REINVENT – PROJECT NR 730053

Report on Synthesis Workshop

"Transition to fossil-free industries: technology pathways and policies"

March 18, 2019, Brussels

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Katja Witte and Marvin Ewert, Wuppertal Institute

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Agenda

Policy Day:

Transition to fossil-free industries: technology pathways and policies

18 March 2019

Location: EC, CDMA building, DG RTD, Rue du Champ de Mars 21 / Marsveldstraat 21 1050 Brussels

Technology pathways and roadmaps towards decarbonisation are emerging in the energy intensive industry sectors such as steel, plastics, and others. The role of electrification of hydrogen, circular and biogenic carbon utilisation, CCUS and new interdependencies between sectors are salient features of such pathways and for re-industrialising Europe as well as core elements of the future EU Long Term Strategy for a climate neutral economy. The event takes stock of the current understanding of future options and strategies and based on this explores the implications for future policy-making, research and society at large. The event brings together an EU-funded project and national as well as regional initiatives related to the decarbonisation of energy intensive industry sectors

AGENDA

09:15 – 10:00	Registration and Coffee
10:00 – 10:45	Industrial policy and the EU Long Term Strategy
	Chair/moderator: Peter Handley, Head of Resource Efficiency Unit, DG Grow
	Welcome and opening speech: Franz Immler, Head of Sector Climate Action, EASME
	Setting the scene: Deep decarbonisation of industries in the EU. Prof. Dr. Stefan Lechtenböhmer, Director Future Energy and Industry Systems, Wuppertal Institute
	REINVENT: Realizing innovations in transitions for decarbonising industry. Prof. Dr. Lars J. Nilsson, Lund University, project coordinator REINVENT
	IN4climate.NRW: Initiative for a climate neutral basic industry. Dr. Michael Walther, Project Manager, IN4climate.NRW

Round table panel discussion: Dr. Brigitta Huckestein, BASF; Pierre Dechamps/Anastasios Kentarchos, DG RTD; Imke Lübbecke, WWF European Policy Office; Àngels Orduña, A.SPIRE office

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Event co-hosted by EASME, DG RTD, the initiative

10:45 – 12:15 SESSION 1: Electrification and hydrogen

The session on electrification of heavy industries in Europe provides an overview on and discussion of possible electrification pathways mainly for the sectors of steel making, plastics and others. It shall be discussed which sector could establish when and where in Europe an electrified production and what that means for electricity supply as well as cross-sectoral synergies.

Chair/moderator and opening: Prof. Dr. Stefan Lechtenböhmer, Director Future Energy and Industry Systems, Wuppertal Institute

Brief presentations:

Strategies from the perspective of the EC: Domenico Rossetti di Valdalbero, Deputy Head of Unit Coal and Steel of the Directorate 'Industrial Technologies', DG RTD

Electrification pathways REINVENT and HYBRIT – lessons learnt: Dr. Marlene Arens, Postdoctoral fellow at Environmental and Energy Systems Studies, Lund University

Swedish strategies in dealing with electrification and hydrogen: Klara Helstad, Head Sustainable Industry Unit, Swedish Energy Agency

Speaker from energy and steel industry on their H_2 strategies for non-fossil steelmaking: Dr. Hans-Jörn Weddige, Group Coordinator Energy, Climate and Environment Policies, thyssenkrupp AG

Renewable Energy for Industry, Cédric Philibert, Senior Analyst in the Renewable Energy Division, International Energy Agency

Round table panel discussion: Domenico Rossetti di Valdalbero, DG RTD; Dr. Marlene Arens, Lund University; Klara Helstad, Swedish Energy Agency; Dr. Hans-Jörn Weddige, thyssenkrupp AG; Cédric Philibert/Andreas Schröder, International Energy Agency; Eric Lecomte, DG Ener; Jesper Kansbod, HYBRIT

12:15 – 13:15 Lunch

13:15 – 14:45 SESSION 2: Circular economy

Within the framework of the session on circular economy, possible future pathways of a comprehensive transformation towards a circular economy will be discussed on the basis of selected scenarios and strategies from energy intensive industries. The challenges and questions for the design of different branches of industry as well as their necessary innovation processes associated with this are the starting point for the session.

Chair/moderator and opening: Dr. Henning Wilts, Director of the Division Circular Economy, Wuppertal Institute

Brief presentations:

Turning waste from steel industry into valuable feedstock for energy intensive industry: Massimo De Pieri, RESLAG project

Outcomes of research on decarbonisation strategy for energy intensive industries, based on the "Clean Planet for all" mid-century strategy: Georgios Zazias, INNOPATHS project

Insights of the different technological paths for Clean Steel: Gerald Stubbe, representative of LOWCARBONFUTURE from Research Fund for Coal and Steel Programme

Speaker from chemical industry on lessons learnt from their specific interventions: Dr. Christoph Sievering, Head of Global Positioning & Advocacy: Energy, Climate, Circular Economy, Covestro

Incorporating dynamically and flexibly designed buildings into a circular economy: Caroline Henrotay, BAMB project

Round table panel discussion: Massimo De Pieri, RESLAG project; Georgios Zazias, INNOPATHS project; Gerald Stubbe, LOWCARBONFUTURE; Dr. Christoph Sievering, Covestro; Caroline Henrotay, BAMB project; Peter Handley, DG Grow; Rob van der Meer, Heidelberg Cement; Domenico Rossetti di Valdalbero, DG RTD

14:45 – 15:15 Coffee break

15:15 – 16:45 Session 3: Biogenic carbon economy, carbon utilisation and new interdependencies between sectors

The main question of the session is how the pulp and paper industry and others as a whole can contribute to the decarbonisation of other sectors. Scenarios in which biogenic carbon is separated and used as feedstock (CCU) imply a high demand for hydrogen, completely new value chains and closed carbon cycles.

Chair/moderator and opening: Franz Immler, Head of Sector Climate Action, EASME together with Prof. Dr. Lars J. Nilsson, Head of the Department of Technology and Society in the Faculty of Engineering, Lund University

Brief presentations:

REINVENT project: identified pathways in the field of fuel change and energy efficiency, biorefineries and Bio-CCU: Fredric Bauer, Postdoctoral Fellow, Lund University

A future closed loop biogenic carbon economy with CCU and hydrogen: Jorgo Chatzimarkakis, Secretary General Hydrogen Europe

CCU: CO_2 Plus - Broadening the raw material base through the Utilisation of CO_2: Dr. Barbara Olfe-Kräutlein, Senior Research Associate/Scientific Project Lead Societal Aspects of CO_2 Utilization, IASS Potsdam

CCU in the context of a long-term GHG emission reduction strategy: Florie Gonsolin, Manager Energy & Climate, CEFIC

Round table panel discussion: Fredric Bauer, Lund University; Jorgo Chatzimarkakis, Hydrogen Europe; Dr. Barbara Olfe-Kräutlein, IASS Potsdam; Florie Gonsolin, CEFIC; Dr. Martin Porter, Cambridge Institute for Sustainability Leadership; Cédric Philibert/Andreas Schröder, International Energy Agency

16:45 – 17:00 CLOSURE / Wrap up

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Event co-hosted by EASME, DG RTD, the initiative

List of Participants

Last Name	First Name	Institution
Achampong	Leia	WWF
Andreas	Justus	Bellona Europe
Aniballe	Maria Rita	UCR Regione Campania
Arens	Marlene	Lund University
Bauer	Fredric	Lund University
Belin	Flore	GRTgaz
Boyer	Alexandre	Rud Pedersen
Chatzimarkakis	Jorgo	Hydrogen Europe
Cholakova	Daniela	Aurubis AG
D’Angelo	Daniele	Engie
Dechamps	Pierre	DG RTD
De Meerleer	Anja	Government Belgium
Denis	Ronny	Toyota Europe
Denizart	Elodie	Region Hauts-de-France Brussels Office
De Pieri	Massimo	RESLAG Project - LCE
Difonzo	Tommaso	Enel
Düssler	Frank	Georgsmarienhütte Holding GmbH
Eche	Caroline	France Industry
Gabrielaitiene	Irena	EASME
Garthaus	Sandra	IN4Climate.NRW
Glasner	Christoph	Fraunhofer Umsicht
Gonsolin	Florie	CEFIC
Handley	Peter	DG Growth
Helstad	Klara	Swedish Energy Agency
Henrotay	Caroline	BAMP Project
Hinterlang	Jan	VCI
Huckestein	Brigitta	BASF SE
Immler	Franz	EASME
Jularic	Mirko	Rep. NRW EU
Jungk	Gunnar	Thyssenkrupp Steel Europe AG
Kansbod	Jesper	Hybrit Development AB
Kentarchos	Anastasios	DG RTD
Khayat	Samir	IN4Climate.NRW
Klevnas	Per	IT 50
Klos	Benjamin	German Steel Association
Kunnas	Sanni	VCI
Laguillo	Andrea	Gobierno de Cantabria
Lechtenböhmer	Stefan	Wuppertal Institut
Lecomte	Eric	DG Ener
Lenkeit	Kirsten	Open Grid Europe GmbH
Liaigre	Angéle	Pays de la Loire Europe
Lübbecke	Imke	WWF European Policy Office
Malfroid	Cedric	Skynet
Mock	Thomas	Hydro Aluminium Rolled Products
Molterer	Alexander	Dow Chemicals

