Decarbonization & Destabilization a Multi-Level Perspective on the Dutch steel-making industry

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Preface

Conducting this study was a journey of exploration. It started from the point where I wanted to investigate the barriers and drivers and current position of the energy transition towards a greener future. But this journey quickly resulted in finding out that heavy industry and Energy-Intensive Industries (EII) were one of the main underdeveloped sectors regarding decarbonization and sustainability efforts, in fact, sparking my curiosity why especially these industries were lacking decarbonization results. Policies and efforts did exist for these industries to push them towards decarbonizing their processes?

This research started in early 2021, at which point in time the discussion and social protest among the Dutch IJmond region was ongoing, if not at its peak. This debate and my research in EII characteristics presented fruitful combinations. Combining the two discussions could result into verifying scientific data with real world data on both characteristics and barriers towards change or innovation, I argued.

Besides, I want to distinguish what aspects of decarbonizing, and enhancing local steel-making industries, or heavy industries in general need to be considered in the debate. This is useful for policymakers, industry stakeholders, but also local residents and the wider public in future situations or ongoing transitions. Acknowledging there might be a problem is the first step to address imperfections and solving them.

I want to express my huge gratitude to Dr. A. F. Correljé for the many insightful and interesting discussions and meetings throughout the course of this research. Although we didn't meet regularly, the discussions we had were always broadening my view on what aspects and different view points could be taken to look at the same situation. This added towards the broad and explorative characteristic of this study.

The interviewees ned to be given thanks for their participation in this study and to open up on their thoughts and motives on issues discussed. I have enjoyed our conversations very much, and it opened up another field of data gathering for me. Without you it had been impossible to construct some form of a comprehensive picture of the situation.

Last but not least I want to express my endless gratitude to my friends an family for supporting my journey, towards finishing my studies, to listen to and accept me grumbling about my scientific adventures. You kept me focused on the final destination.

Dedicated to my dad and in loving memory of my mother, who supported me, my academic struggles and aspirations with endless patience. Without you none of my efforts would have been fruitful.

Abbreviation List

Here the list of abbreviations which have been used in this report, and their description are presented.

BAT	Best Available Technology
BCA	Border Carbon Adjustment
BF	Blast Furnace
BF-BOF	Blast Furnace Basic Oxygen Furnace
BOF	Basic Oxygen Furnace
CBDR	Common But Differentiated Responsibility
CCS	Carbon Capture and Storage
CCU	Carbon Capture and Usage
CCUS	Carbon Capture, Utilization and storage
CH4	methane
CO2	carbon dioxide
DRI	Direct Reduced Iron
DRI-EAF	Direct Reduced Iron plus Electric Arc Furnace
EAF	Electric Arc Furnaces
EII	Energy-Intensive Industries
EPI	Energy-intensive Processing Industries
ERS	Environmental Regulation Service
ERT	European Round table of Industrialists
EU	European Union
EU-ETS	European Emissions Trading Scheme
GHG	greenhouse gas
H	Hydrogen
ID	Industrial District
IPCC	Intergovernmental Panel on Climate Change
MEP	members of the European Parliament
MLP	Multi-Level Perspective
N2O	nitrous oxide
NEA	Dutch Emissions Authority
NIMBY	Not-In-My-Backyard
RDS	Royal Dutch Shell company
ROI	Return On Investment
SA	Social Acceptance
ST-system	Socio-Technical system
TIM	Territorial Innovation Model
TRL	Technology Readiness Level
WYSIATI	What You See Is All There Is

Executive Summary

Nowadays a growing concern among the scientific community, and the wider public are pushing politicians and countries to design policies for reversing the course of warming the plant. These efforts are backed up by, for example, the Kyoto Protocol and the Paris Agreement. As resources are limited, studies have tried to identify sectors and practices which are the most polluting. These industries are typically named Energy-Intensive Industry, referring to the high energy and temperature needs of these industries. Numerous studies have looking into the ways to decarbonize these sectors, technologically, economically, but also to what extend these changes have effect on social and spatial aspects of society.

Recently, social protest surged in the IJmond region after black snow was encountered next to the large steel-making industry, the backyard of close neighbourhoods. Questions surfaced regarding public health, and local externalities of the industry. In this study, the Multi-Level Perspective (MLP) framework is employed to identify what forces and dynamics are stabilizing and destabilizing the Dutch steel-making industry in the IJmond region.

As the steel-making industry in the Netherlands accounts for thousands of direct and indirect job opportunities, and it adds to the strategic benefit of having one's own steel-making plant, decarbonizing this industry is a complex issue. Asking for a need to balance economic growth, strategic benefits, and public health. But what exactly is the problem? The industry has been in the region for over a hundred years, why is social protest surging just recently?

For this study a non-structured approach is chosen regarding primary as well as secondary data gathering methods. The MLP framework is applied and complemented with the concepts of Social Acceptance (SA) by Wüstenhagen et al. (2007), framing by Bruijn (2017), and the geography perspective proposed by Coenen et al. (2012).

Secondary data was collected via back- and forward rolling on articles that happened to be interesting regarding the decarbonization of EIIs, social protest in the IJmond region, and the MLP. The levels of stakeholders (niche, regime, landscape) were identified and resulted in identifying actors to interview with regard to the IJmond region case (Tata Steel IJmuiden BV, Environmental Regulation Service (ERS) IJmond, NH Nieuws). These actors were then questioned about themes that were identified through secondary data like scientific articles on social, technological and economic barriers and effects, and regional (Dutch) newspaper articles.

It was found that both stabilizing and destabilizing factors were present.

Stabilization was showed by the abundance of policy power struggles. Information and framing, organized pressure, and direct lobbying strategies were applied by EII for favourable legislation with regard to their industry practices.

Destabilization of the regime span across different concepts. The misalignment of rule sets by both mechanisms of evolutionary-economics (presented by the emerging green-steel niche market preferences and the growing support for supply-push policy measures) and social-institutional ones (normative rule sets were misaligned as residents lost their trust and faith in monitoring bodies) were identified. Cultural discourse was displayed by the presence of both actor credibility deterioration (The polluted snow and graphite rains in combination with their voiced compliance with permits and regulation) and the shift of experiential commensurability of perceived story-lines between regime and niche actors (When reports on health problems distinguished graphite rains harmful for children, although previously these had been flagged as non-harmful ones, but neglecting the measures that were taken to prevent graphite rains in the future).

Furthermore, the transition phase and path were characterized according to Geels and Schot (2007) and Geels (2019). The niche-innovation of Direct Reduced Iron (DRI) and Electric Arc Furnaces (EAF) is considered to be substituting that of Blast Furnace Basic Oxygen Furnace (BF-BOF), and the landscape developments are considered to be applying pressure to the regime to change there industrial practices. Concluding that the nature of interaction between landscape development, niche-innovations and the regime level are characterized as disruptive and competitive. The niche-technology itself is considered to be ready for progression into regime level, represented by the indicators of market-share, powerful actors joining the support network, and strong expectations that DRI and EAF are on a route towards enhancing their performance and price. The different land-

scape developments, phase and path are visualized in figure 8 on page 49 presenting an overview of the different forces adding to the socio-technical transition in the IJmond region.

Additionally, it is shown that the regime actors, and thus incumbent firms, are able to produce radical innovation routes, also presented by Geels (2019). It must be noted that innovation or sustainability achievements are not merely attributable to the performance of one company alone. institutional comparative advantages and institutional thickness are presented by Coenen et al. (2012) to be of influence and should be considered as well when comparing contexts. The SA concept as proposed by Wüstenhagen et al. (2007) teaches u that it has played a considerable role in the past and present decision-making process. But also is going to play an extensive role in future citing decisions, especially now that the 'green hydrogen' route is chosen.

This study concludes with a section on research experiences with regard to using the multi-level perspective and conducting unstructured interviews on a sensitive and controversial topic. In this section critique with regard to the perspective, and additional findings.

MLP is considered to be good for exploring the boundaries on which a certain transition 'problem' is extending to. At first the different social groups are seen as discriminating ones, in a sense that problems, values, groups from the real world can only fit in on or the other. But after gathering secondary and primary data sets, it became apparent that some stakeholders, values, and discussions can fit in more than one social group. Making it difficult for consecutive studies to follow the same methodology and achieving the same results with the same data sets.

Socio-Technical system (ST-system) change initiation has been attributed to the niche-level. But resulting from later studies and reviews, this characteristic is also attributed to the landscape-level. It is proposed that also the regime-level can initiate a transition process. Regime actors abandoning social rule sets and believes creating, internal tension between regime actors.

Further exploration on what the geography perspective proposed by Coenen et al. (2012) can enhance the comparison of different territorial transition processes, and how institutional comparative advantages or thickness are determining these differences.

Although Öhman et al. (2022) argue for a different conclusion on the technology readiness of steel-making production processes, this is based on a different strategy of readiness determination. When Öhman et al. (2022) way of reasoning with regard to the readiness of technology, the same conclusion is reasoned for.

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1 Introduction

In this section the context in which the problem is set and the relevance to the curriculum of the study of Management of Technology are presented. Concluding this chapter is a further outlook on what the remaining sections are presenting.

1.1 Context

Climate is warning, sea levels are rising and it seems that human behaviour of emitting a disastrous amounts of greenhouse gas (GHG) is at the core of these changes (NASA, 2018; Nerem et al., 2018; U.S. GCRP, 2017). GHG is a group of gasses that trap the heat of the earth, namely carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), and fluorinated gasses. To revert this fallout and combat climate change, countries have joined forces to lower emissions (e.g. the Kyoto Protocol (Tardi, 2021) and the Paris Agreement (Climate Focus, 2015)). To decelerate the warming of the earth, a widely known, two-fold strategy is used: adaptation and mitigation. Meaning, respectively, that humans have to adapt to the changing climate, but also to (drastically) lower human influence on the climate (Climate Focus, 2015). Although many parties acknowledged action had to be taken quickly in order to reduce GHG emissions, being on track towards net-zero emissions in 2050 is more the exception than the rule (Lebling et al., 2020).

Since the Kyoto Protocol has taken effect and the Paris Agreement was signed by 191 parties, numerous policies have been implemented and businesses have tried to adhere to these new climate standards (UNFCCC, 2015). In recent studies, negative impacts are shown to be inherent to climate mitigation actions. More specifically, these negative impacts are across social, economic, and policy making aspects (Åhman et al., 2017; Brock et al., 2020; Carley et al., 2018; Gabaldón-Estevan et al., 2016; Mayer et al., 2019; Nurdiawati and Urban, 2021; Sovacool et al., 2015; Sovacool, 2021; Wesseling et al., 2017).
Apart from these identified problems in different fields, predictions on emissions causing climate change are not optimistic. Production-related CO2 emissions are projected to continue to rise, as developing countries enhance their standard of living (Bataille, 2019; Napp et al., 2014). Energy consumption is projected to rise as well by 40%, and as final energy consumption are for the most part carbon intense fossil fuels, this adds to an intensifying call for decarbonization (Crijns-Graus et al., 2020; Napp et al., 2014).

The biggest portion of emissions globally derive from the Industry sector (Rissman et al., 2020). The industry sector itself is also consisting of many different kinds, but the top polluting ones have been put in one basket (e.g. Energy-intensive Processing Industries (EPI), EII, energy-intensive basic materials industry, or hard-to-abate sectors) but all refer to the same types: Iron and steel making, paper and pulp, cement making, chemicals, and the plastics industry (Bataille, 2020; Energy Transitions Commission, 2018; Rissman et al., 2020). McKinsey's report on the net-zero transition even concludes that the steel and cement-making industry makes up for 14% of global CO2 emissions and 47% of industry's CO2 emissions (Krishman et al., 2022). As Crijns-Graus et al. (2020) projects that final energy consumption will rise by 40%, studies advocating energy efficiency measures for sustainability purposes are arguably not 'radical' enough (Napp et al., 2014; Rissman et al., 2020; Ritchie and Roser, 2021).

Fan and Friedmann (2021) concludes that decarbonization of steel-making industry is lacking in most countries, and is often not included in policy measures or innovation agenda's. Sovacool (2021) concludes that without proactive governance low-carbon transitions can also be 'more antagonistic, exclusionary, violent, and destructive' (p.14). Recently, Intergovernmental Panel on Climate Change (IPCC) concluded in their final concluding report on climate change that current emissions are not dropping, but still rising, noting that current climate policies are far from enough to achieve Paris Agreement standards (Brugh, 2022).

This is where the steel making industry in the Netherlands becomes of great interest. Recently social protest surged after locals encountered fresh snow being painted black, presumably by pollution from the local steel making plant (Oei, 2021b).

Although several technology pathways are discussed in studies on decarbonizing the steel making industry and EIIs, none of them are commercially available yet (Gerres et al., 2019). Gerres et al. (2019) further explains that from a historical perspective it can be concluded that extensive public incentives are needed for new innovative technology to aid in climate mitigation practices. A more

recent report focused on advising on the Dutch pathway towards sustainable steel production concluded that the Dutch steel-making industry is already operating on an excellent efficiency level with regards to energy consumption and significantly reducing CO2 emissions are requiring even more 'substantial investments than ever before' (Keys et al., 2019, p.4).

The Dutch government is initiating a process in which hydrogen will be the main sustainable energy carrier in the future, needed to achieve 55% emission reductions in 2030 and 100% GHG in 2050 (Rijksoverheid, 2019). The steel making industry is responsible for 8% of the total emissions of the Netherlands and is clustered in the IJmond region of the Netherlands (NOS op3, 2021), offering the government their help in achieving net-zero transition goals (Koster, 2021a).

The arising question is: What will be the future of the steel making industry in the Dutch IJmond region? Some want the industry gone, but because the industry also provides 11.000 jobs directly plus more than 40.000 jobs indirectly, the socio-economical value is considerable (Stooker, 2021).

As Sovacool et al. (2020) argues that socio-technical approaches would benefit adoption modelling with regards to low-carbon innovations, the socio-technical perspective is deemed useful for analysing the IJmond region. Additionally, Gillard et al. (2016) declares that there is a growing need for focusing on system-wide radical transformations with regard to sustainability or green transitions, as an alternative to the present abundance of incremental component adjustments. The MLP framework argues that radical innovations are crucial for system-wide transitions, niche innovations are salient to radical innovations, and technology and society are interdependent on each other, a suitable argument for adopting this framework in analysing the IJmond region and the social effects of the steel-making industry.

The MLP perspective distinguishes three different interacting levels: the socio-technical landscape, the socio-technical regime, and the technological niche level. Although it is not completely correct, at first sight the different levels can be seen as macro-meso-micro networks and activities. Geels (2011) argues that the levels are referring to 'different degrees of structuration of local practices, which relate to differences in scale and the number of actors that reproduce regimes (and niches)' (p. 37). The regime and niche level each have their own degree of Science, Culture, Technology, Policy, Industry, and Market and user preferences and the social-technical landscape level represents an exogenous environment. In general, the regime level remains stable until landscape developments, niche technologies or internal regime pressure intensify, destabilizing the regime and creating windows of opportunity for new technologies and social changes. The framework does not provide a workable theory (e.g. when 'A' happens, 'B' occurs) but provides analytical concepts for identifying different forces, on three different levels, for analyzing system transitions.

What is causing the sudden public debate in the IJmond region on the local steel-making industry, which has been there for over 100 years? What pressures in the socio-technical landscape, the regime, or the technological niche level are causing this change in perspective?

In *section 2* the MLP framework is elaborated by presenting its three levels, social groups, social rules, past and solved critique on the framework, past use of MLP, and how change occurs according to the framework. Based on the critique of the framework, the concepts of SA by Wüstenhagen et al. (2007), framing by Bruijn (2017), and the geography perspective proposal by Coenen et al. (2012) are added to create a more comprehensive, detailed version of the MLP framework. Concluding, research questions are presented to guide the study, accompanied by explaining the way of data-gathering for this study.

Section 3 presents the data which were found, categorized on the level of regime, niche-innovations, and landscape developments, and there respective social groups.

Section 4 presents the presence of concepts described in section 2. As a concluding chapter to this study, it answers the sub- and main research question of this study.

Section 5 presents points of discussion with regard to the execution of the study and answers found to the research questions. It also presents topics that demand further research.

1.2 Management of Technology

The ambitions on decarbonizing the industry and other sectors tremendously affect business processes of procurement and their use of assets. As well as a growing understanding of climate effects on consumers, changing their needs, wants and expectation of business and industrial sectors. Research on gaining new insights on what these consequences might lead to with regard to social, economic and policy-making empowers the decision-making of policy makers and corporations in what strategies are better than others to achieve the goals that are aspired. Adding to this field of research resonates with the core values of the Management of Technology program at TU Delft, in which technologies are seen as a corporate resource to achieve a balance in the social, economic and technological environment (TU Delft, 2021).

2 MLP and transition

In this section, both the theories, concepts, and frameworks are explained, which are used in the remaining part of the study. Firstly the MLP is explained, which 'levels' it acknowledges, in which cases it has been used before, what criticisms have been voiced and solved. Then the SA by Wüstenhagen et al. (2007) is proposed as an addition to this perspective. Afterwards, it is explained how change occurs in ST-systems, what pathways and phases are present according the the latest additions of Geels (2019). Resulting in the research questions and sub questions in section 2.9 that determine the goal of the study.

Afterwards, in 2.10 the data gathering methods are explained, how the interview questions where constructed, how additional elements were found to be present in the sustainability discussion of the Dutch steel-making industry, and how data triangulation is used to argue for issues and conclusions.

2.1 Multi-Level Perspective

The MLP perspective provides a helicopter view on a transition, analysing on three analytical levels. It also allows a broad view of time perspective. Because of this and acknowledging the interaction between society and technology or innovations and their influence on each other, this is deemed a suitable framework to look at the the transition taking place in the Dutch steel-making industry.
Together with the co-evolutionary view on society and technology, MLP is incorporated in the so-called 'socio-technical perspective', present in the Dutch energy transition approach (Kemp, 2010).

Co-evolutionary meaning that society and technology influence *each other*. This interaction brings about path dependencies, technological lock-ins and irreversible (landscape) developments (Kemp, 2010).

Questioning the emergence of new sectoral systems from old ones, Geels (2004) developed a three-dimensional framework that allowed identifying interactions between existing (regime) systems with new (niche) ideas and macro (landscape) developments. Geels and Schot (2007) define transitions as 'changes from one socio-technical regime to another' (p. 399). It focuses on explaining what changes or stabilizes existing Socio-Technical systems (ST-sytems), and proposes that interactions with the other two-levels are crucial in understanding ST-system changes (Geels, 2004).

As we learn in the figure below, the three levels interact with each other in different ways. Although a figure simplifies the concept of MLP and the levels presented seem to be consisting of the same things, the socio-technical landscape differs inherently from the of socio-technical regime and niche level (Geels and Schot, 2007). The characteristics and differences between the levels are explained in the next paragraphs.

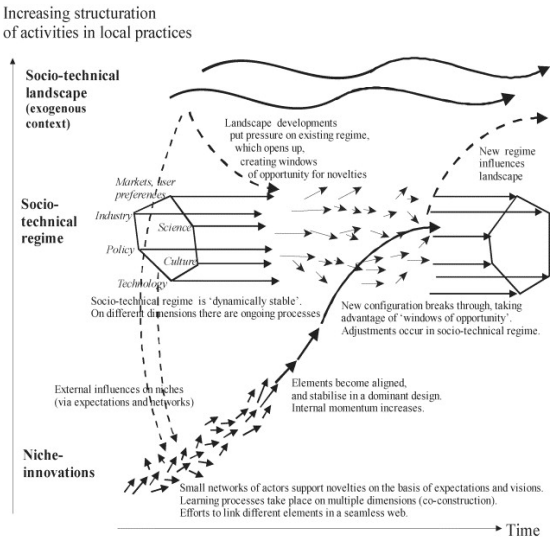

Figure 1: MLP visualized, taken from (Geels, 2004)

2.1.1 Socio-technical Regime

This regime concept is an extended version of that of Nelson and Winter (1982) version of the technological regime: 'shared cognitive routines in an engineering community and explained patterned development along technological trajectories' (Geels and Schot, 2007, p. 400). The 'socio' factor in this is added by sociologists and argues that 'scientists, policymakers, users and special-interest groups also contribute to patterning of technological developement' Geels and Schot (2007). This means that the socio-technical regime consists of multiple social groups interlinked by 'rules' that are being acknowledged by these groups, also referred to as the 'deep structure' of ST-systems (Geels, 2004). Building on top of the idea that social groups are linked by rules, that these rules stabilize their regime, the social groups can also be considered as different regimes. Thus, the socio-technical regime is considered to be consisting of

multiple social regime groups: Technology, markets and user preference, culture, policy, science, and industry regime (Geels, 2004). In short, the socio-technical regime refers to 'the semi-coherent set of rules that orient and coordinate the activities of the social groups that reproduce various elements of ST-systems' (Geels, 2011, p. 27).

2.1.2 Social groups

The social groups each have their own distinctive characteristics but also overlap in some manner (Geels, 2004). This set of social groups is not definitive and is just a snap shot in time, as social groups evolve and new ones emerge, thus making concluding boundaries for social groups not possible (Geels, 2004). For analytical purposes, the different distinctions of social groups are elaborated below, some requiring more elaboration than others.

