TECHNOLOGICAL INNOVATION SYSTEMS FOR DECARBONISATION OF STEEL PRODUCTION

- Implications for European Decision Makers -

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Background

EU is the world's third largest contributor to CO_2 emissions.[1] In order to fulfil the goals stated in the European Commission's *Low carbon roadmap*, EU must cut domestic CO_2 emissions by 80-95% until 2050 (compared to 1990 levels).[2] Despite substantial industrial efforts to decarbonise in the past, the EU steel industry is still a major contributor to European CO_2 emissions, and is currently in strong need of developing radical process innovations to be able to decarbonise further.[3]

Scope and objectives of study

This study is aiming to describe the current innovation system of the EU steel industry, and outline some key implications for improvement of innovation initiatives fostering development of breakthrough, low-carbon process technologies. The main recipients are European decision makers with decision making power who are operating within, or in close proximity to, the EU steel industry. The research is guided by four research questions:

1) WHERE does innovation take place?
2) WHO are the main influencers of innovation?
3) WHY does the industry innovate?
4) WHAT does the industry do, in terms of innovation?

Theoretical foundation

There are numerous definitions of innovation in literature, but this study defines innovation as 'value creation through inventiveness'.

Technological innovations can be divided into product innovations and process innovations, and this study focuses on process innovations, which are defined as how things should be produced, or sold, or done.[4] The maturity of a technology can be evaluated through the Technology Readiness Level (TRL), which is a tool for measuring the readiness for commercialisation (or operational use).[5] An innovation system is the ecosystem of actors and factors, within which an innovation activity takes place.[6] As innovation is a continuous process it cannot be easily measured, and the full innovation system must be taking into consideration in order to fully understand the implications to an industry.

Methodology

The study uses a semi-structured approach, including both qualitative and quantitative data. Primary data was collected through eleven in-depth interviews with respondents from different stakeholder categories, all with high expertise on the EU steel industry. Secondary data was conducted through literature reviews of scientific articles as well as a brief analysis of public industrial documents. In order to assure credibility of the study, the study's validity, reliability and triangulation was taken into consideration. Validity and reliability could be assured through a holistic approach to the innovation system, and by letting the respondents review their answers after the interview. Methods triangulation and triangulation of sources was conducted by combining different methods of data collection

[*] This article is a subset of a Master thesis with the same title and author.
[1] EDGAR (2016).
[2] CLIMATE ACTION (2016).
[3] Åhman, M. & Nilsson, L. J., (2015), p. 92.
[4] Oslo Manual (2005), pp. 15-17.
[5] ISO (2013).
[6] Gailly (2012), pp. 99-108.

and by choosing respondents from different stakeholder categories.

The 4W-framework for mapping of technological innovation systems

In order to map the technological innovation system of the EU steel industry, a new framework was developed, named 'the 4W-framework'. The framework is illustrated in Figure 1 below. *Where* maps the external environment, including uncontrollable factors and actors, such as framework conditions and industry initiatives for collaboration on innovation. *Who* analyses the key influencers of innovation, divided into drivers and obstacles, within the external or internal environment. *Why* maps the innovative climate within the industry, such as the industry's attitude towards innovation, including interests and incentives to decarbonise. *What* refers to the development of breakthrough decarbonisation technologies within the industry, including current initiatives, predicted future development and which expected actions need to be undertaken in order to fulfil the decarbonisation goals for year 2050. The four research areas cover the technological innovation system and list a number of concluding recommendations to key decision makers inside and outside the industry. Under the following headlines, each of the four research questions is answered respectively.

