxonomy. This is understandable belief since there are examples such as ABN AMRO that proactively created their own system, but a common European taxonomy is a necessary step. This way have one standard that is valid for everyone, otherwise everyone has a different definition and interpretation of what is circularity and sustainability in general. An example that depicts the need for a common policy is the issue of the overcapacity in the sector. Big companies have tried to close plants in Spain and France to reduce the overcapacity issue but that that comes with a political cost. Because it translate on loss of employment. Thus, there was political influence in this cases to stop this act. It is proposed in this thesis, that by developing a common taxonomy a sense of common market will be created within

Europe and thus the importance of circularity and turn to sustainability will be priority for all member nations. Without a common taxonomy, the banking system is free to interpreted sustainability with different ways, and political influence can slow down the rate of transition.

In this thesis it is proposed that the public sector could be a force that accelerate the transition by playing a de-risking role. It is important to reflect on the fact that there is a debate regarding if this de-risking role of the public sector is a good deal for banks, because if there is no default, the bank 'profits', but when there is a default, the banks are protected while the EU will bear the loss, basically compensating the bank. This question is valid and during the process of the thesis played a role on keeping a middle distance in this debate so an unbiased result can be offered. The transition towards to a circular and zero carbon economy can be a great opportunity for the banking sector. It is evident that there is effort from big banks to capitalise it with de-risked green finance being attractive for big financial firms (such as BlackRock). A big question is how much of their initiatives aim for real change and how much is a green-washing attempt. A good example that shows why this debate exists is the product of green bonds. So far green bonds are used mostly in projects that refinance an already existing asset that in most cases was build using finance that do not come from green sources.

Reflecting on the issue of possible green-washing using products like green bonds and benefiting from a de-risking role of the public sector, we understand that there should be stricter policing involved. That is why it is recommended that a common Taxonomy is established. Having a specific set of sustainability conditions and criteria that every new project within the steel industry will have to follow to acquire finance that fall in the category of green, is necessary. According to the Transport & Environment, a European federation of green NGOs, currently the banking sector and rating agencies are free to define for themselves what constitutes a "sustainable investment." enabling the fear for green-washing. By having a common standard, the public sector can still play a de-risking role, but then there will be specific criteria to hold them accountable. In this effort for turning our economy to a circular and zero carbon, the private banks should be a part because this way we can achieve a better financial discipline. At the same time, in this reflection it is important to propose the need for bigger involvement of the public investment banks as financiers of this transition. Initiatives like the InvestNL (national development bank) should be more encouraged. In the aftermath of this research I believe that the public development banks have a chance to be the main finance power within this transition. At the same time that needs political will and having sustainability as priority.

During this crisis that emerged due to COVID- 19, in Europe we found ourselves in front of the realization that the current system we created within EU is more in favor of corporate profit than environmental and social growth. Specific within the steel industry this crisis brought a halt in production and created a liquidity issue. At the same time it brings a big opportunity for change. The European Union should use this crisis as an opportunity to impose rules that would allow for a more circular steel production by making for examples credit/subsidies conditional on certain green performance criteria and at the same time enforce a more green public procurement to balance this measure. From the research the majority of the responders believe that more strong measures push towards the realization of the Carbon Leakage Fear, but there is also a small number that believes that this is an empty claim. Reflecting on these opposite ideas, I would have to side with the second one. During the literature review it was not found that there are actual companies that moved outside of the EU due to the fact that financially they could not bare more environmental friendly policies that translate to big infrastructural changes. What it was found is that the whole industry was transformed and adopted a new technology within two decades to be able to survive the competition. By allowing the energy intensive industries (like steel) to keep the employees as hostages demanding the politicians to force EU to slow down with this transition, the EU will only lose. Of course it is important to state that in this issue part of the blame is also with the politicians that do not want to be involved in such a political risk.

Of course it should be stated that this plurality in views during the interviews was really beneficial for the research. It allowed for a fair depiction of the current reality and helped the research to be richer. Moreover, it showcased that there is a knowledge gap or else a wider spectrum of how we define sustainability, circularity and where the steel industry is placed within this spectrum. In the same organisation (ABN AMRO) employees from different departments had a different perspectives regarding the steel industry and where the belong within sustainability[2], but the respondent from the Sustainability department was really enthusiastic with a common Taxonomy for all EU. The most positive outcome is that the majority of the respondents were deeply interested on how to assist their clients with their efforts for sustainability.). As a researcher it was important and pleasant to see a traditional banking institution such as ABN AMRO, is engaged in an internal dialogue to try to define with the best way possible how to move to a more sustainable banking system and how to help their steel clients become more circular.