Technology refers to the core of the industry. The technologies used in the processes of the firms. Take the example of steam technology in Geels (2002) on the transition from sail boats to steam ships.

Science represents (scientific) research being done in the field. Which stabilize or destabilize the regime believes.

Culture is about cultural dynamics. In this aspect, competing social groups are articulating their own version of their realities and story lines on public stages (e.g. newspapers). Their goal is to influence the views and opinions of relevant outside groups (politicians, wider public) which are the foundation of their financial or public support or protection (Geels, 2019). Whether a version of a story line is being accepted or deemed true or useful by outside groups varies during transition processes, depending on the way of framing, and various aspects: *empirical fit* (how story lines fit with perceived facts about the world), *experiential commensurability* (how story lines resonate with the lived experience of its audience), *macro-cultural resonance* (how story lines fit with broader cultural repertoires), *actor credibility* (perceived knowledgeability and trustworthiness of actors promoting a story line) (Geels, 2019, p. 193). A quick example is the case of solar-PV technologies. These are viewed by regime incumbents as being high of costs, drain on economic development and have system integration problems. While niche actors are emphasizing their potential on climate mitigation, new business growth, and a new energy paradigm (Geels, 2019).

Markets and user preferences refer to the characteristics on how markets are configured and what new entrants are confronted with. Additionally, the demand side of markets, referred to as user preferences are typically distinguished here.

Industry characterizes the production side of the markets which are being reviewed. It aims to analyze why certain industries are different to others, in a way that factors can be found that explain why change happens or does not happen.

Policy refers to the political power struggles that play in transitions of systems. Geels (2019) further described this analytical social group as one that refers to the political balance of power between the regime and the niche level. 'A power struggle between dominant coalitions (adhering to established policy frames and governance styles that help stabilize socio-technical regimes) and new coalitions (policy entrepreneurs who advocate new frames an policies that stimulate niche-innovations)' (Geels, 2019).

2.1.3 Social Rules

Geels (2004) distinguishes three groups of rules that are being present in between these social groups, and can be used in analyses: *regulative* (formal rules e.g. government regulations, rewards and punishments backed up with sanctions), *normative* (e.g. values, role expectations, responsibilities, and rights), and *cognitive ones* (e.g. priorities, problem agendas, beliefs, search heuristics). Geels (2004) describes these regime rules as semi-coherent rule sets, being interlinked and thus alternating one rule without changing others is difficult. The alignment between these rules are what produces strength. In other words, the rules linking the social groups are also the reasons behind stabilization of regimes: 'cognitive routines that blind engineers to developments outside their focus, regulations and standards, adaptation of lifestyles to technical systems, sunk investments in machines, and infrastructure and competencies' (Geels and Schot, 2007, p. 400).

Later, Geels (2019) presented these rules as causes to techno-economic, social and cognitive, and institutional and political lock-in mechanisms and salient to incremental and path-dependent innovation in regimes.

2.1.4 Technological Niches

The niche concept of MLP can be treated to be similar to the socio-technical regime, as in that

it consists of the same social groups, but has less stringent and flexible set of rules between them, allowing for radical change and innovations (Geels, 2004). Geels (2011) defined them as follows:

> Niches are 'protected spaces' such as R&D laboratories, subsidised demonstration projects, or small market niches where users have special demands and are willing to support emerging innovations. Niche actors (such as entrepreneurs, start-ups, spin-offs) work on radical innovations that deviate from existing regimes. Niche-actors hope that their promising novelties are eventually used in the regime or even replace it. (p. 27)

Replacing the existing regime is not easy. As elaborated for socio-techincal regimes, the regimes adhere to rules that stabilize each other, and additional lock-in mechanisms contribute to the stabilization of regimes. In this framework niches are considered to be of huge importance in system transitions. Regimes typically only produce incremental innovations, whereas niches produce radical ideas and innovations. This is why niches are considered to play a big role in systemic change and transitions (Geels, 2011). In Geels (2019) the focus is more on sustainable green transitions and proposes that additional challenges for these green niche-innovations are: lack of benefits of economies of scale and long periods of incremental improvements, and radical innovations may suffer from the liability of newness which degrades the access to financial resources, social acceptance, and cultural legitimacy.

2.1.5 Socio-technical landscape

The socio-technical landscape level is seen as a different 'kind' of analytical level, being exogenous to the regime and niche level (Geels and Schot, 2007). In this landscape level, two different kinds of changes are considered: 'slow-changing developments (e.g. demographics, cultural repertoires, societal concerns, geo-politics, macro-economic trends) and external shocks (e.g. wars, financial crises, accidents, oil price shocks) (Geels, 2019, p. 190). Geels and Schot (2007) presents that the landscape level is similar to the static idea of rivers, soil conditions and lakes in biological evolution, but also dynamic 'i.e. analogies for rainfall patterns, storms' (Geels and Schot, 2007, p. 403). The landscape is a broad context that makes some actions easier than others and 'do not mechanically impact niches and regimes, but need to be perceived and translated by actors to exert influence' (Geels and Schot, 2007, p. 404).

2.2 Historical use

The MLP framework is considered to be a process theory, and as such can be utilised for identifying different social groups influencing each other in technological transition processes (Geels, 2019). This also means that this perspective does not allow for distinguishing causal relations, but explains outcomes by 'event sequences and the timing and conjunctures of event-chains' (Geels, 2011, p. 34). This framework has been previously used for identifying historical technological transitions paths such us the development of sail ships to steam-propelled ships (Geels, 2002, 2004). This questions the use of the framework for a small time frame (3–5 years) aimed by this study. But in Geels and Schot (2007) it is argued that process theories need two complementing components; long-run and short-run developments. As depicted by the long empirical transition studies, the long-run developments have been identified by MLP before. But also the short-run developments can be effectively shown by utilizing the MLP framework due to the acknowledgement of 'linkages between processes at different levels are made by actors in their cognitions and activities, the dynamics in the MLP are not mechanical but socially constructed (...) these "local" dynamics can be shown in elaborate single case studies' (Geels and Schot, 2007, p. 414).

2.3 MLP critique

Over the years, the MLP has been reviewed and elaborated further to incorporate critique and reinforce weaknesses. Criticisms are e.g. the limited attention to politics and power, cultural meanings, narrowly focusing on technological innovation, and over privileging bottom-up disruption pathways.

One of the first criticisms on the MLP framework was delivered by Berkhout et al. (2004). It criticises the idea that transition from one system to another is characterised by niche-driven technologies being developed in level of niches, moving towards competing with existing regimes, competing, and eventually outperforming existing regime technologies and replacing them. Geels and Schot (2007) reply to this by developing four different

pathways resulting from different starting points in the landscape or niche level. Also noting that the timing of these events (niche developments first follow by landscape developments or the other way around), provokes different transition trajectories. These trajectories are further explained in section 2.8 Transition pathways and phases.

Another critique focusing on the landscape level as being a 'garbage can' type of level is aimed to be solved by Geels (2011) in three ways:

1. Adding more dynamic to the landscape level (distinguishing changes that; do not change (or very slowly), rapid external shocks, or trend-like long-term transitions

2. Paying more attention to landscape forces that assist in *stabilizing* the regime

3. To investigate how regimes *influence* landscape developments or the socio-technical landscape in general.

These points are taken into account later when the research questions are designed in section 2.9.

Geels (2019) acknowledges that a fair criticism is that 'socio-technical transitions research says less about social sustainability (e.g. inequality, poverty, work conditions) than about environmental sustainability' (p. 189). The IJmond region's public protest seems to be emerging from the alignment of social *and* environmental sustainability, using the MLP framework may add to the empirical base, but also to the range of scenarios and scopes the MLP has been applied to. As previous studies that use an MLP regenerate historical transitions of technologies and markets, and this study only aims to analyze a certain regional transition.

2.4 Social acceptance triangle

To reinforce the social sustainability aspect of this study, Wüstenhagen et al. (2007) distinction of SA is used. Wüstenhagen et al. (2007) argues that SA is consisting of three different factors and proposes the social acceptance triangle, displayed in figure 2 on page 15.

A key feature of *socio-political acceptance* is that in general, social acceptance of renewable energy technologies is high, even when a government is lacking effort in supporting those technologies (Wüstenhagen et al., 2007). But problems occur when moving from global to local acceptance. In siting decisions (where would new renewable energy technologies need to be placed in the landscape), social acceptance is considered the main reason behind barriers towards successfully achieving renewable energy technology projects at an implementation level (Wüstenhagen et al., 2007).

Community acceptance is the aspect in which the infamous concept of Not-In-My-Backyard (NIMBY) is staged. Although scholars are not yet aligned with regards to social acceptance diminishing or enhancing when renewable energy technologies are built in their local regions, it is acknowledged that the social acceptance 'curve' is U-shaped. Losing some of its acceptance level during the building period. This aspect of community acceptance is built on three pillars: procedural justice (Are all stakeholders taken into account and voiced in the decision-making process), distributional justice (are benefits and costs shared correctly?), and trust in the investors or policy-makers that advocate the renewable energy project. Wüstenhagen et al. (2007) notes that different parts of a community perceive justice and trust differently, in particular outcome fairness, outcome favourability and process fairness. When events and outcomes are perceived by the community, or parts of it, to be unfair, this is a trigger towards protests, divided communities, and damaged relationships. Notable when these actions' or events' benefits are not equally divided across the community.

Also, trust is seen as a very important factor to facility siting decisions. Trust and fairness with regards to siting decisions are mostly linked with and the need for openness:

> How potential risks are defined, how information about those risks is produced, and how and by whom they are managed. [...] It is also noted that the 'the opennes of the process for local involvement and the flexibility and open mind of the actors from outside are crucial, because things can easily go wrong.(Wüstenhagen et al., 2007, p.2687)

Market acceptance is still lacking extensive research and is thus left out for consideration in this study (Wüstenhagen et al., 2007).

Figure 2: Social acceptance triangle, taken from Wüstenhagen et al. (2007)

Lastly, Wüstenhagen et al. (2007) notes that social acceptance is of great importance to a new innovation regarding fossil power generation transitioning towards a greener future: Carbon Capture and Storage (CCS). It is noted that the wider public have generally little knowledge about CCS but also, surprisingly, have little desire for more information. Adding that trust in (professional) stakeholders is particularly important in this case. But 'NGOs were found to be trusted the most, and industry least by the general public' (Wüstenhagen et al., 2007, p. 2687).

2.5 Geography and space

As mentioned before, this study is focused on a specific territory: the Dutch IJmond region. This deviates from the typical application of MLP studies. But such a geographical boundary might be of great value. Coenen et al. (2012) argues that the conceptual frameworks of Territorial Innovation Studies and MLP lack a geographical, territorial or scalar perspective. With regards to the MLP, this means that the geographical perspective is treated implicitly, 'leaving institutional structures to seemingly float freely across a boundless, global plane' (Coenen et al., 2012, p. 973).

> To provide a more systematic and rigorous account of why, for what reason and where certain concatenations of institutional and innovative interactions comprising transition trajectories occur, we argue that transitions approaches need a more spatially sensitive framing of the institutional contexts within which transition processes evolve. (p. 973)

Coenen et al. (2012) argues for adding concepts from the field of economic geography. This means that adding an 'institutional economic geography' perspective would enhance transition studies in questioning 'the extent to which and in what ways geographically uneven transition processes are shaped and mediated by institutional structures' (Coenen et al., 2012, p. 973). Although the scope of this study focuses on executing the MLP framework complemented with the concepts of Social Acceptance and Framing, the concept of Geography adds a fruitful base for further exploration on how *comparative institutional advantages* and *institutional thickness* can explain the differences in sustainability transition achievements across regional and national territories. To nurture this potential exploration in the near future, the ideas by Coenen et al. (2012) on how the MLP could be complemented with a spatial perspective, and are, where applicable, noted in section 3 and 4.

Comparative institutional advantages and institutional thickness relate, respectively, to a national and regional level of institutional differences. Institutions refers to the regulative, normative and cognitive rule sets, defined before.

Comparative institutional advantages has been used to explain 'why some countries provide better framework conditions for firms to engage in radical innovation than others'.

Institutional thickness refers to 'the comparative performance of governance bodies in terms of their ability to work together locally, and persuade or compel sufficient external agents to support their activities'. (Coenen et al., 2012)

With these concepts in mind, comparing different sectors, companies, industrial regions, or territories becomes a more nuanced activity then has been done by Dutch newspaper articles, which is further elaborated on page 30. Adding this perspective to this analyses also adds to the comparability between single case studies (Coenen et al., 2012).

2.6 Framing

If a problem or discussion becomes one of the public or political debate, actors will most likely chose sides. Depending on which side one is on, or part of, determines the way in which these problems or events are articulated to opponents or the wider public. The concept of 'Framing', is about using frames to simplify complex situations and convey a powerful message to a wider public, but also putting an embedded message on opponents and proponents of that frame. Because of the different viewpoints of proponents and opponents on the industry in the IJmond region are so clearly present, this notion is used as well to depict the different

frames in the discussion and why some are valuable and in which way they are valuable. A quick example is that of a foreign individual, working in one's country. Which can be framed as an 'illegal immigrant' or an 'undocumented worker'. Using one of the two frames immediately incurs positive or negative images and associations in a discussion and in one's mind.

2.6.1 What are the features of a good frame?

Bruijn (2017) explains a couple of reasons why and how these frames work.

Frames are catchy, they are easy to remember and convey. An example provided by Bruijn (2017) is he following: 'don't give people fish, teach them how to fish (p. 24)'.

We intuitively agree with frames. Such that from the single moment the frame is presented people agree with it. It is hard to imagine anyone is thinking the opposite side of a frame. Such as referring to the fish example, that anyone would prefer handing out fish instead of teaching people to catch the fish on their own.

Frames contain a villain. Almost every frame contains a villain that would or is pictured as someone that would, prefer to do the bad choice in the frame. Again referring to the fishing example, that villain would prefer handing out instead of teaching how to fish. These villains don't have to be mentioned explicitly. Proclaiming that you want to teach people how to fish, implicates that opponents of your view prefer to hand out fish.

Frames challenge your opponent's core values. This is explained by Bruijn (2017) by the example of paying taxes that cover student's tuition and student loans. Left-wing parties emphasize the aspect of free or low-cost of college and university enhancing low-income social groups. Opponents generally emphasize that graduates in general earn more money than non-graduates. Meaning that college and university funding is particularly unfair for those who don't go to college. Exemplified by Bruijn (2017) by the following example: "Why should a plumber pay for a future lawyer to go to law school?" (p. 26).

Frames tap into social undercurrents. Every society has stories that are generally believed to be true. Such as the general negative perception towards over-management and bureaucracy in organisations like schools and hospitals. Framing that two school or hospitals merging into one would easily result in the following frame: "A bigger hospital means more managers, and less health professionals, more bureaucracy, and less care" (p. 28).

These are features of a good frame to convey one's message, values and the presumed position of the opponents values and opinion on the subject.

2.6.2 How does a frame work?

Now that the frame is presented, the opponent has to react. By either stepping into the frame or proposing a different one. If one steps into the frame, one is forced to discuss the issue on your terms. This has consequences for the remaining part of the discussion or debate (Bruijn, 2017). These consequences are explained in this paragraph.

Opponents are put on the defensive. Resulting from when people intuitively agree with a frame, everyone opposing it, is condemned to be wrong.

Frames easily get free air time. When one steps into one's frame and uses their language to convey their message, the initial frame used gets free air time and will most certainly gain free air time when doing so. This is explained by Bruijn (2017) in the following example on the fishing rod story:

> I am really annoyed, by this cheap rhetoric. My policy has always been to empower people, to teach them how to fish. Development aid is all about handing out fishing rods. The essence of my policy is to teach people how to fish. (p. 30)

What would stick within one's mind if this was a response to the teach-them-how-to-fish frame? It most certainly would be that teaching them how to fish was a core argument. As the opponents to development aid was trying to achieve.

Heavy burdens of proof are placed on the opponents of frames, and light ones on the owners of the frames. This means that when a frame is presented, people who are confronted with the frame are very sensitive to information confirming that frame.

Frames require complicated answers. A good frame is a simple frame, and simple frames require complicated answers and complicated answers are almost always vulnerable to criticism or follow-up questions, weakening even more the credibility and position of the opponent.

Frames are confirmed by denying them. When someone accuses another person of being impolite, incorrect, unfriendly or explained by Bruijn (2017) example; the French prime minister claimed

in 2014 to discuss the state of the European economy "France is not the sick man of Europe". This makes us wonder why someone would say such a thing, maybe there's some truth to it? There's no smoke without fire. It might not be that France is the sick man of Europe, but there might be something wrong with the country, but amongst all, this certainly wasn't the intention of the prime minister.

2.6.3 Why is it or should framing be used?

Apart from how to weaponize against framing there is also a question whether or not framing should be used in the first place, from a moral point of view. Bruijn (2017) presents some arguments for both sides of this moral debate, leaving the choice to the reader. It is not covered by the scope of this study to discuss the moral reasons behind framing as this study is on analyzing the social and technological dynamics in the IJmond region. But it might be of value to present the mechanisms or tactics to deal with frames that are imposed on actors during the ongoing debate on the transition process.

Framing is used for the simple reason that complex situations are hard to convey in short messages and airtime. To fully understand every aspect of a situation quite sometime is needed to present data, methodology, and conclusions. This all can be avoided if the essence of the problem is captured together with a proposed solution. This is done by using frames: a lens or filter to convey one's core values and intentions to a wider public or in a debate.

2.6.4 Reframing

Bruijn (2017) also proposes several strategies to reframe discussions in order to win debates:

The 3P model. The 3p model is about using three different ways of reframing, by choosing between policy frames, principle frames, and personal engagement frames. The strategy entails that if a frame based on of the three P's, use on or both of other P's to reframe the problem according to your perspective or language and values. This is not merely a political game, but a respectable strategy to unfold the foundation on which politicians base their believes and policies. By asking about their principles, questioning their principles and inquire policy effectiveness, a more comprehensive picture is depicted than by just presenting one of those perspectives or P's.

Victims, villains, and heroes. This strategy is played around portraying proponents and opponents of a policy proposal as one of the three roles. These roles usually play around certain emotion e.g. injustice and inequality. When emotions become very strong, tolerance for complexity decreases, and people tend to think in terms of victims, villains, and heroes (Bruijn, 2017). People or politicians are accepted as heroes when four expectations of the hero-role are met in some way. Heroes must resonate with the victims and their opinions, and oppose the villains. The hero must take action, to directly take on the villains, without side-stepping or proposing a detour. Heroes proposing clear cut problem definitions and clear solutions are felt to be in control, proposing complex solutions and problem definitions corrupts the hero-role. The hero's actions also need to be taken now rather than later. This strategy is all about introducing different narratives in which one is not the villain, but the hero.

Opponent's values. Although one's principles can be acknowledged by a broad range of people when these values are like equal opportunities and the need of a free market, such values also have downsides. For example, equal opportunities for all could result in not rewarding excellence and sustaining lower standards than when opportunities are not equal. Defending the idea or the need of a free market could also mean that one is in favour of a sink or swim society in which 10% of the population is below the poverty line. This strategy is about highlighting the downsides of the opponents values and providing concrete examples of how these downsides affect policies and outcomes. It is also possible to hijack the opponent's values by connecting their values with your policy proposals. Bruijn (2017) argues that values and emotions are a good way to establish a relationship with your audience. By connecting opponent's values with one's policy proposals or propositions, one might be able to reach the hearts and minds of their audience and opponents. When one is confronted with this strategy, where an opponents takes your own values, transforms, or hijacks them, it is essential to stick to those values, but also arguing that the opponent is betraying those values.

Opposite perspective. Playing with opposite perspectives is very effective in debates as well. When one is confronted for example a frame or perspective based on normative values and behaviour, to win, one must take on the opposite perspective and arguing for factual statements (Bruijn, 2017). These opposites are: operations vs strategy, real-

ity vs ideals, politics vs policy and process vs content. To reframe or resist these opposite perspective frames, one must clearly identify what perspective the opponent is taking with their frame (factual statement, operational consequences, reality, politics, or processes), and reframe their argument in the complete opposite (normative statements, strategic ambitions, idealistic views, policy consequences, content).

META-framing is about condemning the frame itself that is used. This is clearly exemplified by Bruijn (2017) with an example of the start of a presidential debate. Prior to the debate a story came out that one of the participants of the debate proposed an open marriage back in the day. The first question of the host is whether the accused would like to take some time to explain that story. The accused does not step into that frame, but condemns the frame itself. By rattling on about using such a story as an opening to a presidential debate, and that setting such standards for these debates would diminish young leader's to pursue such a position in the future. Reframing in this case could be done by repeating the frame itself, and accusing the one that condemns the frame itself of looking the other way or avoiding answering the question.

Emotions and monopolies. Although Bruijn (2017) argues that his list of framing and reframing strategies is probably not a comprehensive one, the last one of his list is about heavily emotional loaded debates. Illustrated by Bruijn (2017) with examples in which politicians come face-to-face with a member of the wider public. In these discussions the member of the wider public presents a frame that resonates with everyday's life of the man in the street, representing the real world. Politicians are prone to articulating their world of systems, which is assumed to be disconnected from the real world. Because frames about the real world are almost always stronger than frames of the world of systems, re-articulating the politicians' intentions on policies is likely to end up badly (Bruijn, 2017). To reframe this situation, or the end up gaining the trust of the people voicing their concerns should be aimed on connecting and empathizing with the people, followed up by voicing one's values and how these affect policy decision.