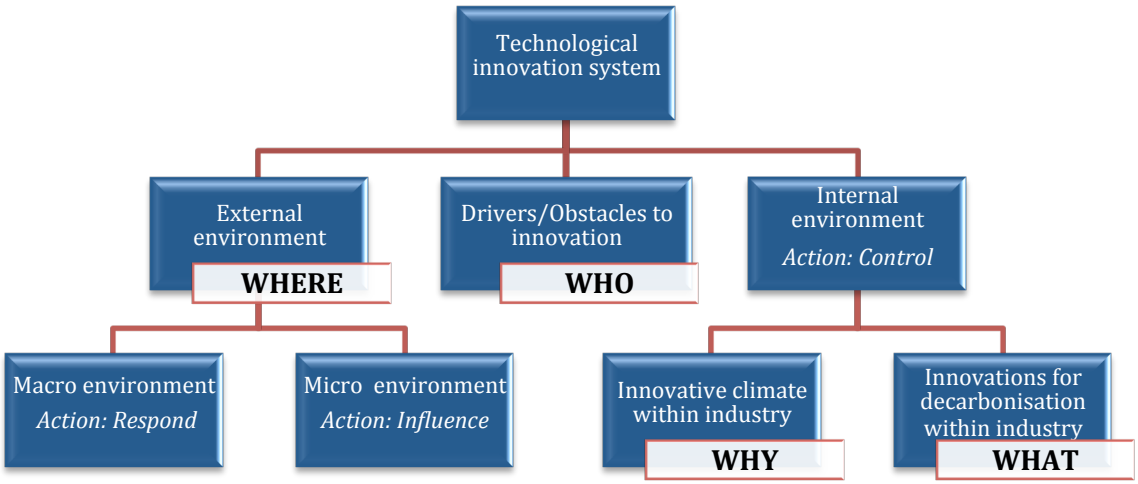

Figure 1. The 4W-framework for mapping of an industry's technological innovation system.

WHERE

A firm's external environment can be divided into macro environment and micro environment.[7] The macro environment consists of uncontrollable factors and can be described through the PESTLE framework.[8] The industry must develop a strategy for response to these factors.[9]

The actors and factors within the micro environment are partly controllable and could to some extent be influenced. Here, the full value chain of steel production must be taken into consideration.

Innovation in the EU steel industry takes place at a highly competitive market, where international competition and low growth rates strongly affect the industry's ability to innovate. EU is aiming to be a forerunner in decarbonisation, but the industry is under frequent threat of carbon leakage. The ULCOS initiative is an important example of industrial collaboration on innovation for decarbonisation, but current collaborative efforts are weak, both between industry actors and EU policy makers,

[7] Kotler, P. & Armstrong, G. (2001), p. 90.
[8] Johnson, G. et al (2009), p. 25.
[9] Jain, A. K., (2009) pp. 61-75.

as well as within the industry itself. Stronger willingness and allocation of more resources will be needed to fulfil the goals for year 2050.

WHO

The main influencers of innovation are factors and actors expected to have a significant impact on the EU steel industry's ability to develop breakthrough decarbonisation technologies. As illustrated in Figure 2, four key actors and factors can be identified, which play an especially strong role in driving or hampering the industry's innovation capabilities: Regulation, Industry organisations, Downstream actors (such as customers and end users) and the Top-level Management of steel producing companies. Regulation and Top-level Management are currently perceived as both driving and hampering forces, whereas Industry organisations are said to play a directly hampering role in the innovation process. The respondents describe Downstream actors as neutral with insignificant influence, and the most efficient force to turn these actors into strong drivers is likely to be Academia. Notably, the respondents describe also Academia as a neutral force, despite extensive research and numerous published articles aiming to drive decarbonisation of the EU steel industry. A possible explanation could be that Academia fails to communicate academic findings to industrial actors throughout the technological innovation system, and are hence not successful in their aim to be drivers of innovation.

Based on these findings, the formulated recommendations have been directed to four key actors: Steel producers, Industry organisations, Policy makers and Academia.