Having the process of interviewing as a big part of my research it helped me personally as a researcher to understand better the topic and gain knowledge on how to approach the different actors. From the first interview to the last one I observed a big difference on how my approach became more professional and how it became easier to ask harder questions. Also, during the the interviews I realized the value of this research and I got motivation to further continue with it. Now with the completion of the research I believe, that this method it is fitted to achieve the aims and objectives of the thesis. Through the interviews, a realistic representation is given on how the banking sector and the steel industry views their relationship through a transition to a more circular economy. If I could continue with my research I would love to have more interviews with participants from the European Investment Bank and other public investment banks. I think that would add there perspective on how they can assist the steel industry and it would give a better understanding of how public and private banking could collaborate with each other.

[2]People coming from the Basic Materials department were more optimistic for the efforts of their clients towards circularity and sustainability and could see an opportunity for green finance in this sector. From the other side all the other departments were more skeptical on how steel fits on the green spectrum for products like green bonds. An other interesting difference is that the majority of the departments were satisfied with their current in house system of sustainability criteria GSRI, while the sustainability department of the bank is really interested in adopting the final EU taxonomy

8.4 | Final Remarks

The results of the research show that even though time is not on our side and the climate change is progressing, within in the EU we are in an initial stage that we try to build know-how regarding how we should perceive achieving a steel industry with zero CO_2 emissions. It is clear from the results that there is need for collaboration between the sectors to assess the current situation of the sector, make correctional adjustments in policies (ETS system e.g) and create clear long-term strategies for the next 30 years (transition period) as part of the Green Deal.

Currently the European Green Deal (that European Circular Economy Action Plan) is the main "force" of the European Union to fight against climate change with the promise to manage the targets to reduce greenhouse gas emissions by 55% in 2030. However, this plan due to its dependency on global finance does give freedom for clear systematic change within the European Union in an inclusive way (Storm, 2020). The final result for this research is that for the banking sector to be incentivised to assist their steel industry clients, they first need a good "tool" to give them specific criteria to assess the state of their clients and their performance. To be able to provide concrete policies and "tools" which can help achieve systematic change that is not going to hurt the consumer (lower income), there is need for political will and actions because the time is running out.

The history of the European Union is connected with the steel industry with big bonds since EU started as the Coal and Steel Community. It is evident from the results of this research that EU sees steel as an integral part and thus there is a sense of protectionism towards this sector. I believe that if this protectionism is translated to helpful policies that provide access to capital with the purpose to creative a competitive circular market, the steel industry will be for years to come a valuable part of this Union.

A

ULCOS programme technologies

The research of Keys et al. (2019) provides a good comparison regarding the different technologies that are developed currently under the umbrella of the ULCOS programme. The programme is a unique coperation of the steel sector with research institutes and universities with the aim to reduce the CO_2 footprint of the steel industry by 50% (Meijer et al., 2009).

The different technologies that have not been introduced in the main report are the following:

- Top gas recycling furnace-TGR-BF
  This technology builds on the conventional mills with a different top, that provides a more concentrated CO_2 emissions outcome, that is more prefered for CCS

- Direct reduction process (UCLORED, H-DR)
  It is already a used technology (7% pf current production) This type of technology is using natural gas instead of coke (as reduction agent) (Keys et al., 2019)

- ULCOWIN and ULCOLYSIS
  This technology is the most premature compared to the rest of the programme. They require a lot of energy that makes them less feasible to scale up (Keys et al., 2019).

The Figure A.1 provides a comparison between the different technological pathways regarding the total energy and consumption of each technology (Keys et al., 2019). The calculation for this estimation includes the fuel consumption and coke (reductant substance) used in the conventional BOF (Keys et al., 2019).