2.6.5 Why is framing added in this methodology

The concept of framing is added to the methodology to show that facts and events can be twisted to serve both sides of an argument or discussion. Although Bruijn (2017) particularly focuses on debates between politicians, in my opinion it can also add a certain value to identify these frames in the debate between industry, politicians, the local and wider public. It may serve the purpose to create awareness that arguments made for one side of the debate, may also have the capacity to impose believes and prejudices without needing the necessary arguments or facts for those believes. Becoming aware of such frames, and looking beyond the mere accusations and believes of stakeholders creates a more comprehensive picture of a situation, allowing for conversation and focusing on the values that are actually at stake.

Moreover, it allows a better understanding on why arguments or sentiments of the local public are resonating better with politicians and the wider public than arguments from the side of the industry actors. Analyzing which framing strategies have been used, could potentially be valuable to future debates, weaponizing both sides of the discussion with ways to articulate their concerns and goals.

Additionally, from a bigger picture point of view, it may allow for depicting the shift in perspective or frame from which the steel-making industry is looked at. From strategic hero, to polluting villain, to a first mover in the hydrogen economy.

2.7 Socio-technical system change

There are two flavours of endogenous processes of rule changes present in the niche and regime level: evolutionary-economic ('rules change indirectly through market selection of product variations') and social-institutional ('actors directly negotiate about rules in communities') (Geels and Schot, 2007, p. 404).

The evolutionary-economic change can occur in two ways; a mutation in the routines of a firm fits better with the selection requirements, and imitation of changed rules appliance by competing firms.

The social-institutional is about social groups interacting upon rules. When new technologies emerge, different groups get familiar with it and define their own problems, interpretations and solutions. As the groups keep interacting on conferences, in journals and at workshops, a shared believe system of the new technology is created. 'Collective-action groups are often important in socio-institutional dynamics, e.g. social movements, special-interest groups, professional associations, branch organisations' (Geels and Schot, 2007, p. 405).

Also, landscape and niche developments can be reinforcing or disrupting regime rules and activities. Whether landscape developments and niche innovations have disruptive or reinforcing relationships depends on the nature of these developments and innovations. Together with the niche-innovation relationship with regimes being *competitive* or *symbiotic* deliver different pathways: Transformation, De-alignment and re-alignment, Technological substitution, reconfiguration, or a sequence of transition pathways (Geels and Schot, 2007).

2.8 Transition pathways and phases

Although previously criticized, Geels (2019) summarizes the ST-system dynamic process as:

> (a) niche-innovations gradually build up internal momentum, (b) niche-innovations and landscape changes create pressure on the system and regime, and (c) destabilization of the regime creates windows of opportunity for niche-innovations, which then diffuse and disrupt the existing system. (p. 190)

These dynamics are translated in four different phases of the transition process, as shown in figure 3. Phase one is characterized by experimentation and trial and error processes.

Phase two is about stabilizing the niche innovations, which then establish to find some niche market for production, delivering a predictable flow of resources.

If radical innovation is distributed among niche and regime actors, it tends to provoke discontinuous and disruptive effects (Geels, 2019). This is based on the Schumpeterian evolutionary economics, creating 'gales of creative destruction' and defined as a period of 'flux' (Geels, 2004). In Geels (2019) this period of flux is also named the 'diffusion and disruption' phase of ST-system transition. This phase is driven by 'niche-internal' drivers (e.g. improvements, support from powerful actors) and landscape developments creating windows of opportunities, provoking pressure on the regime and destabilizing it. Right before and during this phase windows of opportunity arise for niche ideas and technologies to breakthrough into the regime level (Geels, 2019).

Phase four is similar to stabilization in phase 2, but on the regime level, meaning that the socio-technical regime is (partly) replaced by niche rules, ideas or technologies. Anchoring in 'regulatory programs, user habits, views of normality, professional standards, technical capabilities' (Geels, 2019, p. 191).

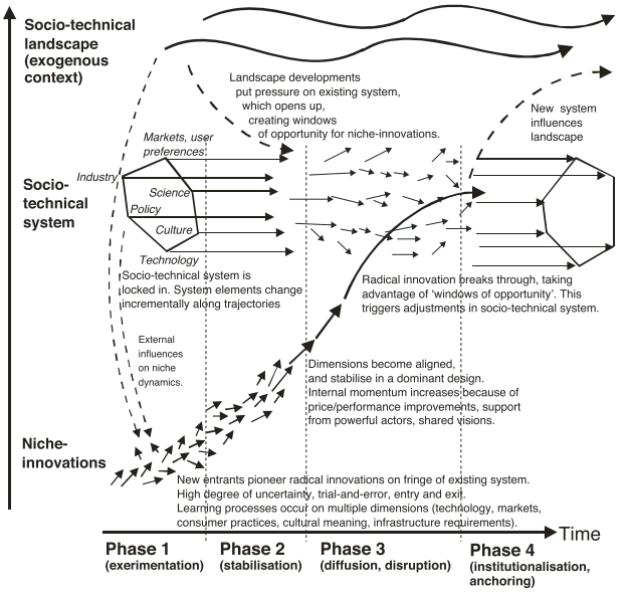

Figure 3: MLP with phases, taken from Geels (2019)

Apart from the different phases, Geels and Schot (2007) propose different kinds of pathways a transition can take. Whether one or the other pathway is taken, depends on several factors. It depends on the *timing* of landscape-developments interaction with the regime level, in combination with whether or not niche-innovations are ready to progress and challenge the regime. Although niche-innovation readiness is not an objective factor, Geels and Schot (2007) distinguish a couple of indicators that characterize the stabilisation needed for niche-innovations to take on the regime technologies:

> (a) learning processes have stabilized in a dominant design, (b) powerful actors have joined the support network, (c) price/performance improvements have improved and there are strong expectations of further improvement (e.g. learning curves) and (d) the innovation is used in market niches, which cumulatively amount to more than 5% market share (Geels and Schot, 2007, p. 405)

Additionally, the *nature of interaction* between landscape developments and the regime, and the niche-innovations with the regime level are distinguishing progression of transition pathways. Whether niche-innovations have symbiotic (if niche-innovations can be seen as add-ons or competence enhancing to regime ones) or competitive

(if niche-innovation is aimed to replace the regime one) and landscape developments are reinforcing (stabilising the regime in their current form) or disruptive (when pressure is applied to transform the regime processes) determines the course of the transition paths.

To visualize the landscape developments, Geels and Schot (2007) offer a follow-up on Suarez and Oliva (2005). Suarez and Oliva (2005) describe five types of environmental change, and Geels and Schot (2007) argue that three of them are of relevance to the MLP type of landscape developments. These three types of change are explained below:

> *Specific shock* corresponds to environmental changes that are rapid and high in intensity, come rarely and are relatively narrow in scope. A specific shock may dissipate and disappear after a while, returning to base line, or it may lead to a structural step-wise change. [...] *Disruptive change* corresponds to changes that occur infrequently, develop gradually, but have a high-intensity effect in one dimension. *Avalanche change* occurs very infrequently, but is of high intensity, of high speed, and simultaneously affects multiple dimensions of the environment. Avalanche change leads to permanent changes in the environment. (p.404)

These landscape developments differ from each other in the following factors: Frequency (number of landscape disruptions per unit of time), amplitude (significance of deviation from 'normal' or initial conditions caused by the disruption), speed (pace of change of disruption), and scope (number of landscape dimensions that are affected by simultaneous disruptions). These factors will assist in concluding what visualization of the landscape developments fits the most in regard to the developments in the IJmond region.

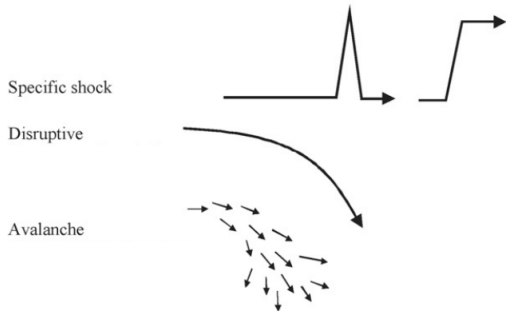

Figure 4: Landscape disruptions from Suarez and Oliva (2005), adopted by Geels and Schot (2007) for visualizing transition pathways

2.9 Research questions

Following up on the elaboration of the MLP framework, in this paragraph the research questions that aim to be answered by this study are presented. These questions result from the MLP framework and its three levels, and the social protest in the IJmond region.

The sub-questions that arise from the theory in combination with the regional protest are the following:

Q1 What forces are stabilizing the regime steel-making industry?

Q2 What forces are *de*stabilizing the regime steel-making industry?

Q3 What transition path is characterizing the IJmond region, as presented by Geels and Schot (2007)?

- Are the landscape developments disruptive or reinforcing?
- Are the niche-innovations competitive or symbiotic?
- Is the niche technology ready for implementation?
- How can the transition path be visualized?

Q4 What phase characterizes the current situation in the IJmond region?

Q5 What does the concept of SA add to our understanding of the dynamics of the IJmond region?

Q6 Is the steel-making regime capable of radical innovation?

Compiling the answers to these sub-questions presents an answer to a broader, main research question, defined as:

Which factors stabilize and destabilize the Dutch steel-making industry regime and how can the socio-technical transition be visualized?

2.10 Data-gathering

This study is developed by a curiosity driven question with regard to what makes the IJmond region and steel-making industry so special with regards to balancing national interest and seemingly regional negative effects. In this paragraph the way in which both primary and secondary data are gathered is presented. The study is explorative in nature as the topic appears to be complex and although there is a trend towards more attention to the social aspect consequences of decarbonization efforts, a comprehensive set of aspects is still lacking.

2.10.1 Literature

Scientific literature has been used to get a grip on what aspects have already been researched in other cases, sectors, or regions.

In particular, Wesseling et al. (2017) on the characteristics of EIIs was particularly helpful in determining barriers towards innovation or change among these industries. In terms of the MLP, these added to the description of the regime level and its limitations to change and rules between groups in the regime.

Also, Wüstenhagen et al. (2007) was very insightful in acknowledging that social acceptance in a broad sense is becoming more and more a determining factor with regards to sustainability project implementations. It backed up the notion that projects that affect landscape and communities beyond the boundaries of a companies' premises are prone to social acceptance.

Since researching on the steel-making industry decarbonization potentials leads to encountering several names for them (e.g. EEI, EPI, hard-to-abate sectors, heavy industry), a systematic literature research was done on web of science and scopus, solely to determine the different sectors that are referred to by those names. It appeared that these names all refer to the same kinds (iron & steel-making, chemical, plastics, paper & pulp, and cement making industries). However this also delivered an extensive base of literature on what actions or policies with regards to energy-savings, incremental innovations, and radical innovations were possible or needed moving towards a more sustainable and greener future.

2.10.2 Rolling back- and forward

This flow of research can be characterized by for- and backward rolling in which articles using or being used by other articles are also seen as potential pools of fruitful information. This was done by using the website of ConnectedPapers. ConnectedPapers visualises related articles to the 'root article' to assist in finding related articles in same or other fields of scientific research. Articles that have high citations in other articles are presented by a bigger circle then articles with low citation scores. Articles that are stronger related to the root article are linked with a thicker line to the dot which represents the root article. An example for Geels (2004) is displayed below.

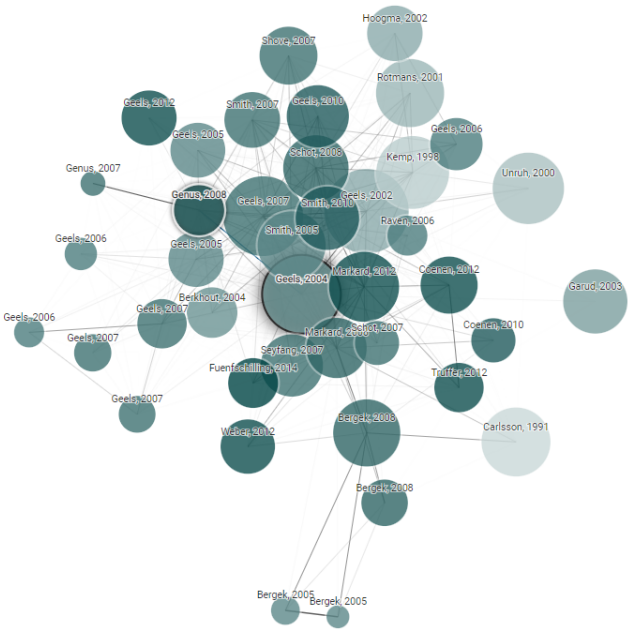

Figure 5: Example of ConnectedPapers for Geels (2004), produced on february 14th, 2022

Furthermore, in the interview with NH Nieuws the theme of lobby tactics and the seemingly incorrect allocation of the European Emissions Trading Scheme (EU-ETS) scheme was noted. This leads to more information on lobby tactics of EIIs, exemptions of the EU-ETS and steel market developments. Resulting in reading the Carbon Welfare report by Corporate Europe Observatory, revealing lobbying tactics exploited by EIIs, Steel-making industries, and the energy sector with regards to a favourable approach of the EU-ETS for their industries. Although this report presents the EIIs and

steel-making industries in a very negative way, it is insightful to get a sense of regime-level influences. It must also be recognized that environmentalist organisations and NGOs lobby in the same way, rightly noted by one of the Dutch steel-making industry employees interviewed for this study.

2.10.3 Interviews

In this study, semi-structured interviews have been conducted with three stakeholder groups situated in and outside the Dutch steel-making industry. The interviews are semi-structured in the sense that they are not completely unstructured as prior to the interviews, several important themes with regards to iron and steel-making industry decarbonization in general and the IJmond region in particular have been identified. Reading the literature on decarbonization efforts in general and in particular for EIIs, presented three reoccurring topics: Policy-making, technological decarbonization options, and social effects of decarbonization. These were used for semi-structuring the interviews.

The theme of industry characteristics was compiled by using the stylized facts of iron and steel making industry by Wesseling et al. (2017) and Öhman et al. (2022) on identifying the conditions for technology transfer of hydrogen-based steel-making in Europe. The latter presented an example interview which was conducted in 20 interviews.

Information on policy-making was mainly gathered by reviewing literature on policy-making and incentive needs with regard to decarbonization of EIIs. For example Koasidis et al. (2020); Nurdiawati and Urban (2021); Fan and Friedmann (2021); Åhman et al. (2017) and Wesseling et al. (2017).

The social protest theme was mainly composed by reading articles from Dutch regional and national newspapers (e.g. NH Nieuws, AD, NRC, de Telegraaf, de Volkskrant), and the Dutch public broadcasting agency (NOS).

Because the situation in the IJmond region had become that tense, the interview questions had to be presented in a way that did not suggest one or the other side of the debate to be true or false. The stakeholders that appeared to be suitable for interviewing, were chosen according to the levels of the MLP framework. Tata Steel IJmuiden BV is essentially the only steel producing company in the Netherlands, and thus embodying the regime level of the industry. Employees of both the public affairs department and the Sustainability Program were interviewed. The 'Omgevingsdienst' (ERS) IJmuiden is an agency that controls the permits around industrial practices, and therefore can also be placed in the regime level, but with a certain amount of autonomy towards the industrial practices of Tata Steel IJmuiden. A landscape development such as tightening of emission permits, rooted in the European Union (EU) would be interpreted by this agency and imposed on the (local) industry.

Additionally, NH Nieuws can be seen as an actor that voices the concerns of local residents, with an even bigger autonomy towards the industry in a sense that it doesn't have to justify it's accusations towards anyone. Other stakeholders have been approached as well, but due to the sensitive nature of the situation, and the surging public and political involvement, most of them were proved not being prepared to be interviewed.

The first interview was conducted with a journalist of NH Nieuws and was quite unstructured and was not limited in any way in a sense of confidentiality as the journalist was just voicing both concerns of local residents and the industry. On the opposite side, both the employees of Tata Steel IJmuiden and ERS IJmuiden voiced concerns about confidentiality prior to the interviews and the use of the data gathered afterwards, one more time showing the sensitive nature of the topic.

The interviews with employees of Tata Steel IJmuiden and Omgevingsdienst IJmond were similar to each other, but different from the NH Nieuws interview. The employees of Tata Steel were part of the Public Affairs and Decarbonization department. The interview with NH Nieuws was characterized as very open and the interviewee was not shy on opening up on 'sensitive' subjects or accusations made towards the industry or public agencies. In the other two interviews (with Tata Steel IJmuiden and Omgevingsdienst IJmond), sensitive information or events were approached more carefully, as the interviewer felt that this might sabotage the established report with interviewees, shattering interview proceedings. Maintaining a good report with interviewees is also seen as an important factor to successful interviewing by Sekaran and Bougie (2016).

Below an example of interview questions is presented.

Theme: energy-intensive/steel industry

- What characterizes the steel industry, or energy-intensive industries in general, from

other sectors?

- What are the barriers towards innovation in the EII/steel industry?
- What is the present discussion on industry decarbonization in the Netherlands or EU?
- What are the main drivers for decarbonization within the steel industry?
- What are the main challenges/barriers towards decarbonization in the steel industry?
- What do you think are the key technologies or pathways for the steel industry that are currently discussed, and which do you think is the most promising one?

There are similar production sides of steel all across Europe, also with residential areas in close proximity to them (e.g Duisburg, Salzgitter, Bremen, Eisenhüttenstadt (DEU), Dunkirk, For-Sur-Mer (FRA))

- Why do you think health risks regarding regional residents/stakeholders is such a highlighted aspect in IJmuiden?
- Do you think the policies are more stimulating for short-term benefits or than for long term goals?
- Is there anything else you want to add?

(Adjusted, taken from Öhman et al. (2022))

Theme: Policy-making

- What is the current focus on decarbonizing the (steel) industry?
- What policies are in place to enhance this change?
- Why are they (not) effective?
- What are the current barriers towards decarbonizing the industry?
- What policies are in place to overcome these barriers?
- Why are these policies (not) effective?

Theme: Local externalities

- What future options do you think are possible with regard to the steel industry in this area and why?
- Why do you feel that especially the last two to three years the public debate on the local steel industry has (re)appeared?
- Has the steel industry's pollution on the region always been part of public debate?
- What disturbs you (mostly), with regard to the reaction on the apparently polluting nature of the steel industry?
- What would be a solution to solve this problem of Tata Steel's production plant and future similar problems?
  - Would it be helpful to create a common place where local residents, corporate stakeholders, and policy makers discuss their recommendations, problems, and suggestions? (Innovation Commons by Potts (2016))
  - Would collaborating across sectors, local governments and pursuing multi-level integration prevent future conflicts to happen? (Linton et al., 2021)
  - Would critical stakeholder analysis, power & interests relationships alongside free, prior, & informed consent contribute to solve future problems?
- What else comes to your mind discussing these questions about the future of the region and the local steel industry?

Not every topic and question were answered by all interviewees. This is not a problem as not all stakeholders have expertise in all of the subjects. But all of the themes *were* mentioned during the interviews, allowing the interviewees to voice there knowledge on all of them. Hereby, their different (limited) viewpoints on all the theme's could be considered afterwards.

The interviews were recorded, and transcribed in anonymous form, and are available on request. These transcripts were then put into Atlas.ti to indicate various themes occurring in each interview. The interview itself was designed around three themes (industry, policy-making, and local externalities) which partly explain the themes occurring in the interviews. In every interview there were questions similar to 'Is there anything else that comes to mind talking about this subject, you want to add or refer to?' which probed for other themes or factors being present in this complex

socio-technical problem. This appeared a fruitful tactic to find additional topics of concern within the believes of the different stakeholders and social groups.

2.10.4 Data triangulation

Data triangulation is applied by verifying data gathered via interviews with scientific literature, or newspaper articles. For example, the characteristics of the the steel-making industry in an interview with employees of Tata Steel were verified with data from Wesseling et al. (2017) article on EII characteristics and Bataille (2019, 2020).

The idea presented by the journalist of NH Nieuws that EU-ETS credits were incorrectly distributed was opposed by data from the interview with employees of the Dutch steel-making industry, but confirmed by Redactie Change Inc. (2021).

Also, the perceived sentiment on subsidy leakage thorugh companies to foreign countries was voiced by the journalist. This was opposed by newspaper articles and by the employees of the dutch steel-making industry.

2.11 Research Ethics

When one wants to involve human participants in their study, an ethical perspective has to be taken with regards to acquiring and handling data. For this study a data management plant was constructed and verified by the Human Resource Ethics Committee of the TU Delft. For handling the interview data it was chosen to anonymously transcribe the interviews, so that any personal identifiable information would be left out of the study. These transcriptions and the original audio recordings are being saved for an additional year on a digital location only accessible by the first supervisor and the author of this study. In case further research was going to take place after completion of this study. The journalist of NH Nieuws signed the informed consent form, OD IJmond agreed to it during the interview, and employees of Tata Steel IJmuiden declared that they would like to review the report before publication in order to gain their approval.

3 IJmond instability

In this section, the IJmond is analyzed using the MLP concepts. Thus, the following paragraphs are: socio-technical regime, niche-innovations, and socio-technical Landscape. As socio-technical transition is about landscape and niche interactions with the regime, the regime level will be the first paragraph, after which the niche and landscape level will be elaborated.

