Carbon2Chem

A case study

31 May 2019

Innovation:	**CCU (Carbon Capture and Usage) within the steel and chemical industry**
Intervention:	**Carbon2Chem**
Case Study by:	Helena Mölter (Wuppertal Institute)
Methodology:	7 interviews, 2 site visits, 1 industry conference
Case Study Overview	
Sector(s):	Plastics, Steel
Value Chain Stage(s):	Resource & Production
Type of Intervention:	Technical (with organisational elements)
Date & Duration:	2016-2020
Location:	Germany, North Rhine-Westphalia
Initiating Actors:	ThyssenKrupp, Fraunhofer UMSICHT, MPI CEC
Actor Constellation:	Project partners: AkzoNobel, BASF, Clariant, Covestro, Evonik, Fraunhofer Institut für Solare Energiesysteme ISE, Fraunhofer Institut für Umwelt -, Sicherheits- und Energietechnik (UMSICHT), Karlsruher Institut für Technologie (KIT), The Linde Group, Max-Planck-Institut für Chemische Energiekonversion (MPI CEC), Ruhr-Universtität Bochum (RUB), RWTH Aachen, CAT Catalytic Center, Siemens AG, Thyssenkrupp, TU Kaiserslautern, Volkswagen, ZBT Zentrum für BrennstoffzellenTechnik GmbH Funding institution: Federal Ministry of Education and Research (BMBF)
Short Description of Intervention:	Carbon2Chem is a project at the intersection of the steel and the chemical industry placed in Germany (mainly North Rhine-Westphalia) – following the core idea that unavoidable CO_2 emissions from one production serve as the raw material of another, carbon-based production. Thus, there is a reduction of fossil raw materials for the chemical industry. The blast furnace's gases contain, among other things, hydrogen and nitrogen. Carbon is also present in large quantities: as carbon monoxide (CO), as carbon dioxide (CO_2) and as methane (CH_4). Carbon, hydrogen and nitrogen are the basis for many chemical products. The steel mill gas is refined or conditioned to synthesis gas with the help of renewable energy. The result will be basic chemical products (e.g. fertilisers, methanol, polymers). The project was initiated by ThyssenKrupp, Fraunhofer UMSICHT and Max-Planck-Institute and is now encompassing in total 18 partners from industry and research. Besides the investments of the involved partners, the project is funded by the BMBF with €60m for four years. The contribution towards decarbonisation is expected to be a reduction of 20Mt of CO_2 per year. Though this equals 10% of the yearly emissions of industrial processes and manufacturing industries in Germany, it is important to remark that the emissions will be "re-used" by the chemical sector and might be emitted at a later stage of the value chain in case the carbon loop will not be closed. Nevertheless, the chemical industry can reduce the amount of fossil resources as these resources are provided by the steel industry at Carbon2Chem. But a switch towards a fossil-free steel production without blast furnaces might be hampered through the approach of CCU, as the path dependency of the steel industry towards the existing, high emitting blast furnace route, is strengthened.
Research Theme Summaries	
1. Innovation History & Dynamics:	Driven by the steel industry to reduce CO_2 emissions as the prices for CO_2 emissions certificates are expected to rise, ThyssenKrupp got together with the Fraunhofer Institute as well as the Max-Planck-Institute in order to draft a core vision and idea. The innovation has not circulated yet, but it is expected to be implemented at 50 integrated steel mill sites worldwide, including other industrial sectors such as cement in order to use their off gases. In addition, it is important to mention that NRW has very good pre-conditions as the steel industry is very connected along the value chain and the chemical industry is of high importance – and both industries are locally close together. Though the success of implementing the project ideas on industrial scale is not clear yet, it is clear that several other – non-technical – innovations arose due to the project's activities: In the businesses itself as they had to learn how to work across different