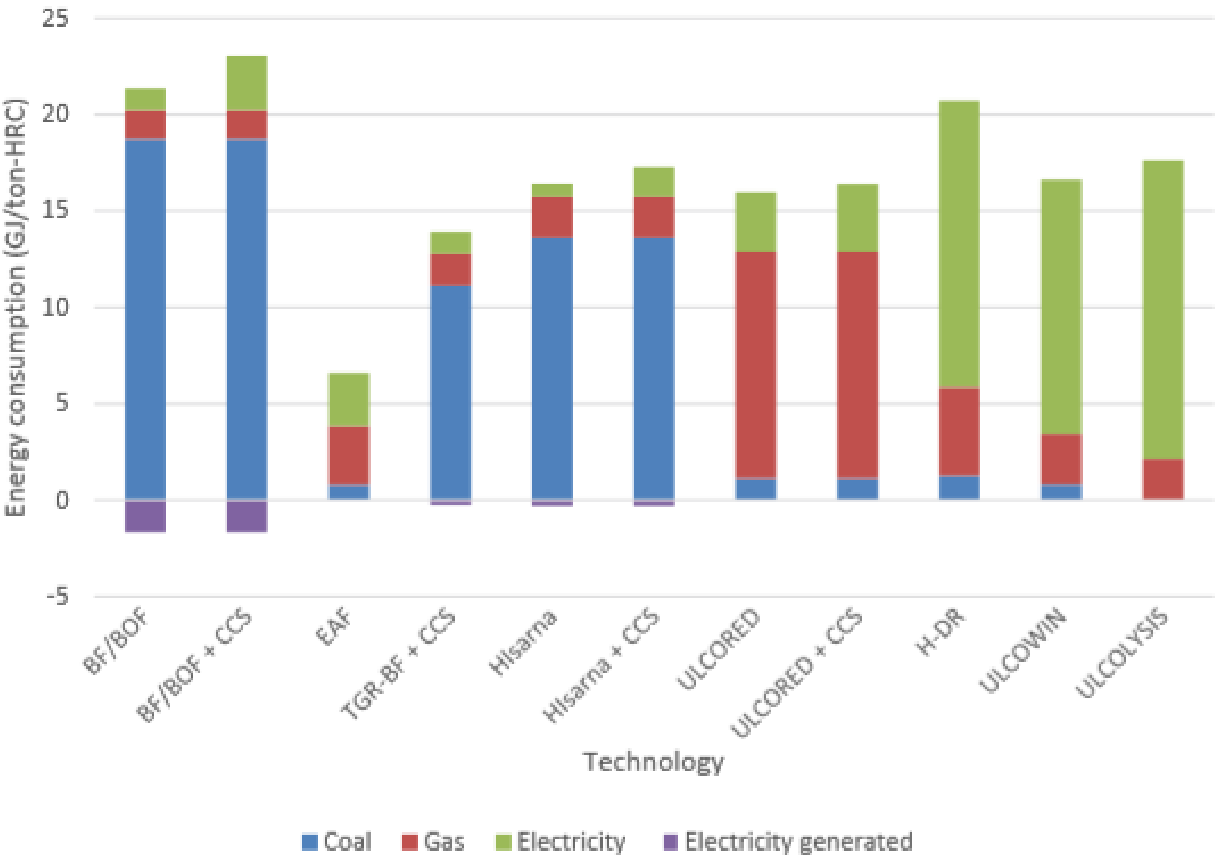

Figure A.1: Annual energy consumption of the technologies developed in the ULCOS programme compared to the BF/BOF process (Keys et al., 2019)

The Figure A.2 gives an estimation (range) of the overnight investment cost of the different technological pathways that are currently under development in the ULCOS programme (Keys et al., 2019). It is important to mention that some decarbonization options are more feasible from others regarding the readiness of the technology. In the Figure A.3 we can she the estimated annual operating cost based on the raw material and the other operating cost. While in the Figure A.4

we can see the annual energy cost of these pathways based on the historical data of 2017 in the Netherlands.