3.1 Socio-technical Regime

This section is structured by the different social groups as presented to be characterizing the regime level, as by Geels (2004); industry, technology, science, culture, market and user preferences, policy, and social rules connecting these groups.

3.1.1 Industry

Looking into the characteristics of EIIs brings about several authors, each with their own method, scope and focus (Åhman et al., 2017; Bataille, 2019; IPCC, 2014; Rumayor et al., 2020; Wesseling et al., 2017). They all agree on the fact that these industries are fundamentally different from non-EIIs, and have the following characteristics:

- High capital intensity (Bataille, 2019; Rissman et al., 2020; Wesseling et al., 2017)
- High energy and temperature needs (Bataille, 2019; Wesseling et al., 2017)
- Low facility turnover (Bataille, 2019) & (IPCC, 2014, Ch.10)
- Relatively low profit-margin (Bataille, 2019; Rissman et al., 2020)
- High carbon- and trade intensity (Åhman et al., 2017; IPCC, 2014)

Besides, other characteristics such as cost sensitivity, technological challenges to decarbonization as emissions come from heat and power generation but *also* from manufacturing processes. As carbon is salient to these manufacturing processes, for example in steel-making carbon is used as a reducing component (Tata Steel IJmuiden BV, 2022). Strategically importance to nations, dependence on bulk and raw materials, cyclical growth and profitability trends, and strong economies of scale are raised by Åhman et al. (2017); Bataille (2019); IPCC (2014); Rumayor et al. (2020); Rissman et al. (2020) and Wesseling et al. (2017).

In the interview conducted with employees of the steel-making industry, the topic of industry characteristics was discussed. One of the employees added that the Technology Readiness Level (TRL) is different for the iron and steel-making industry than other industries.

> The TRLs are on a whole different level for the steel-making industry, compared to other similar industries. If any 'similar' industries even exist. An incremental way of sustainability steps towards radical improvements does not apply here. To move towards radical improvements, radical adjustments have to be made. This means that the last couple of years were concerned with optimizing the conventional production route, but to move beyond these improvements, a significant different production method must be applied. [...] It is a real transformation because moving from using coal as a reductant, to using natural gas and eventually hydrogen brings about massive changes for infrastructure, procurement, processes, and existing industrial plants.

This might be a reason of why radical innovation among heavy industry in general might be prone to incremental innovations. Because of the sheer size of these plants, and the supplementary influence of financial investments, there might be ideological resistance towards radical innovation. As optimization of current processes are more cost-effective than replacing whole plants by new ones. This is also presented by Bataille (2019), stating that the characteristic of high capital cost and risky investments, results in applying conservatism widely among EIIs.

Later, employees of the Dutch steel making industry clarified their statement. It was meant to refer to the current industrial plants being fully optimized and that only a radical turnaround could add to sustainability improvements. Opposing the idea of ideological resistance.

Numerous studies have looked into the TRL of all kinds of sectors and industries. Klar et al. (2016) refer to characteristics such as 'product and process inter-dependencies, scaling problems, the reliance on pilot and demonstration experiments, and the

fact that input and output materials are ingredients, rather than components for differing TRLs in the steel-making industries (p. 1).

Additionally, high energy and temperature needs are required for breaking chemical bonds in the processed raw material. These processes are characterized by high fixed costs and result into large scale industrial plants to reap economies of scale. Also generating high barriers to entry the industry as a new company and characterizing technological innovations as big investments, making high investment costs inherent to radical innovations. (Wesseling et al., 2017)

Other studies have looked into the reasons why decarbonization is taking a slower pace than expected, and refer to those reasons as limiting factors or barriers towards change (Bataille, 2019; Koasidis et al., 2020; Wesseling et al., 2017). From an MLP these can be seen as factors that stabilize the regime to some extend. Deterioration of one or multiple barriers could result into windows of opportunity for niche ideas or technologies.

In the interview of Tata Steel-employees, industry characteristics were also reviewed. It was noted that, although its apparent production capacity, Tata Steel IJmuiden has zero influence on the global market price of steel, exemplifying the trade intensity, the long durability of existing plants and lacking less-GHG-intense product markets were mentioned as factors that characterise the steel industry, slowing down decarbonization and limiting radical innovation (Tata Steel IJmuiden BV, 2022).

These factors are also mentioned by Bataille (2019, 2020); competitive concerns driven by small profit margins resulting from rising costs in making less GHG intense products, trade exposure, energy intensity, lumpy long-lived capital stock, and the historically lack of markets for low GHG intensive commodities. Noted by Wesseling et al. (2017), new technologies need to fit in existing factories due to long-investment cycles of these industrial plants. Another regime stabilizing factor of EIIs is that new entrants to the industry wishing to compete are usually needed to cooperate with established firms, and are typically absorbed by them (Wesseling et al., 2017). The cooperation part is also noted by employees of the Dutch steel industry referring to the HIsarna project as an example, a technological innovation project focused on reducing pre-processing steps and GHG emissions of steel-making.

> We have participated with 55 mid- to small local businesses, additional to international partners across the globe, to design and build the HIsarna project. On all kinds of levels, from strategic to project managing aspects.

Wesseling et al. (2017) relates most of previously mentioned characteristics of EIIs to barriers towards decarbonization. Long investment cycles provide few windows of opportunity for changing technology, Low cyclical profit margins reduce the availability of investment capital and increase the Return On Investment (ROI) times, the high costs and potential loss of market share due to failure in the production process increase the risk perception of innovation, little opportunity for testing and up-scaling of innovations. The incremental improvements to core process technologies over the past decades (often century) disadvantage radical innovations, leading to lock-in, the focus on refurbishing existing large-scale plants (so-called brown field investment), particularly in industrialized countries inhibits more radical innovations.

One of the major supplier of work in the Dutch IJmond region is Tata Steel IJmuiden which specialized in iron and steel-making and delivering their products to over 26 countries (Tata Steel, 2021). The industrial IJmond district emerged in 1918 when the 'Koninklijke Nederlandse Hoogovens en Staalfabrieken NV' (KNHS) were opened for production. More than a hundred years and a couple of acquisitions later, fusion with British steel in 1999, the district is still primarily focused on producing high quality steel. Multiple generations of families have worked here and due to the variety of technologies used in steel making, numerous professions of work are done in the area.

Although in the late 80s the industry was offering 28000 thousand jobs (Broekhuijsen, 2021). Nowadays it is left with delivering 9000 jobs but still, indirectly, responsible for more than 30.000 jobs in related businesses to keep the plants running, retaining its position as the biggest employer in the region. But also making it one of the biggest emitters of CO2 in the Netherlands. (NOS op3, 2021)

In an interview conducted with employees of the Dutch steel-making giant, the uniqueness of the IJmond region on industrial aspects was exemplified:

> We are the core of the industrial ecosystem, with regard to steel-making, service, manufacture and tool-making industry, especially in the IJmond region. Collaboration with other big industrial clusters exists, but on a different level. Because process-wise, the IJmond region is not really comparable to other clusters and thus collaboration, or information sharing, is on infrastructural themes, like [the future of] hydrogen distribution.

In two other interviews, with NH Nieuws and ERS IJmond, the uniqueness of the IJmond region was being attributed to the extreme close proximity to local neighbourhoods (Wijk aan Zee is less than 500 meters north to the industrial cite, and 800m south of the industrial cite, the city of IJmuiden is located), meaning that whatever direction the wind is blowing, some neighbourhood is affected. The uniqueness of heavy industry regions has also been noted by Bataille et al. (2018), noting that heavy industry is one of the hardest sectors to decarbonize due to heterogenity. Referring to the uniqueness of facilities worldwide, in terms of product qualities and processes.

The uniqueness of the IJmond region is also backed up by the lack of social and health negativities reported by newspapers among 'similar' industrial clusters in Germany (e.g. Duisburg/Thyssenkrupp) and France (Dunkirk/Arcelormittal). Although, in the interview with a journalist from NH Nieuws, it was noted that two managers of the steel-making plant Ilva in the south of Italy were convicted to 20 and 22 years of prison because they were responsible deliberately emitting hazardous amounts of gasses over a time period of half a century. The managers did know about the health effects, but refrained from improvements due to economic considerations. In 2012 the national government began investigation after rumors of the hazardous situation surfaced. The trial took 5 years, and the managers still plead to be innocent and are expected to go into appeal (Lanting, 2021).

3.1.2 Technology

Essentially, there are two ways of producing steel: BF-BOF, or EAF (Hoffmann et al., 2020). BF-BOF uses coal as a reductant to produce steel from iron ores and is used for 71% of primary steel production partly explaining the difficulty of decarbonizing the steel industry (Rissman et al., 2020). EAF uses steel scrap or DRI as raw materials. DRI is accounting to almost 7% of global iron production (Keys et al., 2019). Figure 6 shows the inherent differences between the two ways of iron and steel production techniques. The comprehensive differences in steel production between EAF and BF-BOF have also been confirmed in an interview with employees of the Steel-making industry in the IJmond region. Noting that changing their steel production methods from BF-BOF to the DRI and EAF combination route as a 'complete new process', and brings about 'enormous uncertainties' to their business model (Tata Steel IJmuiden BV, 2022).

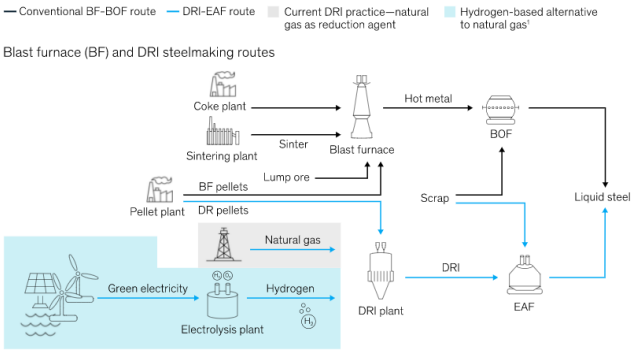

Figure 6: BF-BOF and EAF route of steel production visualized, adjusted and taken from Doyle and Voet (2021)

The picture above shows the steps in the different routes towards primary steel-making. From a BF-BOF perspective raw materials are delivered from a coking, sintering. Iron ores are typically FeO3, and the oxygen component need to be extruded in order to make the iron useful for further processing. This is done by using coal that serves two purposes at once. Providing the heat for melting the iron ores, and by providing the carbon atoms that form chemical bonds with the oxygen and are released as CO2. Coal and Iron ores are delivered in rocky stones and need pre-processing for better quality control. For coal ores, this is done in the so-called coke plant. In this plant the coal is heated up to 1250c without the presence of oxygen. This pushes the impurities (mainly sulfur and hydrogen) out of the rough coal, leaving a porous coal that is nearly all carbon. The iron ore is treated in the sintering plant. Here, 'sinter' is made from 'burning a mix of iron ore powder, fluxes and recycled substances, to create an open-grained, consistent substance' according to Arcelormittal. Removing the oxygen from iron ore is called 'reducing' in which coke (purified coal), is used as a reductant. In the conventional route this is done in the Blast Furnace (BF). Within this blast furnace, a continuous stream of coke, sinter, lime is injected together with hot air, resulting in liquid

iron (also called 'pig iron'), CO2 and a mixture of minerals called slag. The liquid iron still has a high amount of carbon in it, resulting from the previous step of using coke to reduce its oxygen component. To remove the excessive carbon from the pig iron, oxygen is projected into the liquid iron in a Basic Oxygen Furnace (BOF) to reduce its carbon percentage to approximately 0.5% or according to the grade requested. Customer-specific chemical compositions can be added afterwards which is a very precise process.

The DRI route can produce the same liquid steel as the conventional route but is different in the materials and processes needed. It uses a gas (either natural gas or hydrogen) as a reductant instead of coal. But using natural gas still leaves the carbon-intensity of the process unharmed. Only when hydrogen is used, produced from renewable energy sources, the process of DRI becomes less carbon-intense. Pellitised iron ore from the pellet plant is used in the DRI furnace. This results in so-called 'sponge iron' and is solid, in contrast to the liquid form of pig iron. The sponge iron is ready for use in an EAF to melt and produce steel. In the EAF direct and radiant heat is generated by use of an electric arc between graphite electrodes (Flournoy, 2022). The EAF also produces high-quality slag as the BF-BOF route.

To achieve decarbonization by Direct Reduced Iron plus Electric Arc Furnace (DRI-EAF), the gas used in the DRI needs to be produced from renewable energy sources. More specifically, the hydrogen used in DRIs needs to be 'green'. Hydrogen has already been used widely in the chemical industries. Hydrogen can be distinguished in three forms based on their origin; Grey (fossil fuel source with no CCS to remove, store, and stabilize CO2), Blue (fossil fuel source with CCS, or electrolysis using non-renewable electricity but at great capital cost for commercially available CCS and H2 generation equipment.), Green (electrolysis of water, in combination with renewable-sourced electricity generation) (Hornby and Brooks, 2021).

As reported by Hoffmann et al. (2020), almost all regime steel producers are developing strategies to reduce their emissions. Options explored are; BF-BOF efficiencies, Biomass reductants, Carbon Capture and Usage (CCU), EAF combinations with DRI based on natural gas or hydrogen. According to Keys et al. (2019), DRI is still mostly produced by using natural gas, but using hydrogen as reducing agent is gaining momentum, represented by the Swedish HYBRIT project in collaboration with Vattenfall, LKAB and SSAB. SSAB together with Accelormittal and Tata Steel make up for the majority of steel production in Europe, and LKAB is responsible for iron ore mining in the north of Sweden, having customers all over the world (LKAB, 2017).

This gives a small indication on the actors that see this technology being applied in industrial processes in the future.

Additionally, steel can also be produced by only using scrap metal. However, this method massively affects the quality of the end product, noted in the interview with the employees of the Dutch steelmaking industry and deemed not useful for Tata Steel which is focused on producing high-quality steel.

3.1.3 Science

Although multiple studies advocate energy efficiency measures (Napp et al., 2014; Rissman et al., 2020; Ritchie and Roser, 2021), Crijns-Graus et al. (2020) show that together wit the projected increase of final energy consumption by 40%, more than just energy efficiency measures are needed, but also concludes that energy efficiency measures are likely the most cost-effective ones. Alternatively material efficiency in a broad sense is proposed: limiting material use by product design, reuse of materials, recycling of materials and substitution of materials.

Although the decarbonization options are numerous, each with its own emission reduction potential, IPCC (2014) reports that implementing Best Available Technology (BAT) are only going to reduce GHG emissions for about 15-30%. Åhman et al. (2017) exemplifies that further reductions need new innovation and fundamentally different core processes, which in turn need investments and further development before they become commercially and technically viable.

Other improvements proposed are more focused on system-wide efficiency methods; repairing air leaks from sinter plants, programmed heating in the coke ovens, automation of hot-blast stove, increased automation through a MultiGas Analyzer in BOF, Improved process control in EAF (Bataille, 2019; Napp et al., 2014).

Exemptions and shielding of EIIs are not desirable, but Fan and Friedmann (2021) warn that ill-planned or implemented climate policies can

cause severe consequences of loss of market share or critical manufacturing and job loss next to slow or incomplete decarbonization resulting from "protectionist measures and insufficient focus" (p. 28).

Furthermore, Napp et al. (2014) add comparable methods for reducing emissions among iron and steel making plants: switching to more efficient processing routes, increased use of scrap with EAF, waste gas recovery and heat integration, and adoption of efficient methods for casting and rolling. Recently, Crijns-Graus et al. (2020) also acknowledge the longer term GHG reduction value of CCS and fossil fuel substitution by hydrogen or electricity, and also add biomass to this list. The value of CCS is also noted in the interview with employees of the Dutch steel making industry. When talking about why CCS was not chosen as an intermediate step:

> CCS is still, in a general sense, the best way to achieve CO2-reduction. That is why many stakeholders, private and public, take CCS as a valuable option. [...] Because we committed ourselves to reduce CO2 emissions by 2030, we looked at the most cost-effective way of reducing emissions. This appeared to be CCS in the first place, but changed due to two reasons.

The reasons referred to above are presented in the next section on the cultural dynamics in the regime.

In this paragraph the findings depict the stabilizing factors that only mildly refer to the need for radical innovation, and most of all propose efficiency measures.

3.1.4 Culture

In 2015, Tata presented a plan for a solar-PV project for improving their renewable energy sources, which later resulted into disagreements (Duurzaamnieuws, 2015; Gastel and Baas, 2019). Another sustainability promising project by Tata is the HIsarna project, which did get some positive media coverage (Donk, 2018; Groot, 2015), but was framed negatively in newspaper articles for leakage of Dutch innovation subsidies to foreign companies (Houtekamer and Kooiman, 2019). HIsarna's expansion was moved abroad due to lower cost of basic materials, not enough space in the IJmond cluster to expand the HIsarna plant to a greater producing capacity, and the lack of subsidies for the pilot plant. (Houtekamer and Kooiman, 2018, 2019).

Nevertheless, this resulted in the idea that future subsidies also might leak to foreign countries (NH Nieuws, 2022). As the Dutch steel making industry is part of a conglomerate situated in other countries, it was believed that profits might leak as well. In 2020 the former Dutch minister of economic affairs refuted this believe by stating "Tata Steel is not stripped off by its parent company" (Winterman, 2020). Lets refer back to the "France is not the sick man of Europe" example provided by Bruijn (2017), explained in section 2.6. It seems that these events or examples are one of the same magnitude. When there is smoke, there must have been fire, of some sort. As mentioned in section 2.6, denying the accusation of subsidy leakage is similar to stepping into the frame and allowing for free airtime of the argument that one wants to deny.

This lack of awareness on how to frame the believe of leakage, may have resulted in the persistent sentiment of tax-payer Euros leaking via big corporations to foreign economies, depicted in the interview with a NH Nieuws journalist:

> One thinks that, but transparent communication could also help here, that previously, every Euro made resulted into 50 cents being invested in the plant and the region. But that today only 10 cents, or if that there is any left at all to invest. Due to higher prices for coal, obligations to purchase leftover from other departments, market-wise this is legal of course. But this strengthens the feeling that IJmuiden is being depleted.

When talking about the media coverage of the 'big' developments taking place in Sweden regarding green steel production, an employee of the Dutch steel-making clarified:

> The Dutch people, and we in IJmuiden as well, are not that good at it. It is not in our nature to show off our successful achievements. 'Look at our huge achievements'. What you (interviewer) stated earlier is true, this wheel will turned full circle and haunts us.

Later, this was illustrated further by pointing towards the emissions per ton of steel compared between Tata IJmuiden and SSAB. "Tata Steel produces far less CO2-emissions per ton of steel, but SSAB is deemed to be more 'sustainable' ". Also, dutch newspapers reflected on the different stages of sustainability between SSAB (Sweden) and Tata

Steel criticizing the latter's intentions and determination (FD, 2022) . But questioning a companies' capabilities on sustainability improvements merely based on presumed similarity to foreign industry sustainability progress or achievements is ill-considered. Multiple factors are at play in sustainability transitions, for example the abundance of available renewable sources (water, wind and solar), supportive policy programs, wider public concern and the activities of environmentalist groups.

Coenen et al. (2012) indicates via a Danish example of success in windpower that sometimes it is not only up to firms and entrepreneurs to determine (radical) innovation paths or technological progress and refers to territorial institutional advantages influencing innovation strategies.

> The example demonstrates that the Danish success in windpower is not just a matter of picking the right strategy by firms and entrepreneurs but that these strategies are conditioned by specific territorial institutional advantages in terms of e.g. public-private co-ordination, collaboration practices and informal sharing of information. (p. 975)

These findings show that lacking innovation progression or initiatives cannot be attributed to a single company's actions.

In the interview with employees of the steel-making industry, an employee of the public affairs department noted that negative media coverage is hard to fix.

> Something that happens a lot is that information in newspaper articles is not always true. But it is very hard to recover from negative media coverage. One cannot plainly deny the story, and think it is solved. The damage has already been done. [...] When feeling and sentiment are played with in the media, and accusations are made, one cannot just bring facts to the debate or discussion.

Another clue for the use of frames in conveying message as explained before. It might be that journalists and opponents of the big industry probed the so-called 'underlying current' of industry giants having too much power and appear to get away with everything, without giving in any of their own assets and values.

The frame depicting the big industry as polluting the region and not taking care of its responsibilities for society is challenging the core values of these companies. If one may assume that these companies believe to produce or serve society in general, enhancing the capabilities and achievements of men, by achieving better products and higher efficiencies in their processes. If these corporations or actors are then depicted as being bad or wrongdoing towards local residents, this clashes with their believe system, provoking them to step into the 'frame' imposed onto them.

The use of story-telling and frames might also relate to narrative usage, emphasized by Hermwille (2016) explaining the importance of narratives towards ST-system transitions focusing on nuclear power generation, underpinning the fruitfulness of exploring how of frames and language is used in conveying messages opposing or proposing decarbonization and sustainability efforts and pathways.

Together with the disappearance of jobs, and the region around the company housing less employees from the steel-making industry, also loyalty and affiliation with the industry is fading (Broekhuijsen, 2021). In interviews with a local newspaper and ERS IJmuiden, it was reasoned that local residents that had always had lived in that very area considered the industry part of their region, instead newcomers found it less 'normal' that such an industry was that close to neighbourhoods (NH Nieuws, 2022; OD IJmond, 2022).