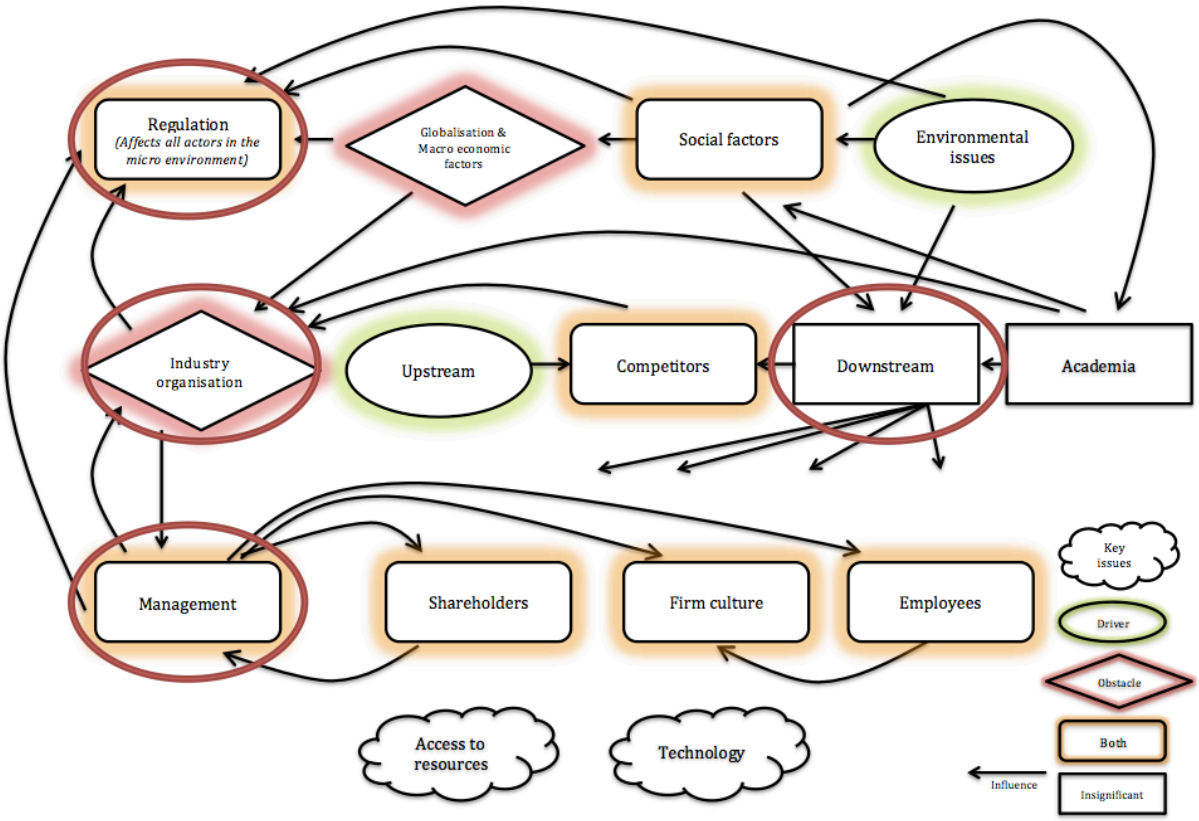

Figure 2. The drivers and obstacles to innovation, and their influence over other actors.

WHY

Part of the internal innovative environment is a controllable factor, analysing why a company innovates, and more specifically the key actors' interest in and incentives to innovate in order to decarbonise.

The EU steel industry's current interest in innovation for decarbonisation is low. With money as the main incentive, current carbon pricing mechanisms fail to pose any strong incentive for the industry to decarbonise.

However, benchmarking on other industry organisations show that enhanced decarbonisation efforts can generate strong side-benefits, such as strengthened stakeholder collaboration, improved public image and a stronger unity of the industry. The European steel industry organisation EUROFER is therefore strongly recommended to follow the example of other industry organisations[10], and improve the industry's willingness to decarbonise through creation of an industry-wide vision for decarbonisation.

WHAT

The second part of the internal innovative environment identifies and analyses what the industry does in terms of innovation, such as current decarbonisation initiatives and investments in innovation. The aim is to identify what additional actions must be undertaken today, in order to fulfil the decarbonisation goals for year 2050.