Müller	Torsten	Fraunhofer Umsicht
Nilsson	Lars	Lund University
Olfe-Kräutlein	Barbara	IASS
Orduna Cao	Àngeles	A.Spire
Paat	Andus	Tallin Universtiy
Philibert	Cédric	IEA
Pico	Jacinto	Naturgy
Porter	Martin	Cambridge Institute
Purvis	Andrew	Worldsteel
Rademaaekers	Koen	Trinomics
Rato	Filomenta	UCR Regione Campania
Rossetti di Valdalbero	Domenico	DG RTD – EU Commission
Ruhbaum	Charlotte	Stiftung Mercator
Santoro	Anna	JRC
Schleier	Julia	RWTH Aachen
Schobbens	Quentin	Climact
Schröder	Andreas	IEA
Singla	Siddarth	Indian Advocat
Stubbe	Gerald	BFI
Taylor	Peter	University of Leeds
Uftring	Felix	Open Grid Europe GmbH
Van der Meer	Rob	HeidelbergCement
Van Iterson	Rannveigh	ECF
Van Sluisfeld	Mariesse	PBL
Vivarelli	Silvia	EASME
Walther	Michael	IN4Climate.NRW
Warren	Luke	CCSA
Weddige	Hans-Jörn	Thysssenkrupp AG
Wich	Teresa	Thyssenkrupp AG
Wilts	Henning	Wuppertal Institut
Witte	Katja	Wuppertal Institut
Wójcik	Ewelina	Association Pro Silesia
Zazias	Georgios	E3 Modelling IKE
Zimmermann	Patrick	WWF

Summary

Innovative technology pathways and decarbonisation roadmaps for energy-intensive industries are key elements of a future long-term EU strategy for a climate-neutral economy and for the reindustrialisation of Europe. During the workshop entitled “Transition to fossil-free industries: technology paths and policies” on 18 March 2018 in Brussels, 79 representatives from different industries, national and EU policy institutions, scientific and environmental organisations discussed the decarbonisation potential of different sectors and the opportunities that can arise from cross-sectoral interactions. The event brought together EU-funded projects and national and regional initiatives related to decarbonisation of energy-intensive industrial sectors. In three sessions, insights and findings on electrification and hydrogen, circular economy and biogenic carbon economy and carbon utilisation were presented and intensively discussed.

Participants agreed that decarbonisation pathways are urgently needed at EU and international level, for which a common climate and industrial policy in Europe is required. Technically, the role of hydrogen and circular economy and the associated technologies, infrastructure investments and value chains were highlighted. It was widely shared that the focus for implementing these is on establishing further cross-industry solutions, overcoming traditional industry boundaries.

The workshop was co-organised by the EU-funded project REINVENT (Realising Innovation in Transitions for Decarbonisation) with EASME and the initiative IN4climate.NRW. A poster exhibition on the first results of the REINVENT project was also held in the foyer of the venue.

Opening Session on Industrial policy and the EU Long Term Strategy

Franz Immler, Head of Sector Climate Action, EASME

Franz Immer welcomes all participants and thanks the auditorium for their interest and participation. Special thanks go to the organizers, the speakers and the panel participants from various fields such as business, associations, initiatives and science. The aim of the event is to inform and discuss the design of future strategies and policies for the implementation of a fossil-free industry. In this context he mentions the publication of the EC called "A Clean Planet for all[1]", which aims at a European strategic long-term vision for a prosperous, modern, competitive and climate-neutral economy by 2050. The publication provides a contribution and framework for the discussion of the workshop. He also reports on the possibility of generating ideas during the workshop that could be included in the EU's 2020 work programme, which forsters scientific support to design mitigation pathways with special regards to industrial innovation.

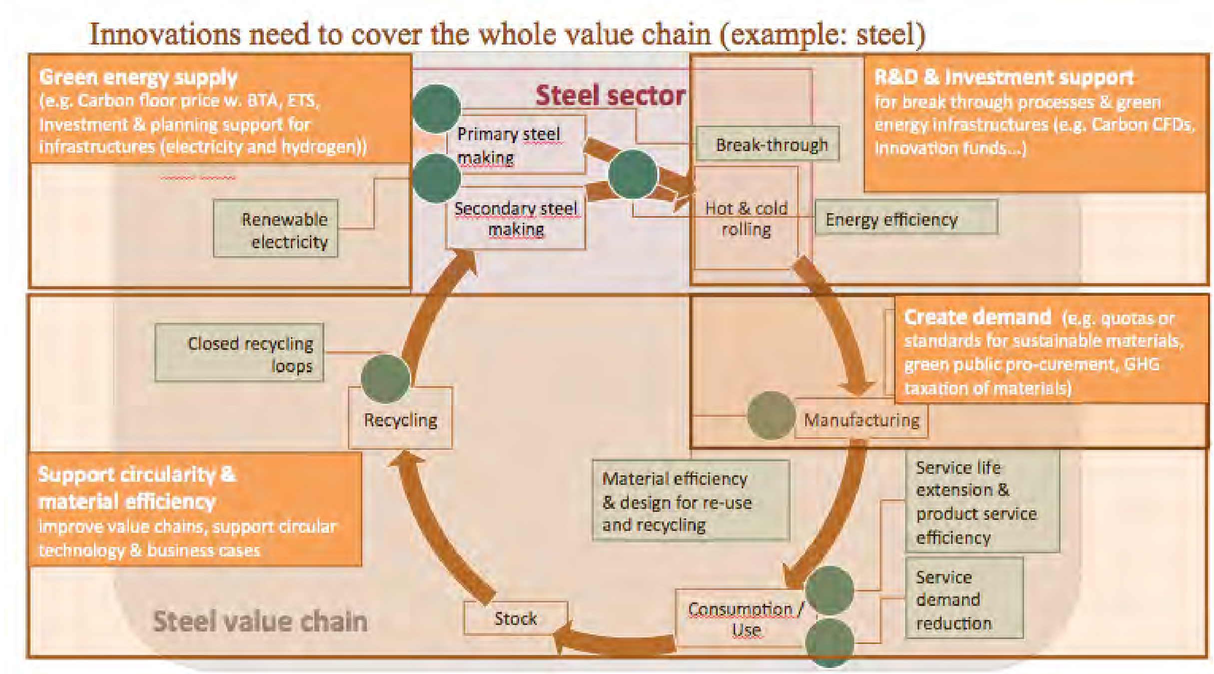
Stefan Lechtenböhmer, Director Future Energy and Industry Systems, Wuppertal Institute

Stefan Lechtenböhmer thanks the EC and the in4climate initiative for conducting the workshop. He sets the thematic framework for the workshop by explaining the enormous contribution of the energy-intensive industry to greenhouse gas emissions. The following five basic materials (steel, cement, plastics, paper, aluminium) are responsible for 20% of global greenhouse gas emissions and are still rising, but he explained that a non-fossil basic industry is possible.

There are essentially three strategies for a deep decarbonisation of the processes for the production of these materials: direct and indirect (hydrogen) electrification, CCU/S and biomass and circularity. The implementation of these strategies requires a number of prerequisites; breakthrough technologies are needed, they need to be developed and invested at high risk. In addition, infrastructures for large quantities of renewable energy or CCS and circular economies must be in place, and last but not least, these changes in industries can significantly change cost structures, leading to some material substitution. On the government side, there is a need for increased risk-taking in the implementation of these strategies and for an active industrial policy with a clear focus on the role and function of the regions.

Stefan Lechtenböhmer presented three strategies and scenarios to avoid greenhouse gas emissions for steel, cement and chemistry production: circularity and reduced (primary) demand, break-through technologies which are linked to RES electricity and biomass and also the use of CCS/CCU. The innovations necessary to implement the strategies must be developed and implemented along the entire value chain, as illustrated here by the example of the steel sector (slide 4).