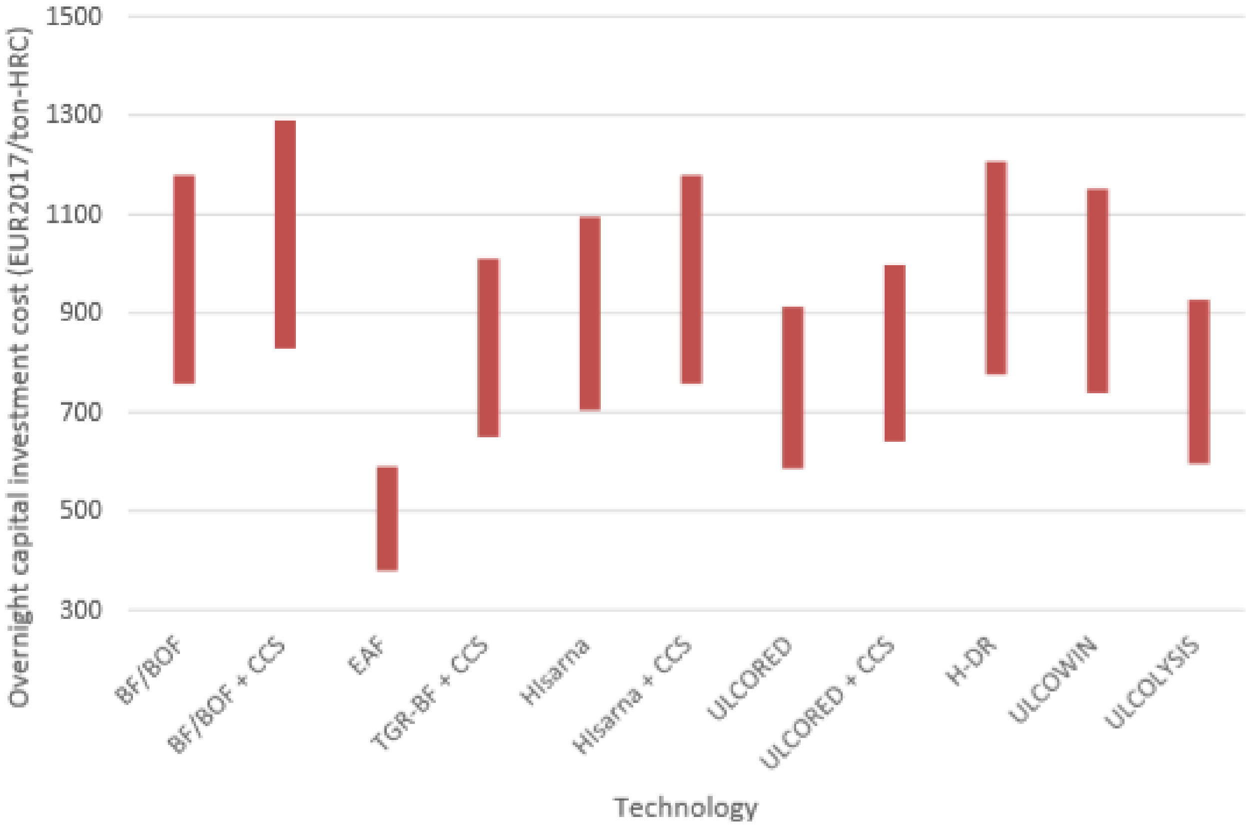

Figure A.2: Overnight capital investment cost of the different ULCOS technological pathways(Keys et al., 2019)