In 2018 the steel industry in IJmuiden celebrated their 100^{th} birthday with a sequence of events which were set off by the King of the Netherlands (FD, 2018). A mayor at the time of a neighbouring city was asked what this meant for them, and replied '100 years of steel comes with 100 years of glory' (Broekhuijsen, 2021). Love for and loyalty to the steel-making industry runs deep (Hek, 2020). Showing the positive sentiment about the industry.

But in the next couple of months this sentiment quickly changed after series of events. The conducted interviews revealed, that it was acknowledged that the exploding social protest in 2019 through 2022 was overlooked for too long (NH Nieuws, 2022; OD IJmond, 2022; Tata Steel IJmuiden BV, 2022). Nowadays employees working in the steel industry get a crooked look, some employees even do not want to talk about the subject anymore (NH Nieuws, 2022).

Over the course of three years, a series of events took place which affected the positive sentiment on the local steel-making industry, present in late 2018:

- Mercury dump in 2018, steel-making industry indicates that they had proper licenses, but framed illegally by ERS (NOS, 2021)
- Graphite rains in 2018 and 2019 in local neighbourhoods, harmful for children playing outside (Koster, 2021b; NH Nieuws, 2019; Schoorl and Kreling, 2020). After which the steel-making industry quickly responded which concluded in these rains being impossible to occur in the future (Tata Steel IJmuiden BV, 2022)
- Black snow around outside industrial fences in 2021 (Oei, 2021b)

Every time such incidents occurred, public anger surged which resulted in a series of investigations in 2021 with regard to the local air quality, health concerns, and causes of these differences with other regions in the Netherlands. Concluding that local air quality in the IJmond was worse then other regions in the Netherlands, higher occurrence of respiratory symptoms, appointing the local steel-making industry as the biggest contributor. The abundance of information also allows for interpretation misalignment. Exemplified by the following two statements on the process regarding emissions permits and enforcement by the journalist of NH Nieuws and an employee of the steel-making industry.

> It does not help that the steel industry measures its own emissions. Occasionally the OD comes by to check on those measures. With regard to the local citizens this feels like marking your own exam. (Journalist)

> We have a 'reporting obligation', which is accredited by an independent third party, finally the Dutch Emissions Authority (NEA) supervises this process in the background. (Steel-making industry)

On the other hand, the Dutch steel-making industry also complies with local, national, and European emission standards, frustrating policy-makers when they investigated the possibilities to pursue betterment on legal grounds (Ministerie van Infrastructuur en Waterstaat, 2021; Bokkum, 2021b). This was also brought as a defensive argument towards the first arguments that the steel-making industry was perceived as a 'polluting' giant, noted in the interview with steel-making industry employees:

> I want to make clear that we as an industry, and the region of IJmond comply with all imposed licenses and emissions to air standards. [...] Which does not take away the fact that as a company you have responsibilities to the neighbourhood. [...] But as my colleague correctly states, when the sentiment is played with, a company cannot come up with factual substantiation. And I think we have been tempted to take on the discussion in a technical manner before, but we are refraining from that perspective recently.

Bringing facts to the table when the discussion is taken to a sentimental level, and the resulting misalignment and frustration become obvious in the interview with the local journalist of NH Nieuws, who noted:

> The link between local pollution and the steel-making industry is though to validate as the pollutants are produced by other industries as well. Which was *cleverly* used by the industry to *downplay* their polluting activities. Up to the point that RIVM concluded from research that the steel-making industry was indeed responsible for a considerable part of the pollutants.

From a framing perspective, bringing facts to the table when a frame of emotions or values is imposed can actually be a good strategy. But in this case emotions played a big part in the discussion. The ineffectiveness of the frame imposed by Tata Steel (in which they insist on complying with permits), can be explained by the difference in power of real world and world of systems frames, referred to by Bruijn (2017) and explained in section 2.6. According to Bruijn (2017), a more suitable response should have been focused on connecting and emphasizing with the worries and values of the people and citizens, before stating the values of Tata Steel and how these would resonate with their own policies or activities.
On December 9th 2020 the Steel-making industry proposed Roadmap+ to accelerate sustainability ambitions, and solve local emissions nuisance, adding on top of the already present sustainability plans (RODI, 2020). Resulting from the negative or untrustworthy attitude towards Tata Steel at the

time, this ambition was considered by some locals as untrustworthy as well (NH Nieuws, 2022). Showing that Tata Steel was or is suffering from actor credibility deterioration and that a negative 'frame' might have been imposed on the company.

On March 25th 2021, the Dutch emission authority declared that the majority of Dutch industrial companies do not count among the scope of Europeans best performing with regard to sustainability factors. The day after, big CO2-emitting companies presented a plan, joining forces to 'assist' the Dutch government in achieving their climate mitigation goals. Tata Steel, DOW Chemical and Shell, together with network operators proposed tens of projects regarding hydrogen production, electrification of industry regions and carbon capture systems (Koster, 2021a). The proposed plan needs public funding as green hydrogen needs to be produced by the use of windfarms on the North Sea and carbon emissions are aimed to be stored in empty gas fields (CCS). Pressure is applied due to the fact that time is limited as these projects take a long time to be completed.

At the end of March 2021, Tata Steel and the Dutch national government agreed in an expression of principles that in 2030, Tata Steel will have reduced their emissions by 5 megatons a year and that they strive for a production of producing 100.000 tons of blue hydrogen by the use of CCS technologies. Within this plan, all of the current assets of the steel-making plants would remain, including the environmentally troublesome assets. The plan encountered local resistance, which questioned the safety and future durability of this technology. Amplified by the idea that the technology has not been applied on this scale yet and wider public opinion in the Netherlands was not at all favourable (NH Nieuws, 2022; DNV GL Netherlands B.V., 2020).

In May 2021, FNV, the employee association already had proposed an alternative plan called 'Green Steel', backed-up by the idea that leaving out the intermediate step would be better, in both environmental sustainability effects and employment opportunities (Tata Steel IJmuiden BV, 2022). Revolving around directly implementing DRI and EAF, this plan directly aims to phase out the most controversial part of the steel-making plant, which is one of the biggest targets of local protest (Tata Steel IJmuiden BV, 2022; Oei, 2021a).

Despite this alternative plan the CCS route was pursued and the Dutch government gave their permission for the CCS plan on the 9th of September 2021, framed by Dutch EIIs as necessary to achieving climate mitigation goals (Koster, 2021a). But a week later, the CCS plan was announced to be superseded by the Green Steel plan of the FNV. In an interview with employees of the steel-making industry, reasons were given.

> Was the public protest the main reason why FNV came up with a more ambitious plan than the CCS route? (interviewer)

> No, it was not. But it did play a role. The main driver is that FNV intrinsically believes that making one big step, from the conventional route directly to DRI and EAF, is better in terms of long-term decarbonization and employment opportunities. [...] What also took part in the decision-making was that the most polluting assets would remain present in the CCS route, but would disappear faster with the DRI route. Something that is viewed positively by local residents. (interviewee)

These reasons are also presented in a newspaper interview with the head of the decarbonization department of Tata Steel, Annemarie Manger. Annemarie mentions that the RIVM reports on the local effects of the steel industry made them wonder what they could do, beyond adhering to emission licences. According to Annemarie, there were several factors at stake: 'the public opinion changes, the technology develops, and a part of our customers want to take on the more expensive but 'green' (less polluting) steel. That wasn't the case two years ago' (Stooker, 2021). In the interview with steel-making employees it was also mentioned that the parent company was 'not a big fan' of the CCS route. This resulted in the change of course announced on the 15th of September 2021, when the Green Steel plan was declared to be pursued (Tata Steel IJmuiden BV, 2022; Schröder, 2021; Le Clercq, 2021). One day before a political debate was planned for discussing the future of the Dutch steel-making industry.

This added towards changing the direction of the political debate from taking the closure of the plant as a serious option, towards cooperative measures and announcing taking away financial hurdles.

3.1.5 Market and user preferences

According to Wesseling et al. (2017), EIIs supply their product to two different markets: bulk basic

material markets and specialized material markets. In general, EIIs are characterized as an oligopoly.

The largest of the two markets is the one made of bulk materials. Products sold in this market are usually competing on price alone and have a global scope. Because of this scope, developing and industrializing countries are a threat to markets (e.g. China and India have a competitive advantage because of lower cost of energy and capital and convenient market access). Additionally, these price fluctuations are caused by global supply and demand shortcomings, establishing cyclical profit margins (Frost & Sullivan, 2018; Wesseling et al., 2017).

The other market is about specialized materials. Alternatively to the bulk material markets, there are also small segments of specialized materials demand. These segments are low-volume, and focused more on reliability, quality and timing of delivery than they are on price. Demand for these specialized materials is low and creates long-lasting ties with customers as close cooperation is usually a base and provokes relations based on trust. Because of these different characteristics, this market is less prone to price-elasticity and has bigger and stable profit margins. (Wesseling et al., 2017)

Bataille (2019) reports that historically there has been no demand for less GHG emitting but more expensive basic materials, such that plants are completely cost-effectively designed without taking account of 'climate costs' (GHG emissions). This is also mentioned by Wesseling et al. (2017) where the argument is that EIIs are less prone to consumer pressures as they deliver to other companies. This would be different if those companies would demand cleaner basic materials, but they, as of yet, do not (Wesseling et al., 2017).

3.1.6 Policy

Wesseling et al. (2017) reports on characteristics of governmental policy targeting EIIs. The policies are mostly focused on local safety and pollutants and incremental energy savings. Besides, firms are afraid they might lose their licenses to operate and thus adhere to regulations with regard to local air, water and soil pollution and safety standards. But these regulations are in general not that strict as one would expect. According to Wesseling et al. (2017) the main reason is economic competitiveness, also noted by Åhman et al. (2017). Combining the perceived lack of urgency with regard to radical innovations, economic importance, and strong lobbying groups that 'tend to take the position of their most conservative member and oppose regulations that they perceive as threatening their (current) competitiveness', policies targeting EIIs tend to focus on incremental innovations (Wesseling et al., 2017; Koasidis et al., 2020). Policy support schemes typically end on the brink of the competitive stage of new technologies, creating a gap between the R&D or pilot stage and up-scaling. Additionally, EIIs are mostly shielded from the direct costs of the EU-ETS scheme. Fan and Friedmann (2021) attribute shielding of EIIs from increased energy and carbon costs to failed policy attempts, bringing up the question what barriers policy-makers are encountering when designing policies.

Nurdiawati and Urban (2021) analyze various technological trajectories and key policies and conclude that several key barriers are limiting policy efforts to effectively influence decarbonization in EIIs. These barriers include a lack of policy targets, regulatory frameworks, and standardizations to guide and accommodate technology development (e.g. CCS and hydrogen). Another important aspect is the danger of focusing on short term goals without considering the long term ones. Which could ultimately lead to carbon lock-in as emissions mitigation would be focused on the cheapest options, and not on decarbonization potentiality. Also backed up by Åhman et al. (2017) who refers to new approaches are in need of more long-term views.

Additionally, Wesseling et al. (2017) also argue for characteristics of EIIs that create bigger challenges for governance; high mitigation costs, capital intensity, investment cycles, global competitiveness, and the lack of co-benefits or competitive edge to clean materials. But lacking policy efforts and achievements might also be the result of lobby groups.

In the interview with NH Nieuws, the exemption of some Dutch companies from the EU-ETS was mentioned:

> Some time ago, the CO2-allowances were implemented and some industries gained those allowances for free. Due to favourable lobby activities, the steel-making industry gained a *lot* of these free allowances, that they were able to sell excessive allowances, resulting in an even better market position. So the plan to push towards less emissions, resulted in a more privileged position.

This is deemed to be false by employees of the steel-

making industry. They claim that there is not at all such a thing as selling CO2-allowances, referring to the approved annual financial statements, backed up by the supervising Dutch Emission Authority (NEA). It is claimed that they even have to buy additional CO2-allowances for their industrial processes. Different arguments are brought forth by 'de Groene Amsterdammer' (a weekly magazine), claiming that free allowances are indeed sold for profit (Sengers and Vos, 2019).

Fortunately, it is not the goal of this study to find out the truth behind every statement made. These contradicting statements are only presented to show the conflicting ideas on the situation, adding to the complexity of the situation and potential routes to a better future.

Lobbying tactics and activities become more clear in an extensive report on lobby processes in the European Council, shedding some light on these tactics. Although this report is written in a hostile way towards lobbyists representing their industries, it is fruitful information to gain a picture on how politicians and legislation comes about. An additional note needs to be made towards the EII lobbyist activities. As noted by an employee of the steel-making industry, similar lobby-techniques are used by environmentalist organizations as well. This sounds plausible, as this is where discussions, arguments, and persuasions for one's believes can be build on.

Balanyá and Reyes (2016) concluded that 'lobbyists met seven times more than public interest groups', noting that the biggest share of meetings came from Eurofer (European steel association) and oil companies. The most frequent argument was results of applying the EU-ETS to EIIs would be 'carbon leakage': deterioration of global competitiveness, resulting in losing market share and job losses, or as a globalized market, that companies would be be left no option but to move their production elsewhere with less strict policy instruments (Balanyá and Reyes, 2016). Balanyá and Reyes (2016) debunk the carbon leakage in its entirety, attributing declining job availability to the over-supply of cheap steel by Chinese companies (Balanyá and Reyes, 2016). According to Rissman et al. (2020) studies are not entirely sure about how much leakage would be caused by such policies, and differ between 0 to 40% in EIIs. Carbon leakage and pricing are closely related to the principle of Common But Differentiated Responsibility (CBDR), which is incorporated in the gloable climate action plan, as countries more strictly adhering to the EU-ETS are lowering their attractiveness to international operating and producing industries (Åhman et al., 2017). Wesseling et al. (2017) presents a more comprehensive argument. They argue that this line of reasoning may hold for some specific global, price-competitive materials but not for complete sectors.

The way in which industry lobbyists exert power on legislation is exemplified by the "Better Regulation" agenda. According to Balanyá and Reyes (2016) this agenda was initiated by the European Round table of Industrialists (ERT), BusinessEurope and others 'to kill off and weaken regulation that industry dislikes' (p. 13). This agenda was later used in 2014 and 2015 as leverage to 'emphasise the need for consistency between the reform of emissions trading and the "Better Regulation" agenda', to attack the EU-ETS (Balanyá and Reyes, 2016, p. 13).

According to Balanyá and Reyes (2016), Eurofer published a continuing stream of 'fake' studies. Lobbyists cloud the credibility of scholars that present the opposite of their believes to exist. By claiming that methodology and impact assessment are not correctly executed and present their findings to be the opposite. After which civil society groups in turn claim that steel industry lobbyists' claims are invalid (Balanyá and Reyes, 2016). Lobbyists have private meetings with members of the European Parliament (MEP) in which they express their worries about upcoming legislation's negative effects on their industry sectors. Lobbyists apply pressure by, for example, explaining the situation in terms that MEP are familiar with. If an MEP has EII in their constituency or country, lobbyists would declare those industries or plants would lose jobs if certain legislation would take effect.

In the Netherlands the idea of a country-wide CO2-tax for all their industrial activities also became a target of lobby activities of EIIs in late 2017 and 2018. The same core argument as in Brussels was used; this would result in massive profit deterioration and job loss, leading to carbon leakage. Trade and industry organizations organised a meeting directly after the twist in climate mitigation legislation (Sengers and Vos, 2019). The biggest labour union of the Netherlands, FNV, added that compensation schemes would be necessary for the steel and industrial enterprises, and if not applied, thousands of jobs would disappear (Redactie Change Inc., 2021). Climate mitigation options that ac-

cording to climate scientists cannot be put on hold any longer. The Dutch government very much needs to achieve their 2030 and 2050 reduction goals are used to exert power to dodge the CO2-tax for the dutch industry (Sengers and Vos, 2019).

Despite this, in 2021 the Dutch government implemented a national carbon tax. According to this carbon tax industrial companies have to pay per ton of emitted CO2 gasses. Companies get a certain carbon tax-free amount of gasses they are allowed to emit. These tax free allowances are calculated according to the most efficient companies in Europe (Redactie Change Inc., 2021). This additional Dutch system focuses on the emissions that are so-called 'avoidable' emissions. Meaning that emission reductions clarified in the 2030 plans, not being realized will be taxed. Similar to the European scheme, the carbon-tax gets progressively more expensive.

But this is arguably a problem solver. As the Dutch government choose for a soft approach and gave a lot of companies exemptions, and expects that it will not affect companies staying behind until 2024. In this case companies pushed for soft approaches, bringing the international market position deterioration argument to the table (Redactie Change Inc., 2021).

Bataille (2019) identifies that in order to make emissions compatible with the Paris Agreement, European countries need to put together a robust technical and policy effort to achieve demand decarbonization with material efficiency and enhanced recycling, production decarbonization by setting the level of BAT to very low or zero, and employ policy to implement take-up and stock turnover. Accordingly, the European Commission considers implementing a Carbon Border Adjustment Mechanism, to defend the competitive position of European firms who are exposed to the carbon-tax (Redactie Change Inc., 2021).

At this point the question arises whether these protectionist measures are helpful from a decarbonization perspective. Maybe it is time to put the European EIIs to the test and push them to decarbonize without immediately setting up safety nets, forcing radical innovation implementation.

3.1.7 Social rules

In the Netherlands companies have to comply with environmental regulations. There are two kinds of scenarios, either the company falls in the general category and standard regulations apply. In the second scenario the company's activities are distinguished as exceptional and custom regulations and licenses have to be designed and applied. These licenses are provided by the state or lower authorities, depending on the size of the company. The licenses are based on calculations and the companies need to measure their activities and emissions according to those calculations. Local ERS are mandated permission to license, to measure and enforcement when necessary. These environmental services need to keep all the companies in their regions in check. They also have an advising role to other environmental services' regions concerning changing or new licensing of companies' activities. These environmental services are also constantly keeping up to date with BAT in every field the companies' licensing are active. The BAT are translated from IPPC European standards to so-called BREF documents which show guidelines to which industries have to adhere. In this way the industries in the Netherlands are (forced) to adhere to BAT-standards and deviations from these permits are financially punished.

Within the regime, close networks and social ties are typically present. Especially between regime firms and technology providers, as innovations are usually assembled in cooperation or outsourced to them. The EIIs are also characterized by weak vertical ties in global supply chains, however their horizontal ties are strong. Another characteristic that comes from high entry costs, new-comers have to cooperate with existing regime actors to become profitable or establish a foothold in the market. In the interview with employees from the Dutch steelmaking industry, it is acknowledged that cooperation is needed towards new process innovations and incremental adjustments, as plants and processes consist of such many different techniques and aspects (Tata Steel IJmuiden BV, 2022). However, a distinction is made between innovation in manufacturing processes and product development.

Product development is very much in cooperation and coordination with customers as their product preferences and manufacturing processes need to be mapped and analyzed to deliver the best possible final product. Highlighting that vertical ties in this aspect are very much present. As far as manufacturing processes are concerned, this is different.

Manufacturing process innovation is indeed

characterized by horizontal ties, however, just up to a certain level. According to employees of the steel-making industry in the Netherlands, the IJmond region can be seen as an eco-system, an industrial cluster, in which collaboration is happening across steel-making, service, and the manufacturing industry. But collaboration with other clusters in the Netherlands or Europe is not on process or manufacturing aspects, these inter-cluster collaborations are more focusing on infrastructures (e.g. hydrogen production and transportation) (Tata Steel IJmuiden BV, 2022).

3.1.8 Conclusion

In the previous paragraphs many aspects of the regime level have passed in review. Drawing one single conclusion for this regime level feels undervalued. In this paragraph key aspects per group are presented in an attempt to maintain the value of recognizing different groups in different levels of the ST-system.

Industry describes the abundance of barriers towards change within the iron & steel making industry and other similar industries (Other industries referred to as EIIs, e.g. chemical, paper & pulp making, cement making). It describes that the steel industry, in general, deals with high entry barriers and long lived capital stock resulting in a focus on incremental improvements in existing plants and technologies. In addition, the industry plants are inhibiting all sorts of technologies from different fields, experts for these plants are also needed from all kinds of fields. Innovating across a whole industrial plant is therefore an interaction between all kinds of experts sharing their knowledge. This interconnection has been depicted by the HIsarna project. These findings are also backed up by a personal conducted interview with employees from a Dutch steel-industry regime actor.

Technology provides the different options of iron and steel making used in the current market. This presents a deeper understanding on the technology side of decarbonizing the industrial processes of iron- and steel making. In the conclusion it is highlighted that it is essential hydrogen being used for the sponge iron is produced by using green hydrogen to achieve its decarbonization aspect and that only using scrap metal for the production of steel in the IJmond region is not viable.

Science presents the studies and findings of decarbonization pathways and energy efficiency measures needed for achieving decarbonization among EIIs. Depicting that incremental efficiency measures are still presented as viable solutions towards sustainability of EIIs.