[1] https://ec.europa.eu/clima/sites/clima/files/docs/pages/com_2018_733_en.pdf



This systemic approach must be promoted much more intensively in the future. Industrial change requires an integrated climate and industrial policy that is geared towards sustainability and deep decarbonisation as a long-term core objective. An industrial policy must integrate climate, energy, innovation and resource efficiency policies with trade, growth and structural policies that encompass all stages of the value chain and all societal stakeholders.

Lars J. Nilsson, project coordinator REINVENT, Lund University

In his role as project coordinator of REINVENT "Realising Innovation in Transitions for Decarbonisation", Lars J. Nillson thanks all participants of the EC who made this workshop possible and organised it. He gives a short introduction to the contents of the REINVENT project, a EC funded HORIZON2020 project with a duration of three years (Nov. 2016 to Oct. 2020).

In order to design possible decarbonisation paths, policy strategies and legal framework conditions that are organised top-down are often evaluated. Within REINVENT, a perspective along the value chain is pursued, starting with the extraction of raw materials through to the end product and its recycling strategy. Ways of decarbonisation are developed, which consider different innovations, ranging from less consumption to electrification. REINVENT focuses on four sectors "steel", "plastics", "pulp & paper" and "meat & dairy", which are very different in terms of their structure (consumption, possible uses, life cycles and recycling rate).

Use of some materials in EU

- PLASTICS
  - Around 100 kg per person
  - Packaging, buildings, cars, electronics
  - Low recycling
- PAPER
  - Around 150 kg per person
  - Packaging, printing paper, hygiene
  - High recycling
- STEEL
  - Over 300 kg per person
  - Construction, cars, machinery
  - Around 12 ton per person in stock
  - Very high recycling

The internal logic of the sectors but also cross-sectoral synergies are considered and researched in order to understand the conditions of change. Here, the topics of today's workshop will be taken up in order to think outside the boxes of the sectors, topics such as electrification and hydrogen, circular economy and biogenic carbon economy are of particular relevance. In addition, we need to think about the needs for governments and institutional capacities; in the case of plastic, for example, there are currently no established responsibilities and structures, and this fact also needs to be further explored within the framework of the project and the workshop.

Michael Walther, project manager IN4climate.NRW

Michael Walther presents the IN4Climate.NRW initiative, founded and financed by the North Rhine-Westphalian Ministry of Economic Affairs.The initiative brings together industry, science and politics to work on the transition towards a low carbon economy. North Rhine-Westphalia is an industry-intensive state. 50% of all energy-intensive sectors in Germany and 10% of all energy-intensive sectors in Europe are located in NRW. The State Government has committed itself to the Paris Agreement, and the initiative is an important step towards contributing to the Agreement. IN4Climate.NRW is a knowledge, working and communication platform. This platform builds innovation teams from science and industry with the aim of identifying relevant low-carbon breakthrough technologies, developing further technologies as well as creating prototypes and upscales and transferring them into further business cases. These innovation teams generate knowledge and ideas for concrete projects, ensure the necessary federal and EU R&D funding with European partners and work on corporate and political strategies. The initiative also develops forward-looking narratives for the basic industries. Networking takes place within and outside NRW with the help of innovative forms of communication. The initiative illustrates North Rhine-Westphalia's exemplary role and at the same time secures the state's position as an important business location.

Summary of the round table panel discussion

Moderator: Peter Handley, Head of Resource Efficiency Unit, DG Grow

Combining competitiveness and climate protection

The Commission's Strategy Vision 2050 published November 2018 makes it very clear that the competitiveness of industry is just as important as taking account of the climate, because by 2050 we must all focus the key sectors of the economy on this climate-neutral and circular form of economy. 2050 is 31 years away and these heavy industries are like tomorrow, because there is only one investment cycle ahead. Time is short and a lot of hard work will have to be done by 2030. Many of these breakthrough technologies need to be tested and piloted and be ready or integrated for use in all sectors. The overall approach from sector to sector is very one-dimensional, we need to do much more to look at the integrated value chain that starts with raw materials and ends with recovery and the end of the use cycle, or starts anew.

Industrial policy is returning to the discourse of the political level

Another aspect is that industrial policy is returning to the discourse of the political level. The European Council will meet at the end of March 2019, and only a few days ago the Commission and the political centre published a paper called Industrial Policy. The Commission is working with a high-level group on the process of energy-intensive industries to develop a master plan for industrial transformation. This will take place by September/October 2019 in a process that brings together all energy-intensive sectors. At least 17 Member States (all Member States are invited) will join the process. It brings trade unions and organised civil society together and integrates the expertise of people who have worked on such issues.

How to integrate the society?

The message of the UNEP is clear. The Commission has made it clearer than ever that achieving the 1.5 degree target is necessary to tackle climate change. Never before has this been so clearly formulated by a European institution. This message from the Commission also shows that climate change is central to our economy and therefore benefits the security of our resource base, our democracy and our way of life. Ned Zero is possible and it is possible to generate important key benefits for people and urban dwellers. But not many will read this report, good communication is needed. People need a translation of what net-zero means in concrete terms for them in everyday life. Acceptance issues must not be underestimated and it must be made clear that this requires enormous efforts at different levels.

Industry has committed itself

The question is not only whether Ned zero can do it, but also what rebound effects can result from it. A balance of different levels has to be seen. 31 years is only one investment period for industries. There is an urgent need for action, now. The good news is that industry has also committed itself.

Role and advantages of Europe

Europe needs a competitive advantage. The main competitors (from China/USA) have much and cheap energy. An advantage for Europe is the common economic market. Innovation in the chemical industry must ensure that it plays a leading role in certain developments in the circular economy. More and more waste must be used as material and a global recycling centre must be created in Europe. This means huge investments and capital-intensive assets at the beginning. Investment leakage must nevertheless be avoided. Many more investments and incentives need to be made. Consideration needs to be given to why global companies should invest in Europe and not elsewhere.

The gap between suppliers and customers

Suppliers must be able to deliver materials that are more sustainable and competitive, so that customers are more willing to accept them. This is also difficult because the customers of the cement industry for example are not the same as the end consumers. Customers need to know that the end consumer trend is towards more sustainable products, more proximity to the product. Success will come when the industry is able to position itself on the market with innovative products in an economically meaningful way. Politics have a strong role to play here and 2019 the industry has the opportunity to receive support for low-carbon products. There is a need for a high level of political commitment in the form of a strategic agenda. Industry and climate has to marry. A guiding principle for policy is needed to overcome these blockages and competitiveness issues and create markets. There has been good experience with the Ecodesign Directive, which sets some efficiency requirements for equipment. Similar aspects need to be discussed around material efficiency in order to make progress in creating an EU market for waste. Waste must be recognised as a commodity and given value. Investments in low-carbon markets need to be increased to make capital cheaper and tax incentives for these investments examined. A review of whether investments are compatible with a net zero vision is necessary before approvals are granted. For this, there is only one attempt to take the right path. Future investments in infrastructure (e.g. gas and hydrogen) are currently being discussed. A new infrastructure investment is needed and a way to manage it.

Sustainable finance

There is a need to raise awareness that investment decisions on climate change must be taken into account, as climate change is ultimately not only an environmental but also an economic factor. Some effects of climate change on the agricultural sector are already visible, the effects are likely to be felt in other energy-intensive sectors as well, and the risks of operations are becoming increasingly visible. It is regrettable that the debate on sustainable finance is often dominated by the shorter term legislative issues. It is certainly a very important aspect of the discussion how to provide funding for new infrastructure and capital costs and how smart financial instruments can minimise part of the risk of investment.

Minimizing investment risks is the magic word for the industry. The industry expects the public sector to help it reduce the risk of investment. Some of the necessary low-carbon technologies are not yet developed, others are there, but need to be scaled-up, or they need to show their economic feasibility, and for that they need the greatest possible scale, which needs to be demonstrated. This requires huge and long-term investment. These are the research and innovation programmes that need to be developed by the EU. Industry is ready if the EU helps to reduce the risk of big demonstrators and large investments.

Public procurement should also be mentioned in this context, which in many respects can ensure that these investments get off the ground.