The EU steel industry is currently undergoing the First Valley of Death (around TRL 4) on the Technology Readiness Level scale. Substantial investments will be needed, in particular from financial EU instruments but also in terms of a long-term commercialisation strategy. The technological challenge is extensive but several existing technologies can be promising in the long-term, including Carbon Capture and Storage (CCS) and Carbon Capture and Usage (CCU).

At the same time, the EU steel industry's approach to the decarbonisation challenge is described as pessimistic, and the respondents do not believe that the industry will be able to fulfil the decarbonisation goals in time solely through the current initiatives.

Recommendations for decision makers

In order to enhance the EU steel industry's innovative capacity and decarbonise until year 2050, all actors must strive at improving their efforts and willingness to develop breakthrough process technologies. No actor can alone develop breakthrough process technologies that decrease the emission levels to the extent needed, and collaborative efforts will be required to enable a low-carbon transition. Below, some key recommendations are formulated, addressing European decision makers who are in a position to drive the low-carbon reforms required to decarbonise the EU steel industry.

Steel producers

The top-level management of steel producing firms must step forward and ensure that the industry takes on a positive, long-term approach to decarbonisation. This includes to strengthen the innovative culture, improve collaboration and make investments of sufficient magnitude. Furthermore, steel producers must support reforms on sustainable carbon pricing and see the EU ETS as an opportunity to reinvest money into decarbonisation initiatives. With increased end-user involvement and a customer willingness to pay for 'sustainable steel', several new business opportunities could emerge and drive a transition towards higher specialisation and increased secondary steel production from scrap. These transitions could enhance the EU steel industry's competitiveness on the global market. Furthermore, the market opportunities for CCU should be further explored.

Industry organisations

Industry organisations must formulate and communicate a long-term vision for decarbonisation of the EU steel industry. This vision could help the industry to become 'the sustainable steel industry' with greater circularity in the economy, and should include strategies for enhanced collaborative efforts and a stronger willingness to decarbonise. A revitalisation of ULCOS could be evaluated, as well as closer collaboration with other industries regarding for example research on CCS and CCU. It is of utmost importance that industry organisations become the facilitators of change and focus on working together with the most progressive actors, as well as to raise public awareness on the need for decarbonisation.

Policy makers

The industry is unable to decarbonise without substantial support from policy makers. Collaboration between policy makers and the industry is in strong need for improvement, as

[10] Examples of progressive industry organisations are CEPI (Confederation of European Paper Industries) and Jernkontoret (The Swedish Steel Producers' Association).

well as for communication and synchronisation of timeframes. Due to strong inter-linkages in the energy system, industrial policies must take on a holistic approach to decarbonisation rather than focusing solely on isolated parts of the system. Furthermore, policy makers should maintain the aim to keep EU a forerunner in decarbonisation, and the EU innovative mindset must be strongly encouraged. Avoiding creation of a risk-averse culture with reluctance to investment should be strongly prioritized, and policy makers must aim to share the risks (including the costs) with the industry throughout the process of developing breakthrough, low-carbon process technologies.

Academia

Academia must improve their efforts to raise public awareness on decarbonisation, and take a more prominent role as a driver of innovation of breakthrough technologies. A core priority should be to improve end-user awareness and encourage stronger end-user involvement in industrial decarbonisation issues.

Summary of findings

Despite the weak prospects, all actors must actively strive towards fulfilling the emission goals for 2050. Current efforts are far from sufficient, and the EU steel industry is missing out on numerous opportunities to enhance their competitiveness and to improve their public image due to lack of willingness and a negative approach.

The 4W-framework developed in this study provides a wide overview of the technological innovation system of the EU steel industry. The mapping highlights the currently weak European competitiveness, and outlines the key actors as well as some key recommendations to these actors. Most recommendations concern the need for improved communication and a stronger industrial willingness to commit to decarbonisation of the EU steel industry.

The 4W-framework can be applied also to other industries, for scientific mapping of the industrial decarbonisation potential.

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