Culture presents an overview of events effecting (un)sustainability efforts and events that happened in the IJmond region. It presents the feeling that the discussion on whether polluting events were justified or not, was taken to a sentimental level, and the regime actors were regrettably not able to recognize it in time. Resulting in an even bigger notion that the regime actors were the 'enemy', who had to be either shut down or punished. It also presents the feeling towards the public protest having effect on the decision-making of the decarbonization route. It also presented examples of how framing of certain events and values occurred in the IJmond region, and how these frames were not accurately and effectively opposed, explained by the concept of framing by Bruijn (2017)

Market and user preferences shows the distinction that is made in these markets. Looking at bulk materials where competition is merely about competitive prices. And the presence of a smaller, specialized market. In this market high quality steels are sold and purchased for premium prices compared to bulk materials. These specialized markets are low-volume, focused on reliability, quality and timing of delivery then they are on price. From a historical view there is a lacking demand for less GHG intense basic materials.

Policy reveals the current thoughts and ideas of scientific papers on policy measures to push industries towards decarbonization. It seems that the main take away is that because of major lobbying tactics, EIIs were exempted from the main cross-sector policy measure for decarbonization: the European Emission Trading System. Bringing in the argument of losing market share and pointing towards eventual job-losses and carbon leakage. Also, the tactics of how lobbyists exerting power over MEP is presented.

Social rules presents the institutional rules that have to complied with in order to do business in the Netherlands. The hierarchy between European emissions regulations, and local enforcement and licensing institutions is described. Also, social relations between regime actors and other industries are described, which are characterized by close ties. But a distinction is made between process and product innovation. Process innovation is characterized by the close vertical ties and product innovation is characterized by close horizontal ties.

3.2 Niche-innovations

Now that the regime level has been extensively described by the different social groups, the level of niche-innovations are described in this chapter. This paragraph aims to describe which new ideas, practices, events, and policies being in contrast with the regime ones, and destabilizing the regime. They occur with regard to EII in general, and the IJmond region in particular. Not all social groups, like in the regime chapter, are present as industry and social rules have not been identified to contain niche ideas or propositions.

3.2.1 Technology

Niche projects that have a potential to assist in decarbonization efforts also need additional R&D efforts. Such as the COURSE 50 project, SCOPE 21, the ULCOS programme, BF-BOF with top recirculation and Carbon Capture, Utilization and storage (CCUS), HISARNA with concentrated CCUS, Hydrogen (H)-DRI in combination with EAF, Aqueous (e.g. SIDERWIN), molten-oxide electrolysis (e.g. Boston Metals), and HYBRIT (Bataille, 2019; Napp et al., 2014; Nurdiawati and Urban, 2021).

Large scale implementation of DRI production technologies comes with its own problems. As iron remains solid during the process of DRI, removing unwanted elements from iron ores becomes more difficult. Resulting in the characteristic that the quality of DRI is closely related to the iron ore input. Therefore, when high quality DRI is demanded, high quality ores are as well. These high quality ores are not obtainable from every single iron ore mine, and can become a major limiting factor to the diffusion of this technology in the steel making industry as high quality mines' capacity are lacking (Doyle and Voet, 2021).

DRI using green hydrogen in combination with EAF is considered to be the ultimate pathway towards decarbonization, also noted in an interview with employees of the Dutch steel-making industry. Only one commercial DRI plant operates, which uses natural gas, and could yield at least an 80% reduction of CO2 compared to the conventional blast furnace route (Fan and Friedmann, 2021). According to Hoffmann et al. (2020), a characteristic of current DRI implementation is its dependency on natural gas prices. As is seen in areas where natural gasses are easily available and consequently prices are low, DRI usage is higher than e.g. Europe where gas prices are higher (Hoffmann et al., 2020).

Although above mentioned articles recognize similar strategies in which the iron and steel making industry needs to decarbonize; material and energy efficiencies, recycling, and reducing process emissions, consistency among the technologies proposed for these strategies are not yet present, as concluded by Gerres et al. (2019), who analyzed articles on decarbonization roadmaps. But as EIIs are heterogeneous and all have unique capabilities and configurations, does not come in as a surpise that consistency is lacking.

Gerres et al. (2019) also note that none of the proposed technologies are commercially available yet, and their 2050 implementation is arguable due to the EIIs characteristic of long innovation cycles. Furthermore, most breakthrough technologies are stuck at the pilot stage because governmental support schemes usually stop funding beyond this stage, passing on up-scaling costs and risks solely to the innovating firms themselves (Wesseling et al., 2017).

Other studies use prediction methods to analyse what technologies should be further promoted and developed for successful decarbonization of industries (Fan and Friedmann, 2021; Otto et al., 2017; Weigel et al., 2016). Concluding that complete integration of renewable energy sources into the coal-based steel industry of Germany would be possible and reduce emissions by 95%.

Bataille (2018; 2020) is optimistic and concludes that technological options to decarbonize to very low and zero GHG emissions compatibility with the Paris Agreement is technically possible with sufficient prioritization, policy effort and within one or two capital stock generations. By making use of one or more, of the three pathways proposed: material efficiency, production/process decarbonization, and reuse or higher volume of recycling (Bataille, 2020). This is similar to what is proposed by Rissman et al. (2020); supply- (e.g. energy efficiency measures and carbon capture) and demand-side interventions (e.g. reduced material use and circular economy). But also doubling the total electric energy demand of the industry (Otto et al., 2017).

In the interview with steel-making industry employees, the readiness of new radical innovations

for steel-making is also talked about. In particular regarding the green hydrogen, DRI, EAF route.

> What really characterizes the hydrogen economy is by use of the chicken and egg story. If there is no demand for hydrogen, no one produces hydrogen. If no one supplies hydrogen, there is demand for it. Now that Tata Steel has announced its Green Steel route, you see that it pierced this notion and took on its role as a pioneer. [...] The day after we announced our hydrogen course, and show our concerns with regard to the infrastructure and production needed, 30 stakeholders stood in line to announce that they would take care of those concerns.

Proclaiming yourself to fulfill the role of pioneer is questionable. But it certainly displays the difficulties with regard to taking on new routes for industries that have such huge plants which bring about huge (financial) uncertainties if these new technologies are not fully proven to be working. This was also noted by an employee of the steel-making industry:

> Tata Steel announced that it would accelerate its decarbonization plans, why is this acceleration not always possible from the start? (interviewer)

> Because this brings about massive uncertainties to one's revenue model. (interviewee)

The findings in this paragraph show the abundance of radical innovation initiatives, the presence of powerful (regime) actors involved in them, and the optimistic view from a scientific community.

3.2.2 Science

In this section, a more theoretical perspective on a different view on how industrial clusters will be shaped. Results of Moulaert and Sekia (2003) and Zucchella (2006) are reviewed to get to grip with some regional concepts, and how industrial regions may evolve. Afterwards, a more general, alternative view on how innovation could be stimulated is presented, proposed by Potts (2016).

Moulaert and Sekia (2003) describe how historically, regional policy evolved from subsidies on investment and employment for companies that invested in needing regions, past local and regional initiatives for economic development, to a literature on "territorial development and regional innovation systems" (p. 290). Showing that regional development programs and policies have always been up for debate.

The main result from Moulaert and Sekia (2003), is that the Territorial Innovation Model (TIM)s (Millieu innovateur, Industrial District, Regional Innovation Systems, New Industrial Spaces, Local Production Systems, and Learning Region) have no clear view, and suffer from conceptual ambiguity. The critical review does, however, bring about a list of characteristics of these innovation models, and could potentially be a first step towards a solution. According to Moulaert and Sekia (2003), the models disagree on the concepts of economies of agglomeration, endogenous development theory, systems of innovation, Network theory, and governance. General disagreement on a one-size-fits-all approach is not new to the findings in this study. Which was also noted in the heterogeneit of EIIs.

Zucchella (2006) focuses on the maturity trajectories of one version of the TIMs, Industrial District (ID)s. Arguing that these IDs have three possible trajectories: disembeddedness, re-embeddedness, and multiple embeddedness. By analysing some Italian IDs, in combination with theoretical concepts and literature reviews, it is argued that IDs are entering a period of crises. Embeddedness refers to inter-organizational relationships, having a social dimension influencing the economic behaviour of partners. Zucchella (2006) argues for multiple embeddedness and re-embeddedness as being alternatives to surviving district crises occurring among these industrial districts. Both these trajectories entail the exploration and integration and/or replacement of existing locally embedded ties with preferable, novel foreign ones. Broadening the view of the ID actors. Although this article was published 16 years ago, it adds to our understanding of what possibilities are present regarding ID development.

According to Potts (2016) innovation brings about two problems: how to stimulate innovation, and how to deal with its consequences. The consequences of innovations refer to the changing and disrupting nature of innovative practices. Build on Schumpeter's gales of creative destruction which visualize innovation as bringing new technologies and methods of producing to an existing or new market, rendering old methods or technologies obsolete.

Actors that are specialists in these 'old' techniques are consequently affected, as well as the companies and markets they are active in. Potts (2016) proposes a new method as an alternative to the widely employed neo-Schumpeterian model. In short, the common model on innovation focuses on the origin of 'new knowledge', while the model proposed by Potts (2016) focuses on 'the discovery of value'. Referring to innovation as a phenomenon that sparks from group and individual interactions. Exchanging specialized knowledge between individuals or groups is deemed to be the way of 'discovering value' of knowledge. To foster innovation, thus, the 'transaction costs' of specialized knowledge must be minimized, transaction costs being the costs needed for exchanging information with other individuals. Potts (2016) concludes its proposition with four layers that need to be pierced in order to effectively nurture innovation. This all could be done in so-called 'Innovation commons' and revolves around the idea of a common pool resource of specialized knowledge, to eventually discover the value of new technologies. Innovation commons need to minimize effectively the transactions costs of exchange decentralized and specialized knowledge.

3.2.3 Culture

In an interview with a journalist from the regional newspaper, when talking about the incident of black snow in 2021, it was clear that residents' worries extended beyond that one incident.

> ... not every year, it is snowing, and when snow *has* fallen, and it *is* painted black, residents wonder if the pollutants have always been in the air, only not visible without the snow. (interviewer)

> The local residents wonder the same thing. They think, 'so this has always been in the air, am I inhaling this on a daily basis?'. (interviewee)

The Dutch institute of health and environment (RIVM) concluded as part of a bigger research of health in the district, that air quality around the industrial district is indeed worse and confirmed that acute health complaints are more likely to occur here than in the two baseline regions (de Rijp and the Zilk (in Dutch)) (Koster, 2021b; RIVM, 2021b). Initially, relating the regional health problems to the local popularity of smoking, socio-economic weakness, and presence of freight transport and other industries, but on a later date appointing the industrial activities of the steel making plant as one of the biggest factors (RIVM, 2021a; Bokkum, 2021c). Another report by the regional health institution (GGD), reported that in the region of Beverwijk (adjoining to IJmuiden and located in the IJmond region) 50% on top of the national average are diagnosed with lung cancer (Redactie, 2020).

Vuijk (2021) presented the absence of the linkage between the health concerns and the industry most probably being a result of vested interests. Right after the report was published, people that were active in reviewing the draft versions of the report claimed that the final version was very much different from the versions they initially reviewed, especially concerning the possible reasons for the staggering rates of lung cancer in Beverwijk. Vuijk (2021) took these accusations seriously and used the law to retrieve all the draft versions of the report, and additional conversations and emails concerning the draft reports, resulting in 'exposing' some stakeholders in the upper management of GGD and local governments to be actively shielding any words or indications that could point towards the local steel making industry for being a possible determinant in these health concerns from the report (Vuijk, 2021). This was later announced as not to be true by Bokkum (2021a).

At first, the local council of Wijk aan Zee was not surprised of the research results but was even more shocked about it. They think the main cause of the health complaints is one particular installation, cokes gas plant 2, and they want it to be closed as soon as possible. Tata Steel's plan to capture CO2 on-side and storing it in empty gas fields in the North Sea, does not please them. "A plant that pollutes the local area for another 15 to 20 years, while being 'sustainable' as CO2 is captured and stored off-shore is not doing any good for the local area" (Oei, 2021a). A hint towards the procedural and distributional justice implications with regard to SA, whether all stakeholders are taken into account and the benefits and costs are shared correctly.

But after the publication of these concerns by Vuijk (2021), they put in official statement that this event made them potentially lose their trust in the GGD altogether. Claiming that these events are just another representation of the 'fear-culture' that is present among local authorities with regard to the massive steel-making industry present in their region. This fear-culture is fed by the as-

sertiveness of the local steel-making industry fighting heavily against every single accusation that is even only partially made towards the steel-making company (Dorpsraad Wijk aan Zee, 2021). Closing their official statement, the local council of Wijk aan Zee calls for the need of an agency that is independent and has no ties to the industry, politics, the health departments of GGD and ERS.

On a later date, an independent actor, Peter Heskes, was asked to investigate the removal of indications towards the local steel-making industry. It was concluded that this was completely justified. Thus, disputing Vuijk's idea of vested interests. But on an additional note, it was also concluded that a series of reports and complaints remained unanswered. Resulting in social protest not being accurately solved, leaving it become bigger over the course of time (Bokkum, 2021b). Another confirmation that social turbulence had been neglected for too long.

On behalf of 1200+ local citizens and ten foundations, Lawyer Bénédicte Ficq has pressed charges on Tata Steel and (formal) leading directors for physical harm to humans and animals in the local area (Frisse Wind, 2022). Ultimately, desiring the acknowledgement that a company cannot go unpunished with such polluting effects on the local area (Borst, 2021).

Another 'public' stakeholder, that also wants the steel industry to shut down, is Jan de Jong. Jan de Jong is only one of many that has a problem with how the industry is dealt with differently. He gives an example about a digital conference with local estate owners and municipalities. The estate owners were asked to lower their CO2 and nitrogen emissions one way or another, if they refused, the estate owners would be imposed to do so, 'we as a local municipality have the power to do so'. But when asked what the steel-making industry, the biggest polluter of the region, would do for reducing their emissions, they answered that these companies were not part of the deal (Schoorl and Kreling, 2021). An example of how the feeling of unfairness between inhabitants, local municipalities, and corporations is fed and preserved. Adding to the procedural and distributional justice aspect of SA.

Stooker (2021), a journalist of FD (Financial Daily paper), asks a similar question in August '21, what would be the best option for the region if the big industry was not there yet? What would be the case if one could start over again? According to Stooker (2021) there appear to be only two options for the industry in the IJmond, CCS or Hydrogen based production. Stooker (2021) makes the comparison between keeping the steel industry alive at 'all costs', while a less polluting powerplant (Hemwegcentrale, Amsterdam, 3.2 megatons of CO2 in 2019, and Tata Steel 5.7 megatons in 2020) has been closed. The question arises why this industry needs to be kept alive, whilst being responsible for about 8% of all emissions in the Netherlands. Down-sizing or closing the industrial steel making plant is argued to have low effect on the rise of unemployment rates, as the employees have specialised technical knowledge, which is very much wanted by the job market (Stooker, 2021). This comparison is not entirely fair, as there is only one steel-making industry, and several more power suppliers. In addition to the strategic purpose of keeping the industry in one's country, noted in the interview with employees of Tata Steel IJmuiden.

During the interview with ERS IJmond, it was also noted that complaints were not merely based on feelings and values, but residents also had knowledge and experience regarding these regional pollution effects and measures.

> There is a lot of knowledge and experience with some of the citizens. Actively joining the thought process is hard, as these arenas are not that common. So they usually have to voice their thoughts by complaints. But also, there are a lot citizens who have a lot of understanding of what is going on. I you can get those people to join the thought process. I think that is were the solution lies, the route to the future.

This seemingly presence of knowledge, the lack of arenas to share those thoughts, and the presumed solution in providing these arenas is, somewhat similar, noted by Coenen et al. (2012) referring to the Danish windpower example. It is referred to as 'specific territorial institutional advantages' which, in turn, refer to public-private co-ordination, collaboration practices and informal sharing of information. Which I think are referred to, although implicitly, by the above quoted interview.

Interviewing employees from the steel-making industry, also revealed that the industry is now taking a leading role towards a hydrogen based economy. While there were still big uncertainties on how and where green hydrogen would be produced,

it did announce to have the ambition to take on this path. Afterwards, about 30 companies revealed they would be able to resolve these uncertainties, aiding in the transition to green hydrogen production and transportation. An example how the (green) hydrogen production, transportation, and use market is characterized with a need of first-movers (Tata Steel IJmuiden BV, 2022).

3.2.4 Market and User preferences

Regarding the lack of less GHG emitting emissions, it seems that market preferences are changing. As previously mentioned by Annemarie Manger, the head of the decarbonization department of Tata Steel, costumers are becoming willing to pay a higher price for less polluting green steel. Also, in the personal conducted interview with steel-making industry employees, it was noted that:

> It is becoming apparent that customers and companies that we deliver to are willing to pay more for steel that has a smaller CO2-footprint or more scrap metal is used. I expect as long as 'green' steel is scarce, a premium is going to be paid for green steel, compared to conventional produced steel products.

BMW invested in 2021 in Boston Metal, which aimed to produce low CO2 intense, or green steel, in the future (Made in Europe, 2021; Willemijns, 2021). Volvo announced a partnership with SSAB, which started producing world's first kilograms of green steel in 2021. This resulted in the first ever produced vehicle made of green steel in October 2021 (SSAB, 2021a,b). Backing up the notion that the markets and user preferences for steel-making and steel products are indeed changing towards a greener future.

3.2.5 Policy

Here, niche policy recommendations, resulting from scientific research and analyses are presented. This very well could be described in the niche group of 'science'. But as these policies may add to the shift of certain regime ideas on policy schemes towards niche ones, I propose that these belong here.

Fan and Friedmann (2021) proposes several general guidelines to stimulate decarbonization of the steel industry. As all approaches for decarbonizing the steel industry are also capable or are already decarbonizing other sectors as well (hydrogen, zero-c electricity, and biomass in transportation or heating sectors) careful resource planning should be adopted 'given the resource limits of any given nature' (p.29). In both Fan and Friedmann (2021) and Friedmann et al. (2019) it is proposed that biomass resources application in the steel industry should be preferred before application in the power sector because other and more alternatives exist in the power sector. If a nation has great economic benefit from their steel industry, a richer innovation agenda should be adopted. Fan and Friedmann (2021) argue 'there is climate and economic competitiveness value in starting today', because of the long time horizon needed to bring new technologies to the market (p.30). Also adding that 'overt market-facing' policies are needed to enhance decarbonization speeds and avoid dislocations. These include:

> Investments in low-carbon infrastructure enablers [...] Support for domestic decarbonization with incentives [...] Green procurement, including authorization to purchase low-carbon steel made by domestic industry at elevated prices. Development of low-carbon production standards as a regulatory driver, matches with border tariffs to avoid leakage and offshoring of jobs and industry. Deliberate early retirement and replacement of current steel-producing facilities with low-emission options [...]. International coordination, including sector "clubs" that include major steel-producing companies and nations. This could serve to develop international low- emission production standards for steel among buyers and sellers. (Fan and Friedmann, 2021, p.30)

Linton et al. (2021) add creating policy, providing financial incentives, fostering a green economy and engaging stakeholders for creating long term political will for transformative changes to this list.

As historically less intense GHG commodities are lacking, Carbon Labelling is proposed by Rissman et al. (2020), Napp et al. (2014), and Lechtenböhmer et al. (2016) to increase awareness of the impact of products, and such increasing the willingness to pay for low-carbon products, creating markets that would encourage production of these commodities. Similarly, Åhman et al. (2017) mention that demand-pull (e.g. niche market creation, such as carbon labelling reinforces) and supply-push (e.g. investment support schemes) are two ways in which decarbonization can be enhanced by policies. Border Carbon Adjustment (BCA) is also proposed by Åhman et al. (2017) to reduce the

impact of carbon pricing on domestic productions moving away from their current locations. Fan and Friedmann (2021), bring about a list of tailored policies for different topics, such as investments in low-carbon infrastructure enables, support for domestic decarbonization with incentives, green procurement, development of low-carbon production standards as a regulatory driver, and international coordination. Nurdiawati and Urban (2021) mentions that R&D efforts should target reducing costs, improving performance and reliability of electrification of heat-related industrial processes, use of biomass feed-stocks, circular economy as well as CCUS technologies, and (green) hydrogen production.

Although, Nurdiawati and Urban (2021) identify that the focus of decarbonization pathways is more on "technological pathways and less on the supportive enabling reforms that would facilitate their uptake". Carley et al. (2018) conclude that there is a need to move 'beyond the political rhetoric to careful consideration to how individuals and communities may be adversely affected by the energy transition' (Carley et al., 2018, p. 138). Also noted by Sovacool (2021) in its review of four case studies, where it is implied that the global community needs a coordinated policy mix to reduce vulnerability across the dimension of raw materials, planning and policy processes, adoption and use of low-carbon technologies, and waste management to make the policy outcomes more equitable and just.

Rissman et al. (2020) and Sovacool et al. (2015) identify problems in social and spatial aspects and propose some strategies to become more aware of these effects and deal with them accordingly: critical stakeholder analysis of interests and power relationships between allies and competitors in adaptation projects, alongside Free, Prior, and Informed Consent from a potentially affected community, keeping people at the centre, avoiding capture of vested interests, opt for policies that promote win-win green growth solutions and utilizing a mix of supply-side and demand-side interventions. This shows that there are many ways to stimulate decarbonization are present, both market push and demand pull for radical innovation and less intense GHG materials are called for.