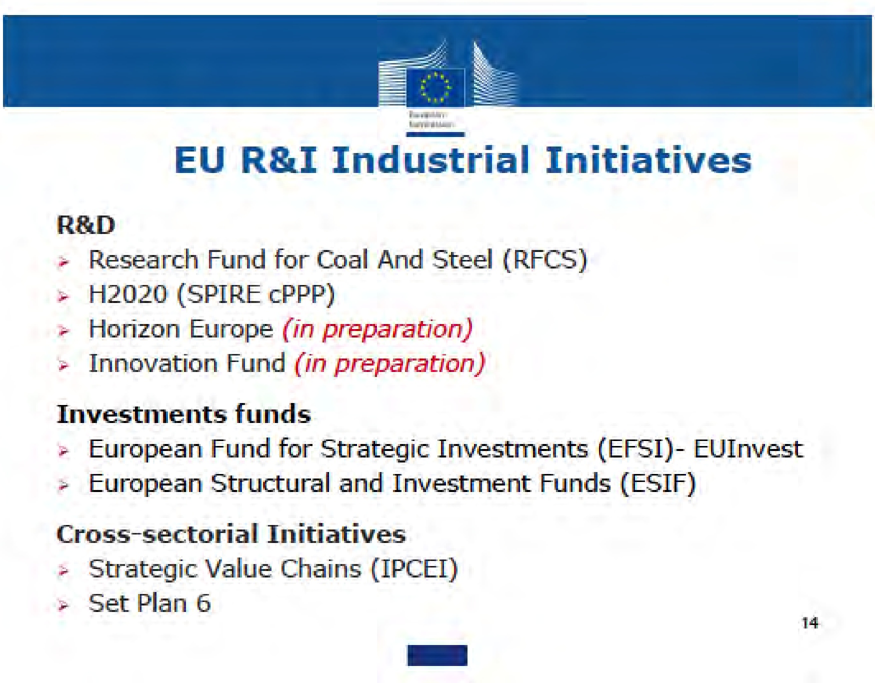
Session 1: Electrification and hydrogen

Domenico Rossetti di Valdabero, DG RTD

Title: “Towards European carbon-neutral industries”

Industry has a declining share of GDP and this development should be kept in mind. Among other things, industry ensures job stability and the sustainability and competitiveness of the entire global economy. The communication of the EC “A clean planet for all” comprises 25 pages (short version) and 393 pages (long version). The EU is leading the way in shifting to clean energy and reducing greenhouse gas emissions. It has most of the legislative instruments at its disposal, but current policies will only reduce CO_2 emissions by 60% by 2050. This is not enough and is not in line with the Paris Agreement. The EU strategy for 2050 aims at Net-zero GHG emissions and this seems feasible but very ambitious. And everyone is personally urged to integrate this goal into everyday life and rethink our lifestyle.

The share of renewable energies is one of the key factors in achieving the targets of the EU Strategy 2050. There are different scenarios; in the most ambitious scenario, the share of renewable primary energy is over 60%. Clean power generation should definitely be seen as a course-setter. For example, the EU has developed the following instruments to support further breakthrough-technologies on the way to gridzero:



Domenico Rossetti di Valdabero concludes with two personal remarks on industry and sustainable lifestyles. Using the example of the development of automobiles, he illustrates that cars have had a fourfold increase in weight since the 1960s until today. And these figures refer to innovative drive technologies such as electric cars. This issue needs to be addressed urgently. After all, decarbonization also means more electricity, e.g. for electric cars. By 2050, power generation will have increased from 35% today to 150% by comparison, i.e. there is a demand of about one million

5MW wind turbines, for example. That is not marginal, that is enormous and this task must be solved.

Marlene Arens, Lund University

Title: “Electrification pathways REINVENT and HYBRIT – lessons learnt”

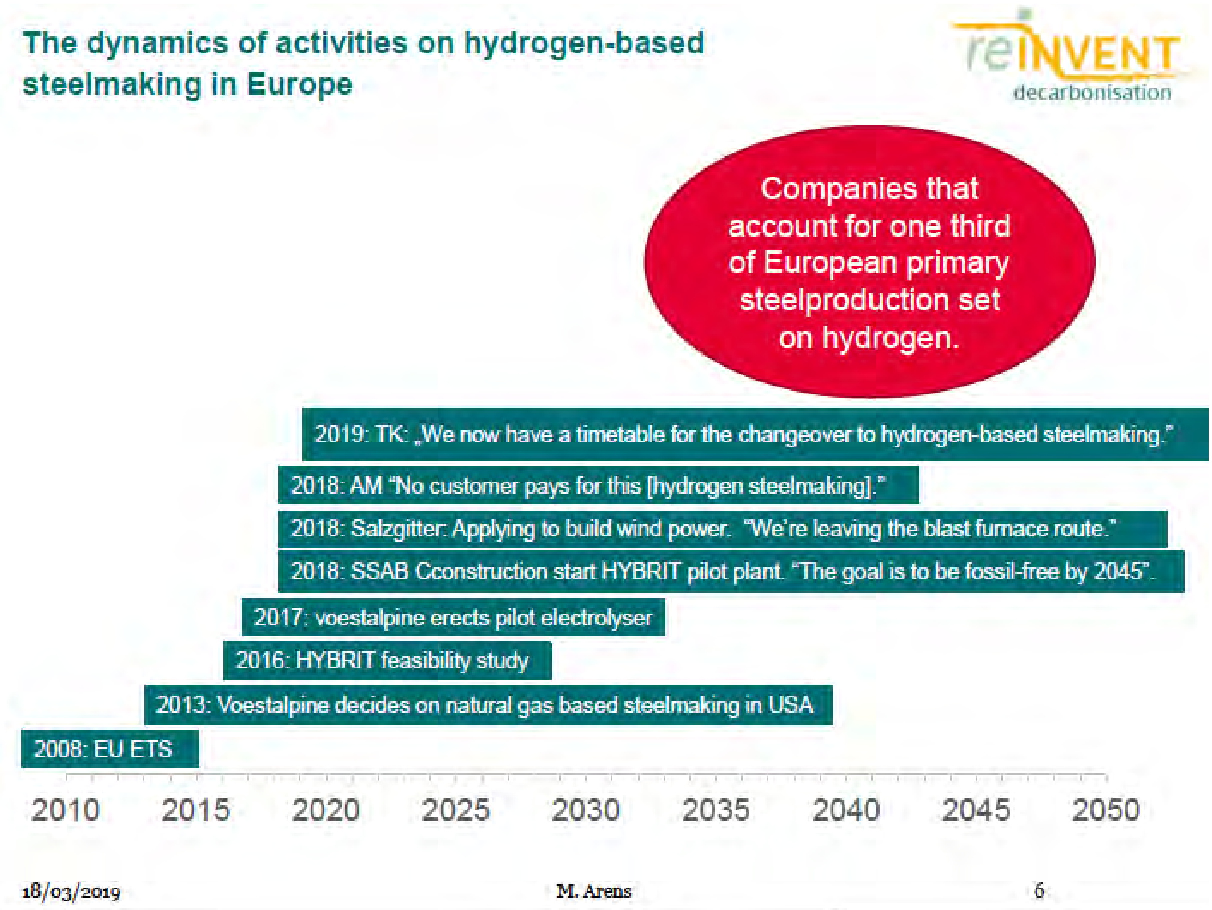
Worldwide, 1,687 million tons of steel are produced annually, with 72% of production using coal. Technically there is also the possibility to use natural gas in the production of steel. This is mainly used in countries with abundant natural gas and it is unclear whether this is an important option for Europe. This process emits less CO_2, but only 4% of the steel is produced with natural gas. Both technology paths are proven and commercially available. A third way leads to the recycling economy, it is the recycling way that has the least environmental impact. This depends on the availability of scrap. This process route is low carbon, only electricity and scrap are needed to produce steel.

In the future, two new ways of producing steel could develop. On the one hand, the use of CCS will have to be discussed, and on the other hand, electricity-based steel production. Steel production based on CCS and electricity would require more research and development activities.

What would this mean for the energy system if we shifted European primary steel production to low carbon steel production? Currently, the steel industry in Europe emits about 5% of CO_2 emissions and accounts for more than 30% of coal consumption. Shifting this energy consumption to either natural gas or electricity would bring about changes. For example, the reduction of CO_2 emissions from the current 5% to almost zero could be achieved through electricity-based production processes that would require hydrogen, for example. But recycling would also save CO_2 emissions if enough scrap was available. Shifting steel production to electricity-based production would, however, result in significantly higher electricity consumption. This share could rise to around 12% of current electricity consumption in Europe.

There are four technological processes for electricity-based steel production. Direct reduction itself does not require electricity, but electricity is needed to produce the hydrogen needed for direct reduction. HYBRIT is a core project from Sweden and also the AG Salzgitter from Germany carries out research activities in this area. There are two other processes that could use electricity, namely plasma steel production and the electrolysis of iron ore. There is a project in Voestalpine in Austria for research into plasma steel production. ThyssenKrupp has announced that it will deal in future with hydrogen-based stable production, both direct reduction and plasma steelmaking.