	business units; along the businesses as they had to find a common solution and optimum for the processes. Moreover, the organisational set-up and methodology of the project is sending impulses to other cross-sectoral co-operations in NRW. The core challenge – besides technical challenges – of the project was in the phase of initiation, but also while the project is still running, to find a common language for such a huge consortium. As there are scientists and industrial partners involved as well as several business units from within the industrial corporates, it takes time to get a common understanding of processes and working methods.
2. Governance Arrangements & Agents of Change:	The project was initiated and is coordinated by ThyssenKrupp, Fraunhofer UMSICHT and Max-Planck-Institute. 14 more partners from industry and science got involved during the phase of initiation. The partners from science and industry are building a bridge from basic research to the market with Carbon2Chem. The industrial partners are seen as the driving forces – the research partners are supporting on the overarching level. Besides the involved partners, politicians and the energy industry are and were important for the implementation of the project. During the phase of initiation, the partners reached out to the ministry in North Rhine-Westphalia (MWIDE). As a consequence, the project was supported from the beginning by the MWIDE in terms of mental support and to convince the government on a national level. Besides the investments of the involved partners, the project is funded by the BMBF with €60m for four years. A key driving factor for the industrial partners to initiate the project were the expected rising prises for CO_2-emission certificates and thus corresponding higher costs. Moreover, the project follows the aim to ensure the competitiveness of the specific sites of the plants. That's also the reason why the ministry of North Rhine-Westphalia (the region where the core partners of the consortium are based) is strongly supporting the project idea.
3. Transformative Capacities:	The idea of Carbon2Chem is demanding skills on a personal as well as on a technical knowledge level. The first-mentioned comprises a tacit, implicit knowledge as for example skills of working together in new teams, with people from different scientific or industrial backgrounds, working in different working environments, learning organisations or new ways of communication. The second-mentioned is an explicit knowledge on technical processes, products and possible market demands. All interviewees mentioned that the existing technical know-how in the consortium on both sides – research and industry – was and is fundamental for the project. In terms of technical challenges that the project is facing, the interviewees describe the consortium as well set up. The project is generating authority towards the funding institution and towards the public through the financial commitment of the industrial partners. This contribution can be seen as a signal that the project won't remain in the laboratory phase, but that an industrial large-scale implementation is aimed to be reached. The potential of the project to achieve CO_2-neutral steel is made distinct in public. The image of a circular economy is consistently used whereas the usage of the term "Carbon Capture and Usage" (CCU) is not used in broad public dissemination materials. While conducting the case study it was striking that the project consortium's members are not talking about decarbonisation but about CO_2-neutrality.
4. Assessment & Evaluation:	In the Carbon2Chem initiative, the accompanying LCA and economic analysis aims to develop corresponding scenarios that include ecologic and economic criteria. As the emissions of the steel industry have to get assessed very carefully by the steel industry due to CO_2-certificates (ETS), very exact data are already available. The challenge that the project is facing is to combine the steel and chemical industries' resource flows into one assessment: The source of CO_2 will be replaced for the chemical industry - so there are two reductions taking place: Emissions from the steel industry and reduction of fossil resources in the chemical industry. Having said that, the project is still running and not finished yet, and neither is the impact assessment of the initiative itself. Moreover, it is a challenge to combine economic and sustainable variables in one assessment which is needed for a successful implementation and up-scaling of the project in the future.
5. Uptake & Consequences:	The core idea of the project is a modular set up whose modules aim to facilitate an implementation of the energy transition. The steel industry hereby serves as an example: This means that the resources which flow into the chemical industry do not necessarily have to come from the steel industry, but can also come from other industries. Thus, the potential to scale up the innovation is very high in case of a successful phase of research

	and implementation. The project idea is applicable for at least 50 steel sites worldwide according to the project partners. Cross-industrial projects between partners that didn't know each other before are taking place more frequently: Including different corporations' cultures and activities that were formerly unrelated businesses and rather risky. Carbon2Chem can be seen as one part of the puzzle e.g. about the influence on the flexibility of the energy market. Moreover, there might be consequences on the gas market e.g. for methane, as worldwide around 10% of methane might get produced by the CO_2 coming from Carbon2Chem (from the steel site of ThyssenKrupp in Duisburg). This means that a large amount of methane would be on the market additionally and the effects for the chemical market are not clear yet.
Conclusion & Outlook	
Key Learnings:	A key driving factor for the industrial partners to initiate the project were the expected rising prises for CO_2-emission certificates and thus corresponding higher costs. Moreover, the project follows the aim to ensure the competitiveness of the specific sites of the plants. That's also the reason why the ministry of North Rhine-Westphalia (the region where the core partners of the consortium are based) is strongly supporting the project idea. The core challenge – besides technical challenges – of the project was in the phase of initiation, but also while the project is still running, to find a common language for such a huge consortium. As there are scientists and industrial partners involved as well as several business units from within the industrial corporations, it takes time to get a common understanding of processes and working methods. The contribution towards decarbonisation is expected to be a reduction of 20Mt of CO_2 per year. Though this equals 10% of yearly emissions of industrial processes and manufacturing industries in Germany, it is important to remark that the emissions will be "re-used" by the chemical sector and might be emitted on a later stage of the value chain in case that the carbon loop won't be closed. Nevertheless, the chemical industry can reduce the amount of fossil resources as these resources are provided by the steel industry at Carbon2Chem. But a switch towards a fossil-free steel production without a blast furnace might be hampered through the approach of CCU, as the path dependency of the steel industry towards the existing, high emitting blast furnace route, is strengthened. An additional learning from the case is that political actors can act as intermediaries in terms of supporting the initiation and institutionalisation of cross-industrial innovations. Nevertheless, public funding helps to gain authority for such large-scale industrial research programs. To conclude: It needs internal drivers for initiation (as a high willingness and motivation of all included persons), but also external drivers such as expected costs due to rising prices for CO_2-emission certificates. In addition, local factors in terms of proximity of the involved industries are favourable conditions for cross-industrial low-carbon innovations.
Open Questions & Further Research Requirements:	Going forward, it would be interesting to see how the project is further proceeding and which effects on decarbonisation will arise in the end. In addition, will be better to examine the impact on social, environmental and economic factors after an industrial implementation of the project. To conclude, both involved sectors may play an important source of change in the REINVENT sectors. But the pathway of CCU will only lead to an effective carbon reduction if it will be combined with a circular economy in the plastics sector.

reINVENT
decarbonisation

For Europe to achieve its long-term climate objectives, carbon-intensive industries have to reduce their emissions.

REINVENT focuses on plastics, steel, paper and meat & dairy – industrial sectors that are key to our daily lives, but where low-carbon transitions are still relatively unexplored.

To gain a broader understanding of the possibilities of transition, entire value chains of the industries are studied. This includes non-technical factors such as supply chains, financing, trade, and social and economic impacts. Together with forward-looking industry leaders and policy-makers, we explore potentials and capabilities for making transitions in these resource-intensive industries.

PARTICIPANTS & FUNDING

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