The lack of demand for clean basic materials are requiring stronger market-pull policy, that governments should have more risk tolerance, become more stakeholder-oriented, and develop low-carbon scenario's, visions and pathways (Wesseling et al., 2017). Åhman et al. (2017) adds that carbon policies need to offset economic efficiency and equity or fairness (Åhman et al., 2017).

Rissman et al. (2020) mention that policy efforts can be divided over several economic channels, to support decarbonization efforts. Ranging from input substitution, process changes and demand reductions to proposing carbon-pricing, more RD&D support, energy efficiency or emissions standards and building codes, and also proposing recycling incentives or requirements.

Partly mentioned before, studies also provide insights in which specific projects other countries are using to achieve deep decarbonization. For instance Nurdiawati and Urban (2021) use Sweden as a prime example of successful decarbonization efforts, referring to the HYBRIT project (which is an example of how a high GHG reduction potential project is prioritised, politically and financially supported despite having a long lead time and investment needs), Fossil Free Sweden (a unique initiative in Sweden that facilitates both the business sector and politics to find common ways to accelerate the transition needed), and noting that inter-firm collaboration within EIIs become more common and a preferred strategy. Fan and Friedmann (2021) note that Sweden, Japan and the Netherlands are some of the rare nations that "support pilots and pre-commercial demonstrations of advanced low-carbon technology options through public-private partnerships, grants, and broad RD&D Support" (2021, p. 30). Adding that upcoming innovative technologies (Molted Oxide Electrolysis (MOE) or Biocoke development) desire specific dedicated R&D funds, to deliver potential market-ready solutions in 10 to 20 years' time. Linton et al. (2021) distils apparent successful governance structures, originating from the review of eight cases across the globe: coordinating with the local government, providing oversight and reporting, collaborating across sectors, pursuing multi-level integration, obtaining funding.

Developing from the idea that EIIs are in need of more strict emission reductions, lobbyists in Brussels aim to enhance acceptable emissions to a lower degree to ensure steel industries can be held legally responsible for their polluting nature, or exceeding emissions (NH Nieuws, 2022).

3.2.6 Conclusion

Technology show that numerous projects, companies, and governments are moving towards decarbonizing their industries. Although a consistent approach is lacking, this is not surprising because of the heterogeneous aspect of EIIs. Also, the need of a first mover in the hydrogen route is explained.

Science presents amongst others the fundamental paradigm shift towards innovation by Potts (2016). This is fruitful information as in the regime level it was depicted that regarding process innovation a lot of expertise from different sectors are needed for achieving industrial plant innovation. With regard to Potts (2016) idea on innovation commons, lowering the transaction costs of knowledge sharing and the discovery of value of innovations, creating these so-called innovation commons might be very helpful in the future. Facilitating transparent communication to local residents with regard to industrial innovation procedures and progressions.

Culture displays the local resident's social protest, and the events that sparked them. It shows that the occurrence of the events sparked small protests, but which were inflated after little was done (in perspective of the local residents) to prevent future events, or that the role of the industrial companies was downplayed.

Market and User preferences show that the lack of a market for less-GHG-emitting basic materials but which is questioned by new information from the interview with employees from the steel-making industry. They think that these markets start to emerge, backed up by the announcements of Volvo and BMW to incorporate green steel in their products.

Policy elaborates on the different scientific grounded ideas on policy schemes and innovation agenda settings. Fan and Friedmann (2021) propose that the steel making industry should be prioritized for decarbonization efforts and schemes. Additionally, demand-pull and supply-push strategies need to be implemented to enhance a market for less-GHG-emitted steel products. On top of these policies need to facilitate equitable, just and fair outcomes. As more risk tolerance, enhancing stakeholder orientation, and off-setting economic efficiency with equity or fairness were proposed. Another indication towards the complex nature of decarbonizing EIIs.

3.3 Socio-technical landscape

Here the higher hierarchy landscape developments are presented. As described in 2.1.5. Firstly the slow-changing developments are presented after which the events that are considered to be external shocks are elaborated.

3.3.1 Slow-changing developments

In May 2021, a Dutch judge had made a remarkable judgement, it was ruled that the emissions reduction plan of 2020 by Royal Dutch Shell company (RDS) does not meet the requirements set by the Paris Agreement, imposing RDS is to reduce their emissions more drastically, and held responsible for the emissions of their 1100 sister companies across the globe (De Rechtspraak, 2021). In 2015, a similar case was won by Urgenda, a Dutch nonprofit foundation, which aims to help enforce national, European and international environment treaties , which accused the Dutch government for not being on track with their emission reductions, obligating the Dutch government to lower their emissions by 2020 with a substantial amount (Urgenda, 2015). This not only presents the growing concerns of the public on climate mitigation action, but also that these concerns are more than just a believe and are legally grounded.

Another similar growing concern is presented by Bokkum (2021c). It shows that in the beginning of the social protest, a feeling of support for Tata Steel IJmuiden across the wider public could be noted, and Tata Steel was 'good' and 'better' than any other competitor in Europe. But this feeling disintegrated as the wider public became aware of the fact that the Dutch Steel-making industry was responsible for 7% of national CO2 emissions.

Another sign of slow chasing perception towards the need to decarbonize and design policies to support sustainability efforts is noted by interview findings of Öhman et al. (2022). They note that the EU proposed several hydrogen economy supporting initiatives in 2020 and a plan for 2030. Interviewees of Öhman et al. (2022) note that "hydrogen is hot".

Apart from the (non) technical barriers and challenges resulting from the industry characteristics of EIIs, there is also a substantial number of studies developed to identify the social and spatial implications caused by energy transitions and decarbonization efforts.

One of the main contributors in this field is Benjamin K. Sovacool. Across different articles and papers, Sovacool argues that "social and political conflicts are inseparable from the process of climate adaptation" (Sovacool et al., 2015). Four European low-carbon transitions have far-reaching and afflicting connections to unemployment and poverty, toxic externalities associated with e-waste, and the exploitation of women and children in cobalt mining that can even "result in or perpetuate environmental dispossession, political dispossession, economic dispossession, and even physical dispossession" (Sovacool et al., 2021). In one of the most recent studies, Sovacool (2021) analysed 198 studies consisting of 332 case studies over a 20-year time frame in the geography and political ecology field of study and concluded that every single one of the case study was related to at least one of four characteristics of enclosure (seizure of land or resources), exclusion (unfair planning), encroachment (ruination of the environment), or entrenchment (decline of inequalities) and 28% related to all four of them.

Another recent paper by Brock et al. (2020), shows that green industrialization can also "create vulnerabilities and exacerbate inequalities, even in wealthy countries as Germany", even linking the negative sides of green industrialization to the same negative sides as conventional fossil-fuel-based economies have: "undemocratic and unsustainable processes, the concentration of corporate power and profits, and externalized waste and pollution are replicated by solar energy". Brock et al. (2020) also refers to the risk of enhancing a globally resurgent political right. Highlighting the need to consider negative externalities of decarbonization and sustainability efforts.

3.3.2 External shocks

2021 was a volatile year for coking coal, which is needed as a raw material in steel production. The price per metric ton surged and stabilized on a higher price prior to 2021. Clercq et al. (2022) argue that this a glimpse of the future of the conventional steel making production market. They advocate that previous price elevations had been seen before, as results from drastic events such as the Queensland floods in 2010 and 2011, but price changed back to their original state in several months, which is not the case in the present coke coal price rise. Clercq et al. (2022) argue that the declining investment in coking coal mines and coke batteries are expected to decline even further due to 'sustainability concerns'. 'Any imbalance in the market could lead to a real, prolonged capacity squeeze in both the coking coal and coke markets, leading to elevated prices' Clercq et al. (2022). Which may as well result in more economically feasibility for alternative production methods such as decarbonized ones.

Although political concern was already apparent in 2011, when a Green Deal was signed between Rijksoverheid and Tata Steel IJmuiden BV on sustainability in the short and long run, it surged after the events of graphite rains and the 100^{th} birthday of steel making industry.

Political support towards climate change in general became even more apparent after Urgenda was ruled favourably in their case against the Dutch government, obligating the state to design a plan to mitigate climate change according to the Paris Agreement ambitions. This resulted in the 'Klimaatakkoord' in the summer of 2019.

In June 2020, one of the left-wing parties backed up the Dutch steel-making industry for innovation and employment aspects, followed in July of that year with an appeal supported unanimously by the Dutch house of representatives to aid the steel-making industry in their efforts towards sustainability and decarbonization, as much as possible (Bokkum, 2021c; Themagroep Energie van PvdA Duurzaam, 2020).

Early September 2021, 14 appeals were submitted by left-wing parties for a debate on what the future of the Dutch steel-making industry should be (NH Nieuws, 2022; Tweede Kamer der Staten-Generaal, 2021). Also, right-wing parties proposed that the very last but realistic option, if needed, was a public investment in the industry (NRC, 2021).

September 17^{th}, the majority of the house of representatives voted to put effort in restricting the steel-making industries in their emissions (Boonman, 2021). This resulted in the presentation of a report by the ministry of I&W about the upcoming efforts towards a healthier region. An aggregate report of the long-term focused 'Green Steel' plan, and their short term focused 'Roadmap Plus' and additional efforts of making current emission legislation more strict and legally grounded (Ministerie van Infrastructuur en Waterstaat, 2021).

In December 2021, the new governmental coalition agreement was presented, containing budget of 5 to 10 billion euros for financing green hydrogen producing plants.

3.4 Conclusion

Within the landscape level, it can be concluded that several themes or transitions are taking place simultaneously, which are exogenous to the regime and niche level.

Gradual transitions that are presented here are the growing concern in the scientific community on negative social and spatial effects of decarbonization, and the growing public concern on climate change. The latter being exemplified by the court rulings with regarding RDS and the Dutch government.

Disruptions on the landscape level that are considered to be shocks are the gradual adjustment of coal prices, which are projected to rise dramatically if stakeholders refrain from reinvesting in (coking) coal mines. Not to forget that, the emerging political support, embodied in the recent coalition agreement financially supporting a hydrogen production and transportation economy, is considered to be a shock-like landscape development. As Geels (2019) described changes in governing coalitions are part of the external landscape environment.

4 Regional destabilization

In this section the previous analyses and theoretical concepts by the MLP are combined to design answers to the research questions. Explaining the dynamics between the regime and niche and landscape level in EIIs and the IJmond region in particular.

4.1 What forces are stabilizing the regime steel-making industry?

Political power struggles are identified in a general sense on EII and case-specific sense in the IJmond region. From a regime level point of view (EII and steel making industry), information and framing, organized pressure, direct lobbying, and confrontational strategies are present.

Information and framing is exemplified by contesting scientific findings with 'fake' studies and accusing unpopular findings for their respective industries to be methodological incorrect. Also, EIIs emphasize that uncertainties with regards to decarbonization potentials are still present, due to limited application of new technologies. Referring to needing more testing and prototyping before commercial application can take place.

Organized pressure might also have taken place, according to the regime proposing two different plans on decarbonizing their industrial processes. One plan focused on CCS in which all of the assets of the regime would remain, also the environmentally harmful ones. The more radical one, promoted by the labour union (FNV), got rid of the environmentally harmful assets in the first steps raising their intrinsic believe that skipping an intermediate step would be more beneficial for the region and employees.

Direct lobbying and confrontational strategies were applied in lobbying for favorable legislation and EU-ETS reforms. As analyzed by the Carbon Welfare report, lobbyists and industry associations (e.g. Eurofer) were seven times more active than public representative groups in Brussels. These actors brought about reasoning with regards to employment risks and ultimately resulting in relocation of plants or investments in foreign countries.

4.2 What forces are *de*stabilizing the regime steel-making industry?

Destabilization (and decline) of the socio-technical regime in the IJmond region (and to some extent in EIIs) is characterised by changing rule sets, increasing external pressures (socio-political pressure, political support shift towards change, social protests, negative story-lines of regime activities, frustration of policymakers), and gradual decreasing commitment of incumbent actors.

4.2.1 Misalignment of rule sets

Evolutionary-economic changes in rule sets is seen in the occurrence of market and user preferences. The lack of markets requesting low GHG emitting basic materials or commodities is presented as a barrier towards change. But these markets are emerging as presented by BMW and Volvo for presenting their investments in green steel technologies and future collaboration with SSAB, which started producing green steel in 2021.

Another barrier that has deteriorated in the IJmond region is that of lacking policy initiatives beyond the R&D stage. Due to growing political support on the plans towards producing 'green' steel, additional subsidies are being reserved for green hydrogen producing plants. But these subsidies are now also coming together with additional requirements concerning sustainability benefits, subsidy leakage to foreign countries and other unaddressed worries.

Social-institutional change can be seen in the IJmond region resulting from various events. One of the reasons behind the social protest can be traced back to the idea that the local residents encountered presumed misalignment between normative rule sets.

Although the Netherlands has institutions that monitor, provide, and enforce licences, a series of events happened between 2018 and 2020 that showed signs of carelessness in the eyes of local residents. Especially the occurrence of the black snow in the area may have well been the final straw that broke the camel's back. On it self, the even can be seen as a singular fault by an industrial process, but as the local residents had clearly more worries unanswered, it sparked social protest.

This can be seen as a growing, presumed, misalignment between the local residents, the industrial companies, and regulating bodies. In particular, role expectations of local residents towards them. Expecting them to do whatever they can to balance their economic goals, industrial processes,

and direct health concerns for their employees and outside their fences. This feeling was inflated due to the technical nature of responses by the industrial companies, pointing towards their compliance with national and European emission regulation.

The new proposed plan for decarbonizing the steel-making industry is ultimately build on using green hydrogen as a feed-stock to the DRI and EAF combination plants. Green hydrogen production is planned to be produced in the northern region of the Netherlands. Wüstenhagen et al. (2007) presented the questionable support for siting decisions on renewable energy production in one region, and exporting the 'benefits' to others. Highlighting the need to address this SA before it might be too late, hindering successfully decarbonizing the steel-making industry as well. Meaning that SA in the IJmond region with regards to the green hydrogen technology might not be a problem in the future, but that of the northern region of the Netherlands, where those industries are planned.

4.2.2 Cultural discourse

In the IJmond region negative cultural discourse has taken place. This seems to be a result of actor credibility deterioration, and a shift in experiential commensurability.

Actor credibility received negativity after complaints on polluting events such as the graphite rains, and black snow. The steel making industry declared their compliance with emissions regulation and process licenses which were later confirmed. But without success of restoring credibility, voiced by the concerns of local residents in the interview with the NH Nieuws journalist regarding the doubtfulness of successfully executing 'Roadmap Plus' and its positive effects.

Experiential commensurability shifted when graphite rains were distinguished as harmful for children, black snow appeared in 2021, and the reports on health problems and causes of RIVM was presented. In the mean time the industrial companies kept referring to licenses and legislation approval, that would rectify the decency of their industrial activities. But what the local residents didn't see or recognized, was what was done to prevent graphite rains from happening in the future.

4.3 What transition path is characterizing the IJmond region?

To make a distinction between which theoretical path is suitable for representing the path of the IJmond region, the timing of landscape-developments and the nature of interaction with the regime level need to be considered. The inherent differences between the substituting technology of DRI and EAF and the regime technology of BF-BOF, and the landscape developments of climate change and growing political concern on the polluting nature of the regime.

4.3.1 Are the landscape developments disruptive or reinforcing?

As presented in section 3.3, landscape developments were present in terms of gradual changes (climate change concern, social protest, political concern), and external shocks (projected high quality iron or and coking coal prices). Whether these are disruptive or reinforcing depends on aspects as described in section 2.8. In this case, the climate change, social protest and political concern challenges the idea behind the current state of the steel-making industry and its processes. It is concerned whether these conventional ways of producing are the way to a better future and challenges its reasoning, ultimately pressuring the regime to reinvent their processes. The potential external price shocks may also push the regime processes to change in a way that these shocks are less affecting the regime's processes.

4.3.2 Are the niche-innovations competitive or symbiotic?

As depicted in the analyses of the different technologies to decarbonize the steel-making industry, it is shows that the conventional way of producing steel (BF-BOF) is radically different from the niche or proposed way of producing steel in a decarbonized way. The DRI-EAF way of producing needs specialized DRI pre-processing plants and EAF for producing liquid steel, in contrast to the conventional way of producing where a BF and BOF are used for producing liquid steel. Concluding that these technologies are in a competitive relationship towards each other.

4.3.3 Is the niche technology ready for implementation?

The niche-technology can also be considered to be ready for progressing to the level of regime implementation. According to the indicators of niche-innovation readiness by Geels and Schot (2007) to be present in this case; Powerful actors have joined the support network (e.g. the HYBRIT project in Sweden, EU's policies enhancing a hydrogen economy), price and performance have improved and strong expectations of further improvements (presented by the the first produced vehicle with green steel-only, collaboration of SSAB and Volvo), and cumulative market share of the niche-innovation amounted to 5-7% in 2019 (Keys et al., 2019; Fan and Friedmann, 2021).

Disruptive landscape developments and competitive niche-innovations together with niche technologies being ready for regime uptake, are according to Geels and Schot (2007) characteristics of the *technological substitution pathway*. Geels and Schot (2007) also describes some aspects for this route. Characterizing this pathway in which regime actors pay minor attention to problems as they think these can be solved by incremental innovations. technological substitution takes place when a specific landscape shock, avalanche change or disruptive change takes place, and exerts huge landscape pressure on the regime level. This pressures creates windows of opportunities and major tensions in the regime level. Geels and Schot (2007) also argues that this pathway has a technology-push character and 'wider co-evolution processes *follow* substitution' (p.410).

4.3.4 How can the transition path be visualized?

Through 4.3.1, 4.3.2, and 4.3.3, it can be concluded that the case of the socio-technical transition within the IJmond region can be considered one of *Technological substitution*. But Geels and Schot (2007) visualizes this with a shock-type landscape development, setting off the technological change. I argue that this is not correctly displaying the case of the IJmond region. I propose a different visualization, chosen from the other visualizations presented by (Geels and Schot, 2007, p.404).

Presented in section 2.8 these are distilled from four factors (frequency, amplitude, speed, scope). In the case of the IJmond region, multiple disruptions have taken place on the socio-technical landscape level (political concern, wider public support shift towards concern, election changes in government coalitions, scientific community concern on decarbonization effects in social and spatial aspects). Apart from the scientific community's worry, all of them took place in the course of about 3 years (from 2018 till 2021 and onward), referring to the high *speed* of these disruptions.

Also, because there is political support for the industry, societal concern took a sharp turn from supporting to scepticism on the industrial activities, the *amplitude* of the landscape developments is considered to be high. Lastly, the *scope* of the landscape developments spans across multiple aspects (scientific community, political parties, wider public, and global price fluctuations). Concluding that the best way to visualize these landscape developments as an *avalanche*, as described by Geels and Schot (2007). Figure 7 below visualizes this transition path with an avalanche characteristic.

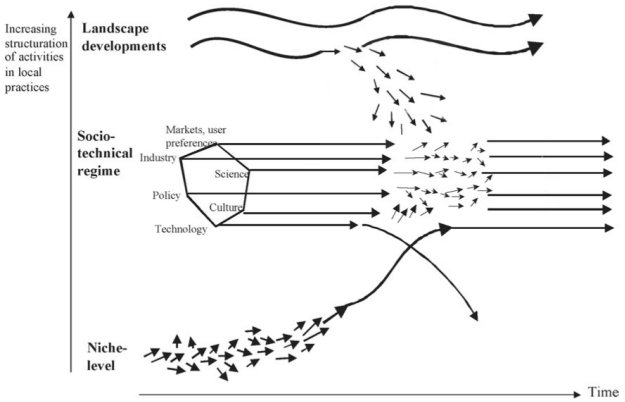

Figure 7: Technological Substitution path, visualized by and taken from Geels and Schot (2007)

4.4 What phase characterizes the current situation in the IJmond region?

Using the appearance of the niche technology of DRI and EAF in niche markets, and creating support from powerful actors shows that the niche technology is stabilised, marking phase 1 as characterized by Geels (2019) is passed. Although detailed start and finish of different phases is not elaborated, phase 3 is characterized by a period of flux in which windows of opportunity and regime destabilization due to landscape pressure and regime internal pressures (Geels, 2019). Phase 4 is about stabilization.

Phase 3 is considered to be charactizing the current status of the IJmond region. As new technologies and ideas have not yet materialized or insti-

tutionalized yet. I propose the figure below as a representation of the current phase, and transition path of the steel-making industry in the IJmond region of the Netherlands.