The electrolysis of iron ore does not require hydrogen. Arcelar Mittal is currently actively working on electrolysis. There could be pilot plants for plasma steel production and electrolysis by 2030. The following chart shows what has happened in the steel industry in recent years:



There are currently many pilot plans and R&D programs and in the steel industry there are many announcements for activities, but at the moment not a ton of commercial steel is produced with hydrogen.

Current developments seem to be driven by climate policy, e.g. through the EU ETS, national legislation or R&D funding (such as innovation funds). Nevertheless, there are some hurdles that need to be considered for the further development of a low carbon steel industry. Social acceptance needs to be taken into account and a systemic approach along the value chain will need to be promoted. Last but not least, the cost issue seems to be unresolved so far, so market making is a point to start from.

Klara Helstad, Swedish Enetgy Agency

Title: "Swedish strategies in dealing with electrification and hydrogen"

The mission of the Swedish Energy Agency is to promote a sustainable energy system that combines environmental sustainability, competitiveness and security of supply. Sweden's climate and energy targets are quite ambitious. Sweden is aiming for 100% renewable electricity production by 2040. Sweden wants no net greenhouse gas emissions by 2045 and 50% more efficient energy use in 2030 compared to 2005. Sweden now has virtually fossil-free electricity and heat production and low per capita CO_2 emissions. In Sweden, despite an energy-intensive industry, energy use per value has decreased.

Many sections of Swedish society are motivated to achieve a fossil-free society. And apart from a few exceptions, companies are also going ahead. The Swedish Energy Agency is doing its best to work together on these issues. It is necessary that the distribution of risks is an important issue in which the state should play a role. Sweden has therefore taken a special initiative called "Fossil Free Sweden". The initiative has encouraged companies to create their own roadmaps on how to become fossil fuel free while increasing their competitiveness. The roadmaps have been very useful in understanding demand and the technologies necessary for progress. Swedish industry accounts for a third of Sweden's greenhouse gas emissions. Every year a new report is published describing the precautionary measures and the different technologies that could be used to reduce emissions. Sweden must find several necessary solutions as it moves forward. Electrification is one of the most important components of the solutions, but biomass and bioenergy are also needed, hydrogen and CCS/BECCS, energy efficiency and also policy issues and markets such as public procurement. It is often necessary to consider many different production processes and within the processes at least three or four alternatives are needed. In Sweden we have an annual budget of around 160 million Euros for energy research and innovation. Nevertheless, it is difficult to finance expensive pilot and demonstration plants with this amount. Therefore, in 2018, the government opened up a new opportunity to finance this transformation, the "Industrial Leap":

New possibility to financing the transition: The "Industrial Leap" – Industriklivet

- Swedish Government through Swedish Energy Agency invest 30 million € each year between 2018-2040
- Shall support huge and complex technology leap to significantly reduce process related emissions in Swedish industry.
- The state shares the risk
- Support can be given to feasibility studies, research, pilot and demonstration projects and full scale investments.
- Report status analysis every year

Energimyndigheten

Three examples of electrification and hydrogen in Sweden are HYBRIT, Cem Zero and Preem. HYBRIT is aiming to replace coking coal, traditionally needed for ore-based steelmaking with hydrogen. This project tests the world's first free steelmaking technology with virtually no carbon footprint. Emission will become water. The objective of CemZero is electrified cement production supplied with electricity from a fossil-free Swedish energy system. Preem and Vattenfall plan a hydrogen gas plant in Gothenburg. The planned plant will contribute to reducing CO_2 emissions by 25.000 tonnes per year from the process, and emissions in the transport sector are expected to fall by around 230.000 tonnes per year when biofuels replace diesel and petrol.

The Swedish Energy Agency has co-financed these projects and hopes for promising results. Some conclusions; it is obvious that partnerships are very important parts of the transition because new alliances may be necessary with other partners and other types of companies. Innovation and entrepreneurship are, of course, also important when it comes to new steps without a comfort zone.

Last but not least, a stronger consensus is needed on what we want to achieve and, of course, risk sharing is important. Even though the risks will be high, the Swedish Energy Agency see many opportunities for transition.

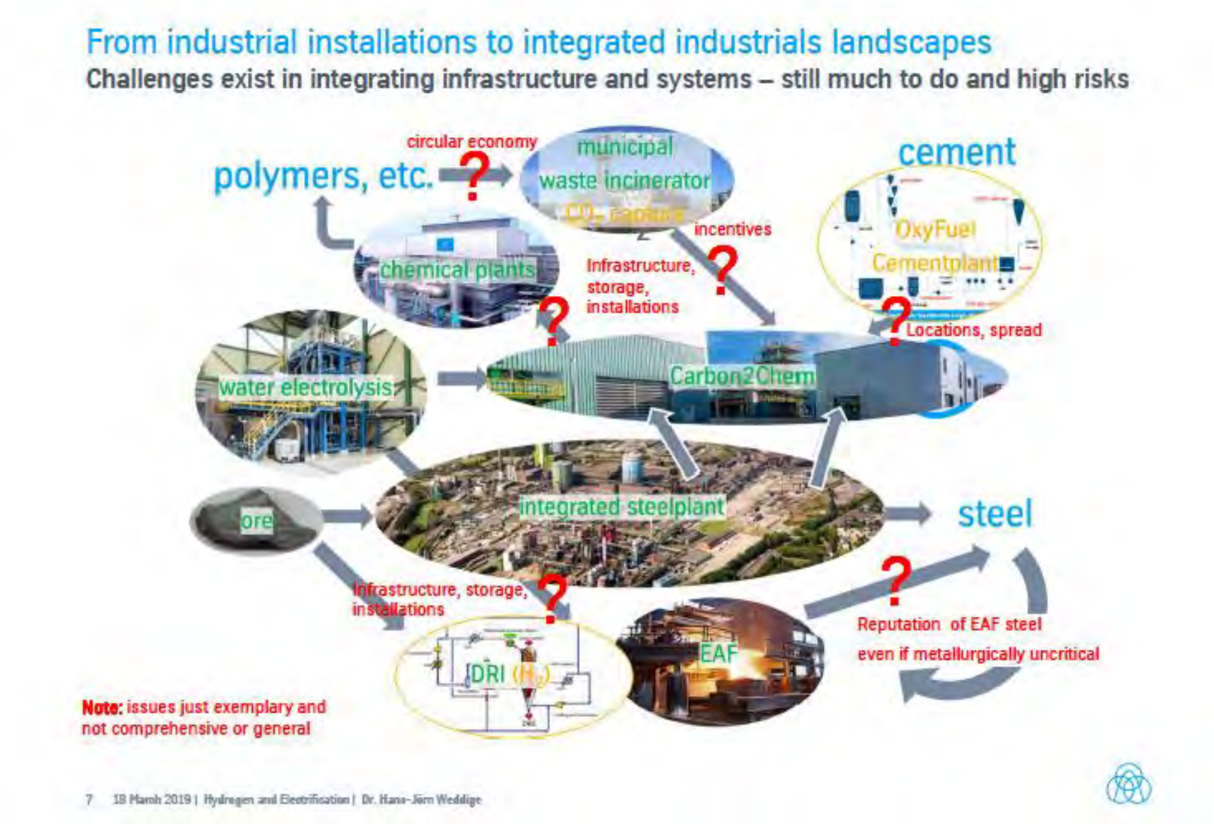
Hans-Jörg Weddige, thyssenkrupp AG

Title: “Strategies for non-fossil steelmaking”

The presentation focuses on the scientific aspects of electrification and hydrogen and not on thyssenkrupp's company policy. Based on the presentation of the basic formula of steel production, it will be discussed how large quantities of carbon monoxide and carbon dioxide produced during the process can be avoided in the future. One solution is the use of green hydrogen. The use of classically produced hydrogen would not be very climate-friendly. The open question is the procurement of the required quantities of green hydrogen. There is a theoretical minimum of hydrogen which corresponds to 4.5 million tons. This requires an energy requirement of about 200 TWh per year. In addition, the production of green hydrogen requires renewable energies that are subject to strong fluctuations. How do we create an energy production that is able to optimize the strong fluctuations of renewable energies in such a way that flexible steel production is possible? Here an overall systemic perspective is important. It must also be borne in mind that electric arc furnaces require a great deal of electricity. Hydrogen is also subject to a changed demand pattern, which will further destabilize the energy grids. This means, for example when looking at electrolysis, that not only the hydrogen producers have to be considered, but also the factor of grid stabilisation is important. It is really important to see the whole system as a concept and to think about it from the end.

The interaction of the different strategies and metrics for steel, cement and polymers must be further researched and harnessed, i.e. the fundamental laws of physics and chemistry must be considered. Circular Economy will be an important aspect of the discussion. From a scientific point of view, these aspects can be answered relatively easily, but what about concrete industrial applicability? How do these approaches get into the plants?