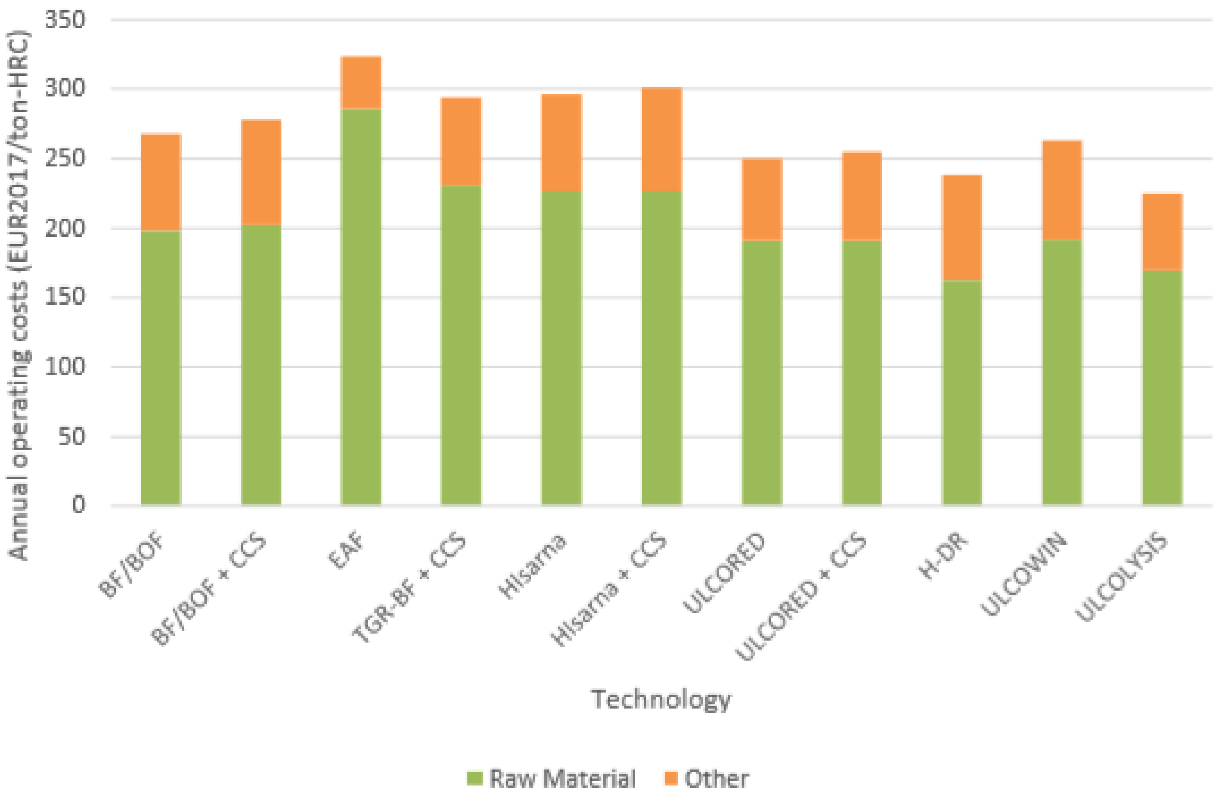

Figure A.3: Annual operating costs - excluding the cost of energy of the different technologies (Keys et al., 2019)

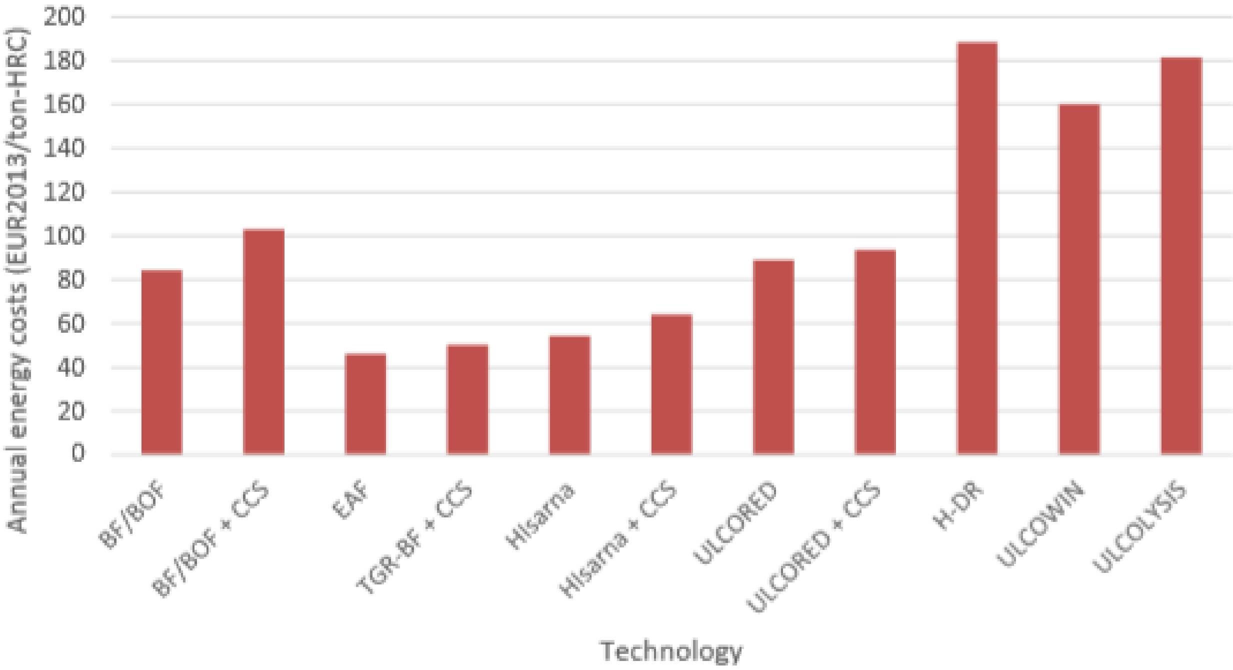

Figure A.4: Annual energy costs of the different technologies (Keys et al., 2019)

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