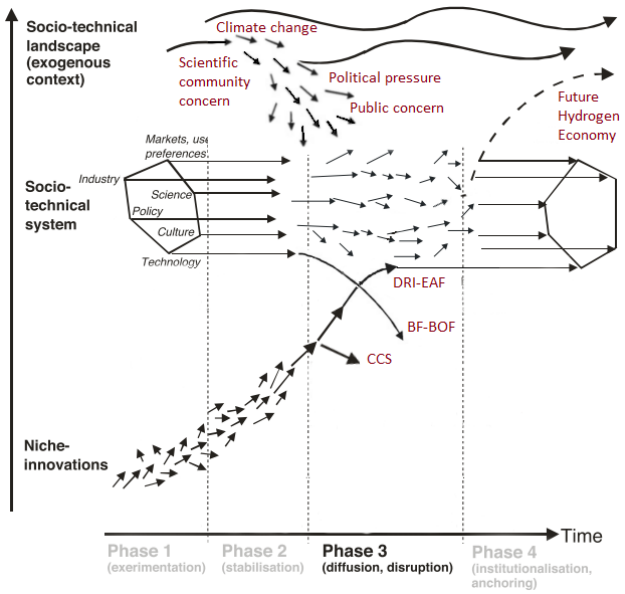

Figure 8: Merged visualization on path and phase in the IJmond region

4.5 Is the steel-making regime capable of radical innovation?

An additional finding in this study is another example of where Schumpeter's dichotomy on radical and incremental innovations is becoming outdated. As presented in 2019's version of the MLP framework it is acknowledged that radical innovation is no longer retained by niche-actors only. Incumbent firms are also capable of radical innovation. With regards to the steel-making industry in the IJmond region it was acknowledged that the former uncertainties on infrastructure (with regards to green hydrogen production) and the subsidies needed to close the gap towards commercial implementation were downgraded in their influence on the projects. Public opinion, forced by legislation in the near future and seemingly attractive financial incentives proposed by political leaders seem to be laying underneath this turn of view.

Also, noted by an employee of the Dutch steel-making industry, the intrinsic believe and desire to become sustainable was a driver in the sustainability transition.

Furthermore, it must be noted that, with regards to the geography perspective proposed by Coenen et al. (2012), capabilities to innovate are not merely attributable and determined by one company or sector alone. As (national) comparative institutional advantages and (regional) institutional thickness are influencing the best strategy for companies and sectors to innovate. A follow-up question could be referring to what institutional differences between successful innovating regions of steel-making industry and less successful ones are present.

Lastly, Coenen et al. (2012) describes that collaboration practices and informal information sharing are examples of specific institutional advantages with regards to the successful Danish windpower industry. This may also relate to innovation commons, elaborated in 3.2.2. A solution for creating these success factors depicted by Coenen et al. (2012) could be by creating spaces or communities in which the transaction costs of sharing and exchanging specialized and distributed knowledge is brought to a minimum, fostering the discovery of *value* of the specialized knowledge. Although this is also known to be troublesome to create ex ante Coenen et al. (2012).

4.6 What does the concept of SA add to our understanding of the dynamics of the IJmond region?

Although it is not entirely clear if the concept of SA only applies to *renewable energy* projects, I propose to use this concept for conventional *and* decarbonizing technologies for the steel-making industry. I also propose that this concept can be used for future siting decisions and the proposed hydrogen economy in the Netherlands. As depicted by an employee of OD IJmond:

> 'I think that especially the region have to realize that first there is going to be more industrial processes and plants. [...] But to get there [a greener way of production], first additional plants have to be built, simultaneously operating next to the conventional ones, before these can be phased-out. Are the people willing to accept that?'

Wüstenhagen et al. (2007) warn decision makers that general acceptance of renewable energy projects can be high, but when it comes to citing decisions, the acceptance can be low. One way to enhance and foster socio-political acceptance is the stimulation of collaborative decision making in spatial planning systems.

As in the interviews with employees of the Dutch steel-making industry, OD IJmond and a journalist of NH Nieuws, the following words or explanations were voiced when talking about future collaborations: 'stay in touch', 'transparency

from all stakeholders', 'explain ideas', 'listen to each other', 'keep the door open for discussion'. Additionally, Wüstenhagen et al. (2007) describes that resistance of local residents can occur when, for example regarding wind farms, siting decisions are placed in close proximity to residents' homes which 'derive a more positive sense of identity from particular rural landscapes' (p.2687). The hydrogen economy proposed, an important driver for the DRI-EAF route will also result in citing decisions. Highlighting the importance of taking care of the SA in the (near) future, in the IJmond region, and elsewhere. An example of how SA already plays a role in the Dutch steel-making industry is the event of an adjustment at the hot-rolling plant in the IJmond region. The town council of Wijk aan Zee asked whether a muffler could be added to a new part of the plant, this was not based on legal grounds, or any other sort of regulation. OD NZKG and the court ruled that it was not necessary according to emission or production permits, but still Tata complied and promised to do so.

Wüstenhagen et al. (2007) adds that the different perceptions and acceptance of CCS are characterized by professional actors backing up CCS ideas and citizens having slightly negative attitudes towards local storage decisions. With a surprising finding that local citizens have little knowledge about CO2-storage but also have little appetite for more information. This is also exemplified by the questions that arose in the debate around the proposed CCS application for the Dutch steel-making industry.

It might have added to the local resistance that trust between the local residents and governmental bodies and industry actors deteriorated as a result of the perceived lack of action with regards to the polluting events in 2018 throughout 2021. A lack of trust towards industry actors had already be noted by Wüstenhagen et al. (2007).

Finally, in the article on the interview with Jan de Jong, an example on how unfairness is perceived to be present among local stakeholders was exemplified. As Wüstenhagen et al. (2007) shows that procedurial and dsitrbutional justice is salient to SA, this is stained by this perceived unfairness. In particular the unfairness with regards to carrying costs and fair decision making processes in dealing with climate change and the participation of heavy industry.

4.7 Which factors stabilize and destabilize the Dutch steel-making industry regime and how can these be visualized?

Finally, the main research question can be answered. This is an aggregated answer of all the sub-research questions presented above.

Stabilizing factors that appeared in the IJmond region are: extensive lobbying by EII lobbyists (their tactics being information and framing, organized pressure, and direct and confrontational strategies).

Destabilizing factors are: misalignment of rule sets (by evolutionary-economic and socio-institutional changes), and cultural discourse (diminished actor credibility, and shifts in experiential commensurability).

The *path* and *phase* of the socio-technical transition can be visualized by use of *avalanche* landscape developments (because these disruptions where characterized by high speed, scope and amplitude, but low frequency), and *technological substitution* (as DRI-EAF is competitive, and landscape developments are considered to be disruptive). The visualization is presented in figure 8.

In the following section the focus will be on the research approach, methodology, and the course of the study. In order to present criticism regarding the used methodology and lessons learned for future studies or research topics.

5 Reflection and consecutive prospects

In this section my research experience in general, using the MLP to analyze an ongoing transition, conducting interviews, and the scientific value of this study is elaborated.

5.1 MLP experience and criticism

In this paragrpah my experience with the MLP framework is presented according to some findings I have encountered during this study.

5.1.1 MLP for exploration

In my opinion, the MLP appears to be a fruitful method for research that have a explorative nature. I agree with the idea of technological innovation being an interaction with social and societal aspects as well, is a robust hypothesis. Especially because of the growing presence of technology in every day life. Additionally, I also think that distinguishing a socio-technical system in three main levels is insightful for determining steps in analyzing different or all parts of a particular socio-technical system.

5.1.2 Deterioration of boundaries

Although I do believe that going from a helicopter view to a more focused view on actors, the boundaries of these levels fade. As actors voice their own and other's experiences they can switch between regime and niche levels. For example local residents can be very hostile towards the steel-making industry, demanding closure and even disappearance of the industry. Holding a niche-idea position towards the regime industry. But their opinion can change as the transition progresses, in which they get additional, contradictory information, becoming supportive to the regime and moving themselves to a regime level, from an MLP.

5.1.3 Subsequent visualizations

Also, looking at the different visualisations of landscape developments, as presented in figure 4 on page 20, it feels to underestimate the value of MLP being a process theory if only one visualization in the course of time can be used. Although not used in this study, I propose the idea that multiple visualizations of landscape developments can be used in a single transition, to more specifically visualize the different landscape developments and their characteristics in a single figure. For example 'shock' visualization before or after an 'avalanche'.

Especially for studies that take a long period of time for their analyses (e.g. sailing ships to steam-propelled ships), there is going to be more then just one or two influences or disruptions on the landscape developments level. Using multiple kinds of the proposed visualizations of those disruptions (as presented in Geels and Schot (2007)), would enhance the visualization and understanding of such a transition.

5.1.4 Process theory critique

In section 2.2 I refer to MLP being a process theory, not allowing for causal relations. This provokes an analysis that only shows what factors played a role in the transition, and do not provide answer in a predicting type of sense. Meaning that future transitions cannot learn from past transitions in the sense that specific factors are not known to cause a certain influence on the transition itself. I do not argue that *nothing* can be learned from past transition analyses with the MLP, but I propose that an effort needs to be made towards distinguishing how *much* certain factors *influence* the transition. Although I do recognize that this might also just be plainly impossible to distinguish the exact influence an event or voiced opinion has on a complex socio-technical system such as society. But pursuing the idea to determine the magnitude of these events or disruptions, might also bring along similar revealing characteristics as depicted in Geels and Schot (2007), in which the timing of landscape developments with regards to the readiness of niche-technologies is argued to provoke different transition pathways.

5.1.5 Socio-technical system change initiation

In one of the most earliest criticisms the characteristic of transitions being niche-driven was criticized. This was later reviewed and resulted in four different pathways presented in Geels and Schot (2007). In Geels (2019) the notion of regime actors being able to pursue radical innovations is noted. This brings me to the point that it might need some additional explanation to reveal that regime actors also (sometimes) act in the niche level. In this way, not only landscape & niche interactions with the regime provokes socio-technical system change, but

also internal socio-technical regime processes provoke system changes. This adds to Geels (2019) note on incumbent firms being able to pursue radical green niche innovations, moving away from Schumpeter's dichotomy (incremental innovation only produced by incumbent firms and radical innovation only provoked by new entrants). Apart from landscape and niche initiation of socio-technical change, I propose that initiation of the change process can also start among regime level social groups.

5.2 Scientific value

This study added to conveying the complexity of the IJmond situation to the wider public and its stakeholders. Distinguishing the established regime and its barriers towards radical decarbonization efforts, the voiced concerns of the local residents and their disconnection with the detailed processes of the industry and viable decarbonization options in both technological and economic sense, and the mutual acknowledgement that transparency in every step of the process towards decarbonizing the industry are essential to evade further social protests and foster a smoother socio-technical transition.

This study has not used a predefined method or route to gather data. It was constantly using new information to gain additional insights and explore new routes and fields of study. This has been noted by Geels (2011) on the complexity of transitions research: 'The research of complex phenomena such as transitions cannot be reduced to the application of methodological procedures and will always contain elements of creative interpretation' (p.36). Another recognition of the use of unstructured research methodologies for topics that have no clear boundaries (yet).

Also, adding to the base of employing MLP for the us of small case studies instead of broad multi-decade transition analyses (Geels and Schot, 2007).

Additionally, this study adds to the direction proposed by Geels (2006) on arguing for more case studies, to determine the value and importance of different factors. As the case of the IJmond can be characterized by negative externalities being one of the key take-aways with regards to the transition process, it may add additional insights if compared to 'internal problems' case studies (Geels, 2006).

Another contribution of this study is adding towards the question or raising call for 'more open and inclusive governance styles' noted by Geels (2019). The findings from the interviews tell that transparency is a much called for aspect in dealing with such socio-technical transition problems. Allowing for local residents to take part in the transition, taking their opinion as valuable, and not closing the door for discussion is asked for, voiced in the interviews with stakeholder in the Dutch IJmond region. Which may even alleviate social acceptance problems (Geels, 2019). In turn, SA is salient to successful implementation of sustainable energy projects (Wüstenhagen et al., 2007).

The arguments of Coenen et al. (2012) on why a more territorial perspective should be added to the MLP and Technological Innovation Systems are also applicable an

This study is focused on one (regime) region, the IJmond. By setting these boundaries, one can get more detailed information on what the barriers and drivers of transitions are in IJmond specific contexts. As mentioned before, Coenen et al. (2012) argues for institutional differences (both institutional comparative advantages as well as institutional thickness) when relating to differences in sustainability innovation achievements and progressions. (Coenen et al., 2012, p. 976) concludes that 'explicitly focusing on territorial embeddedness helps in disclosing the institutional contingencies and particularities of the various contexts where transitions take place'. Although implicitly, this study takes a first step in identifying these institutional contingencies in the IJmond region, regarding the transition process of conventional BF-BOF towards DRI-EAF steel-making industry. Also relating to another conclusion made in Coenen et al. (2012), that transition analyses 'should start to explore, and partly revisit, the meaning played by particular places in the evolution of transitions'. Relating to the meaning of how transition in the IJmond region, and for example the transition in Sweden (pioneered by SSAB) rooting these technologies in society and the global transition of steel-making processes towards a more sustainable future.

5.2.1 Comparing conclusions

In Lefvert et al. (2022) study on the potential paths for CCS in Sweden, one of the conclusions is:

> Unforeseen landscape pressures or other potential factors can influence the trajectory of the transition pathway for CCS in Sweden, including *public acceptance*, industry investment cycles and

bottlenecks in storage capacity. (p.8)

Noting that public acceptance might be a barrier towards CCS implementation is similar to what was found in this study. As the public acceptance, or community acceptance according to Wüstenhagen et al. (2007), happened to be low and a more favoured option (hydrogen) was also available. Lefvert et al. (2022) conclude their article noting that CCS is depicted as an emerging pathway in Sweden but that it would not be the single technology employed to build a carbon-neutral energy system. CCS would be accompanied by other technologies in "an energy system transition to a regime with net negative GHG emissions after 2045" (Lefvert et al., 2022, p.8).

This was also noted in the interviews with employees of the Dutch steel-making industry. In the interview CCS was presented as the best cost-effective way to decarbonize, and that it would most certainly be implemented in the future, although current plans have not yet.

Öhman et al. (2022) conclude that the socio-technical transition path for the iron and steel-making industry is characterized by a de-alignment and re-alignment path, in contrast to the current study concluding that technological substitution is characterizing the transition path. Aside from geographical locations analyzed, the key difference between these two paths as presented in Geels and Schot (2007), is whether niche-innovations *have* or *have not* sufficiently developed. arguing for niche-innovation readiness is not objective, and prone to the viewpoint of the one administering the analysis. I don't think Öhman et al. (2022) is incorrect in characterizing the European hydrogen pathway as one of de-alignment and re-alignment. I do think that determining whether or not a technology is *ready* for advancing to the regime level is something that apparently different methods are able to distinguish. I used the factors determined by Geels and Schot (2007); learning processes have stabilised in a dominant design, powerful actors have joining the support network, price/performance improvements have improved an there are strong expectations of further improvement, and the innovation is used in market niches, which cumulatively amount to more than 5% market share. Öhman et al. (2022) used factors such as the price and the presence of fossil-free electricity, and supporting policies and regulatory framework. These different innovation-readiness methodologies explain the different conclusions on the readiness of hydrogen-based steel-making.

Adding the need for fossil-free electricity to the case of the IJmond region as an indicator for technology readiness may also tilt the niche-technology readiness towards *not* ready for regime implementation. As the Dutch energy production is still mainly based on fossil fuels (oil and gas) (International Energy Agency, 2020).

Brock et al. (2020) noted that there was reasons to think that there was a risk of enhancing a globally resurgent political right. This is in contrast to what was found to be the case in the IJmond region. As the regime industry was perceived to be polluting the region, local protests resulted in a political left-wing surge to demand improvements with regards to the regional air quality.

Relating this study's findings to other findings on similar aspects of sustainability transitions and technology transfers adds to the confidence of this study's findings. Using a predefined framework (MLP) adds to the replicability of this study. Although it must be noted that replicability is degraded due to aspect of time in this study. As the debate in the IJmond region is ongoing, future administered interviews could acquire different data than the data in this study. The small number of interviews conducted is also not enhancing the Rigor of this study, although enhanced by the data triangulation method, in which interview perspectives are related to scientific article and newspaper findings.

5.2.2 Research experience

During my studies at TU Delft, one gets familiar with acquiring data from various sources. This data has a tendency to be part of the secondary data aspect, as for most projects and courses done simultaneously, there is not enough time to investigate and execute primary data gathering methods. For the final assignment of the master program, there is enough time, and it is desirable to do so. For me this resulted in conducting personal interviews with key stakeholders in the decarbonization debate of the Dutch steel-making industry. For me this was the first time I administered such interviews and I learned a few things.

At first, I was hesitating a lot whether I had enough knowledge about the current situation to ask meaningful questions about the subject. But I learned that there are always going to be new

things encountered when conducting unstructured interviews, and this may not be a bad thing. It is very helpful to administer such interviews earlier than later. It helps to gain perspective of what key elements are present, and which other elements are not. Also, questions that explore future interviewees, and additional subjects are a very helpful tool to gain a broader perspective very quickly.

I also found that it is of great value to get familiar with situation and its sensitivity to the participant before administering these interviews. It could only enhance the quality of data acquired if the participant (interviewee) is informed on how their data, comments, or viewpoints are treated and stored. The personal data in particular is very sensitive when subjects are controversial and therefore need to be an even greater focus by the interviewer in reassuring the interviewee that these kinds of data are handled on a confidential basis.

Additionally, as this study was conducted during the peak times of COVID-19, most of the meetings and all interviews were conducted via digital meeting platforms. Pre-COVID-19 I was not experienced with these kinds of meetings and preferred face-to-face ones. Therefore, conducting this research and data gathering primarily via videoconferencing gave me a lot of experience in these kinds of meetings. Adding a lot of flexibility towards the ways in which to acquire data personally and professionally in future.

As it may be clear by now, this study has not departed from a predefined set of questions or assignment. I started from the question of how sustainability efforts in industries were progressing, and why certain companies or countries did a better job than others. Identifying EIIs as the ones lacking progression, sparking my curiosity on why this was the case. I think the biggest challenge was to find a balance between what I wanted to investigate and what I was capable of doing, keeping in mind that I wanted to do something valuable for the real world as well. Compiling my own method of different frameworks and concepts really put my personal view on the IJmond transition. Administering interviews with stakeholders of the region confronted me with the difficulties of the situation, and showing that seemingly simple solutions, are also hard to implement because of the embeddedness and need of the industry in the region and society. I learned to deal with the lack of a pre-defined set of actions to confront a problem, but still managing to design a scientific method to analyze a real world social problem situation and relating conclusions with other scientific articles.

5.3 Additional notes

Kahneman (2011) wrote a book on the systems of the mind. Which is another fruitful topic that may be researched to how *exactly* framing techniques work, and tend to stain actors, groups and stakeholders. I think it is not part of the scope of this study, but Kahneman's findings that first impressions influence our actions and believes without our consciously awareness can be insightful.

More particular, two concepts that triggered thinking framing and Kahneman are linked: the Halo Effect, and the concept of What You See Is All There Is (WYSIATI).

Liking everything about a person, even things you have not (yet) observed is called the *halo effect*. It means that if you like someones policies or values, you also like their appearance, their smile, their voice. In general referring to that person leaves a positive mark or feeling.

Let me refer back to the interview with the journalist of NH Nieuws. It was mentioned that everything that the steel-making industry was now offering as a remedy or improvements, was questioned by the local residents. It appeared that because of the previous polluting events, everything about the industry was seen as polluting, or unacceptable. Even though the plans may very well be enhancing and solving their problems in the future.

WYSIATI is about making assumptions on the data that has been given, but not questioning the data the has *not* been given. It describes how the mind is a machine for jumping to conclusions, even if there is valuable information missing. Kahneman (2011) refers to the example of answering the question:" Will be Mindik be a good leader? she is intelligent and strong...". One would be tempted to acknowledge that Mindik would indeed be a good leader, even though the sentence has not yet been finished. Even if the next two characteristics of the person could very well be corrupt and cruel. Of course, making decisions on information that one does not have is tough and maybe irrelevant, as there is always information missing. But one would need to be aware that the mind is very well trained in jumping to conclusions with available data.

Referring back to the case of the IJmond region, it may add to the awareness of the local residents and industry stakeholders to know that this mecha-

nism exists, and stains most of our conclusions unconsciously. Persuading residents and stakeholders in asking more questions before jumping to conclusions. Evading future situations such as the false accusation of Vuijk on the vested interest behind the GGD health report.

5.4 Research directions

Looking back at the past few months still feels like an ongoing quest. I could still add events and theories to the situation in the IJmond region, acquire more data on the viewpoints, reasons, values, and motives of stakeholders within the regime, niche and landscape level. And I do think this would be interesting to do. This all would certainly paint an even more comprehensive picture of the transition.

Geels (2011) followed up on the statement that research on complex phenomenon will always contain elements of creative interpretation, by noting that: "it is probably fair to say that, so far, transition case studies aimed more at illustration and exploration than at systematic research" (p.36).

Referring to the need for systematic research on transitions. Now that the boundaries of the current problem in the IJmond region have been explored to some extend, it might be time to consult a more systematic approach to fully cover the complex situation. By use of a Q methodology for example.

This study has been focused on tracing the dynamics that appear to be present in the IJmond region, and its transition from to a more sustainable future. This is done by applying a Multi-Level Perspective, which is more about analysing dynamics and forces, instead of determining what forces or moves *caused* other ones in the transition. It is not about causal relations. This brings forth a critique which cannot be refuted; this kind, or these kinds of studies are only capable of analysing events or transitions that already have happened. Using these studies to predict future transitions is thus not fully applicable.

For future research purpose it would be insightful to determine the *impacts* and *how much* certain moves, barriers, and sustainability improvements *affect* the outcome, also noted by Gillard et al. (2016). This also relates to the geography and spatial perspective proposed by Coenen et al. (2012). To enhance comparability analyses, it would assist to focus on territorial spaces, moving towards a multi-level and scalar perspective, when analysing (sustainability) transitions.

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