The classical integrated steelworks is in operation. If we opt for the hydro-metallurgical route, we know clearly that the DRI (directly reduced iron, H2) and EAF (electric arc furnace) work with natural gas. The switch to hydrogen will not be so much the problem. Water electrolysis also works and is already able to flexibly follow the renewable curve. Carbon2Chem as a pilot project, which has been running in Germany since 2018, is also being tested as a path and there are some CCU projects. A lot of experience is already being gained here and there are more good ideas. Considerations are currently being made as to how funding opportunities for first demonstration plants could look together with the European cement industry. The individual technical building blocks for the production of green steel are in place. The question of why there is no net THG neutrality remains open. The problem is how to link these blocks in a meaningful way.



Infrastructure and system integration pose a major hurdle here. Another problem is certainly the great need for renewable energies. At the moment Europe is still very dependent on coal and oil from all over the world. There are major problems for Europe here. Do we want to and can we produce the necessary quantities in Europe? There are much better locations for the production of renewable raw materials, intermediate products and end products. Europe must not only be in the world, it must also be *with* the world. Energy self-sufficiency is not only physically difficult, but also geopolitically dangerous. The world's major political issues, including conflicts, must be taken into account in these considerations. The EU should have a future as a production location, as should EU technologies that are presented and applied worldwide.

Cédric Philibert, International Energy Agency

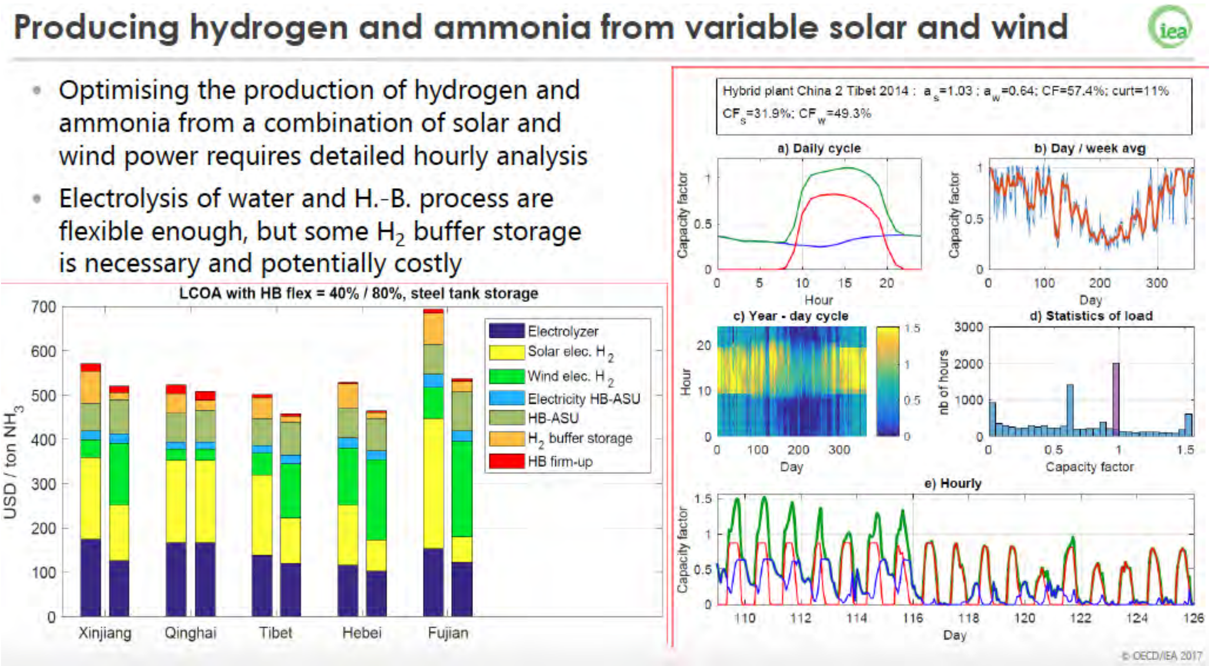
Title: “Renewable energy for industry”

The IEA started its work on renewable energies for industry (https://bit.ly/2QaNIcv) years ago. In the IEA scenarios, we show how to decarbonize a large sector. The cement, chemical, iron and steel sectors, but also transport sectors such as aviation, road transport and shipping pose major challenges for climate change and air quality. Looking at the industrial sectors, there is a mix of energy-related emissions and process emissions, which is particularly challenging. The emergence of low-cost, renewable electricity is a turning point. There have been very rapid cost reductions in recent years, as shown here by the example of wind and solar, through average auction prices according to commission data.

According to hybrid solar and wind full load hours, there are many regions globally that have significantly better resources for generating renewable energy than Europe, e.g. Korea, Japan, Australia, China and the USA. The capacity factors of combined wind and solar energy exceed 50% in vast areas, often far away from major consumption centres, and potentially delivering huge amounts of electricity at less than $30/MWh. Direct electrification can take various forms in industry. There are a number of new technologies that are very effective, e.g. electromagnetic technologies for heating, hardening, melting. In most modelling exercises these are not well considered so far. For a considerable number of cases in the industry there are head pumps and mechanical vapour recompression, which are very effective, and in transition cheap resistors can also be used in boilers or ovens, which benefit from cheaper "excess" energy when available. Electrical technologies can prove cost-effective if they are twice as efficient, closing the cost gap through the direct use of fossil fuels and helping to integrate more renewable energies. Renewable energies can replace fossil fuels in many cases. Electrification takes place in buildings (heating, cooking and lighting), transport (electric vehicles) and industry (steam, power and electrolysis). But there are a number of cases where electrification does not work, hydrogen can be used. After production, it can be converted into other molecules, e.g. ammonia. In this way it can be returned to buildings, transport, power plants (to compensate if renewable energy cannot be produced) and used as a raw material and fuel by industry. (1:41:00)

Green hydrogen from water electrolysis can compete with steam reforming, for example, in terms of costs. However, the quantities of hydrogen would never be sufficient to decarbonise the steel or cement industry. With a capacity factor of over 20 - 40 %, electricity dominates the costs of hydrogen from electrolysis; with a surplus, the hydrogen price rises rapidly if the utilisation factors fall below 3000FLH.

The most important areas for the use of green hydrogen are green ammonia and methanol in their industrial use, these are very important chemicals. Further applications are the greening of ammonia and methanol for their current industrial applications. Direct iron reduction in steel production is also high on the agenda in refineries for fuel purification, as there are not so many other alternatives. NH3 can also be used as a fuel (for shipping, balancing power stations, industrial furnaces). H2, CH4, CH3OH and synthetic HC can also be used as electric fuels - but carbon should preferably be extracted from the air. The best way to do this is to produce improved biofuels/biogas. Renewable fuels and chemicals that are easy to transport and store are likely to range from areas with large resources to large consumption areas. The production of green ammonia from renewable energy sources can compete with the reform of Natural Gas with CCS in areas with excellent resources that provide cost-effective electricity with high capacity factors. The IEA will very soon carry out detailed analyses on the production of hydrogen and ammonia from variable solar and wind turbines.



Offshore wind in Northern Europe has a large, affordable potential. The offshore wind potential in European waters amounts to 2600 - 6000 TWh, which corresponds to 80% to 180% of the current electricity demand. Possible areas of application are: the electrification of buildings, traffic and industry, here for example steel production (electrical extraction or H2-DRI), production of chemicals, cement or other substances.

Finally, proposals for policy measures: Carbon pricing would help to improve competitiveness, but this aspect is not trivial, as we saw recently in France. For heavily traded commodities, competitiveness at the international level is a major issue. At some point it might be useful to add border tax adjustments, standards, mandates, but this will have to be worked out in the future. There should be a discussion on global sectoral agreements. The difficulty is to get started, and this requires the procurement of environmentally friendly materials that can help to drive development forward. We also need public support for research and demonstration and infrastructure issues. Network effects and mass learning are enormously necessary and thorough analysis should help to reduce the risks associated with "selecting the winners". A new era of international cooperation is needed to promote the global decarbonisation of industry.

Summary of the round table panel discussion - session 1

Moderator: Stefan Lechtenböhmer, Wuppertal Institute

Main theme to provide the needed renewable energies

The consideration of the overall picture is of importance. For innovative technologies a large amount of fossil free energy is needed, this is the key question. It is important to find out where renewable energies can be produced cheaply in Europe, but also in Africa. In addition, the question of transport must be clarified. For example, there are huge gas networks throughout Europe. The purchase of energy via high-voltage lines costs a lot for one gigawatt. Large quantities of gas can be transported more cheaply. In some cases it therefore makes sense to run gas pipelines from Africa to Europe.

Many investments are now being made by industries and we need an infrastructure for this transformation in the long term. We can not wait for the electricity system to change.

Inclusion of private energy consumers and change of lifestyles

From a company perspective, we asked ourselves how to bring innovative and a little more expensive products to market? This raises the question of how to deal with end-users. This problem cannot be solved quickly. This needs to be addressed step by step. The private energy consumption can be reduced above all through energy efficiency in the building sector, in addition to the use of renewable energies. The Eco-Design Directive is very important for private use in order to make it clear to consumers in which areas energy can be saved. The purchase of renewable electricity is also possible for private consumers.

What about economic feasibility?

For the industry the economic feasibility includes the operating costs as well as the capital costs. The production of steel for example with hydrogen is currently even more expensive than conventional production. It is uncertain how economic feasibility will develop over the next few years. There are also acquisition costs for which investment must be made. Companies need certainty about the level of public investment and also about operating costs and this information is not available at the moment.

Within the framework of the Swedish projects presented, feasibility studies were carried out on both technological and economic issues before pilot and demonstration projects were carried out. This has been extremely helpful. Under the HYBRIT project, studies have shown that costs increase by 20 to 30 %. These results are in line with the EC report "mission possible", within which the steel sector was considered. The decarbonisation costs for companies are about 20 % and for consumers 1 %. The EU's instruments for managing projects are capable of reducing risk and this is an important key word. Close cooperation within industrial companies and along the value chain, including with universities and with the support of the state and national authorities, is also important.

Link between climate policy and trade policy

There is an interest that not only the industries remain located in Europe, but also that renewable energies are first and foremost generated in Europe. One advantage of the energy transformation is the reduction of energy imports. With regard to Africa, there is also the migration problem and with the production of renewable energies, new jobs can also be created locally, which provide more security in the country.

Multi-level approach

Public procurement is an important issue as well as infrastructure, both aspects are observed by the market. The integration of energy, infrastructure and storage is important, the different states could make these changes possible. The national plans will set out the contribution that the industries will make to shaping the transformation. These are not only promising figures, but also proof that these goals are being achieved. With all these developments, we must not focus solely on Europe. Multinationalism must be ensured, a task that has been neglected in the past.

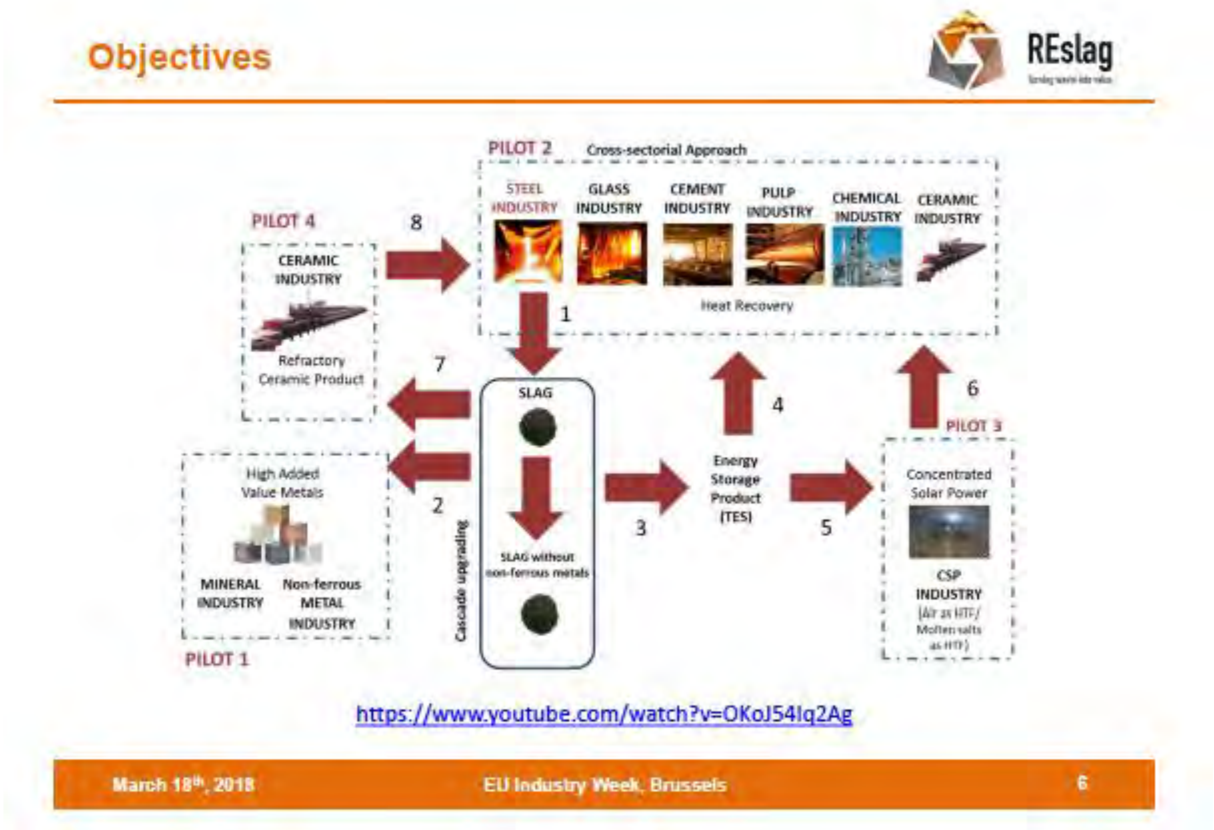
Session 2: Circular Economy

Massimo De Pieri, RESLAG project

Title: “Turning waste from steel industry into valuable low cost feedstock for energy intensive industry”

RESLAG project started in September 2015 and will end in July 2019, it is founded by the EU’s H2020 programme. The consortium consists of 18 partners, including seven companies, eight research institutes and three universities.

The European steel industry produced around 21.4 million tonnes of slag from steel production in 2012. About 24% are not reused, this amount of available material is available for possible recycling. RESLAG is researching four eco-innovative industrial alternative applications for the valorisation of steel slag. The industrial viability of these solutions will be proved through four large scale demonstration pilots that will be built in operating industrial or test facilities.

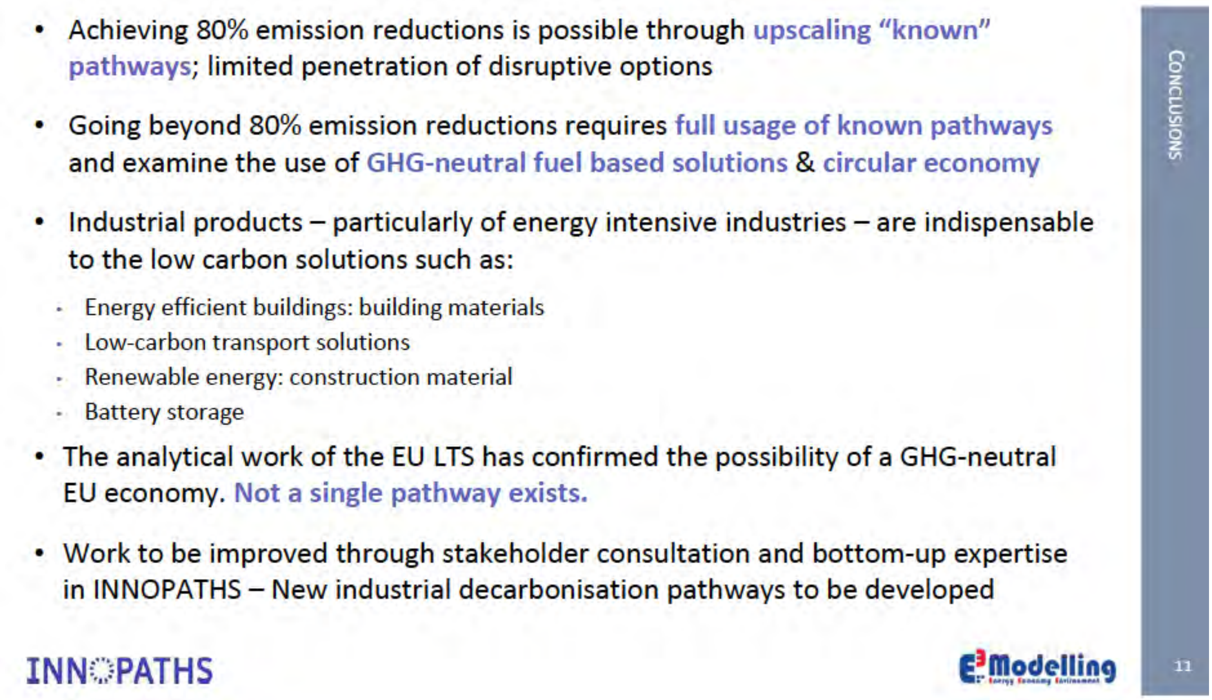


The expected results of RESLAG are the evaluation of the innovative technologies promoted within RESLAG in comparison to the state of the art. An illustration of RESLAG technologies based on the annual slag absorption capacity. To gain knowledge on the most promising ways to use slag waste as secondary raw material instead of landfill and on the promotion and dissemination of circular models for the European market.

Georgias Zazias, INNOPATHS project

Title: “Outcomes of research on decarbonisation strategy for energy intensive industries based on the ‘Clean Planet for all’ long term strategy”

INNOPATHS is a four-year EU funded research project, the consortium includes 15 organisations from 8 European Member States and Switzerland. The aim of the project is to work with key economic and social players to create new, state-of-the-art low carbon routes for the European Union.On the one hand, this is done by evaluating existing scenarios and path studies for the low-carbon transition from a technical, economic and social point of view. It also examines innovation systems and policy landscapes for the main energy-consuming sectors of the economy. The findings from this process will feed into the structure of new low-carbon pathways developed with a wide range of stakeholders from government, industry, academia and civil society. These scenarios are then evaluated quantitatively and qualitatively in terms of their technical, economic and social results. INNOPATHS will examine how to maximise the benefits of these pathways, such as new industries, jobs and competitiveness, and how to mitigate negative impacts, such as on low-income households or on carbon-intensive sectors.

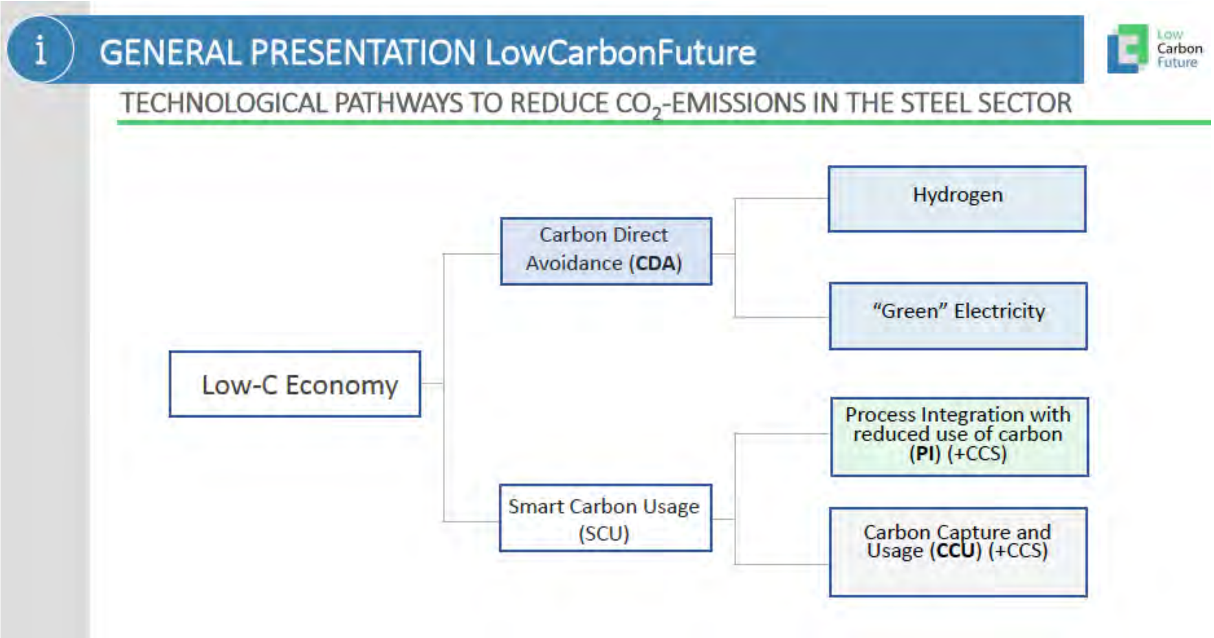


Gerald Stubbe, LowCarbonFuture

Title: “LowCarbonFuture”

The project “LowCarbonFuture” aims to collect, evaluate and promote research projects and knowledge on CO_2 reduction in iron and steel production. The main tasks are the investigation of completed and ongoing research projects on CO_2 reduction technologies in the steel industry. In addition, strategies for technology transfer and the evaluation of CO_2 reduction scenarios will be developed to identify future trends and conditions for the introduction of low carbon steelmaking technologies. The project also creates guidelines for future developments and the development of an

R&D roadmap. The LowCarbonFuture project analyses various technological ways of reducing CO_2 emissions in the steel sector:



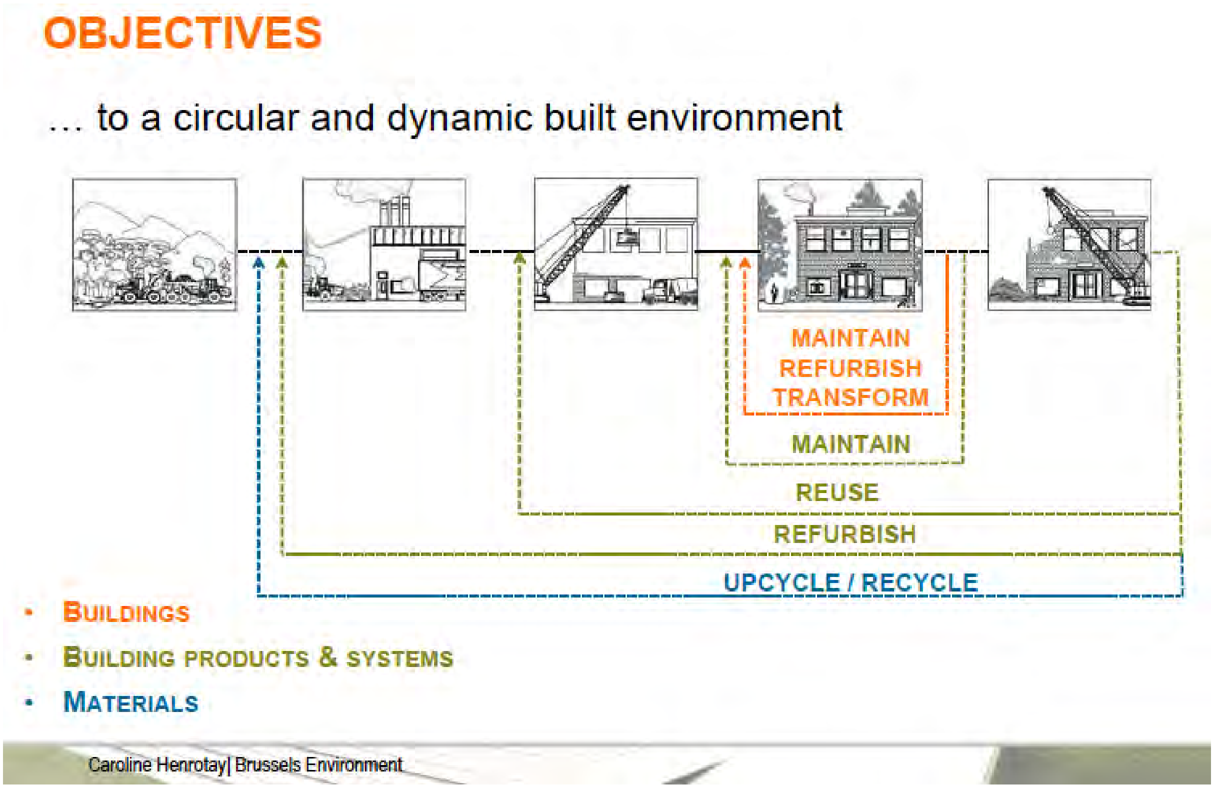
The CO_2 reduction potential of crude steel production is low; it is close to the thermodynamic limit. Nevertheless, efficiency improvements have been achieved in recent decades. In the long term, the steel industry will require the development of breakthrough technologies, and in the short and medium term, bridge technologies based on existing technologies will also be needed.

The challenges in research and development are to consider the different CO_2 reduction potentials and there are different maturity levels for the different technologies. In addition, the scale-up of some technologies will also pose a major challenge. The drivers and obstacles for the implementation of such technologies are manifold. Sufficient green electricity from renewable energy sources must be available, which means tackling a fundamental change in the energy system. On the other hand, the high investment costs for industry must be taken into account. At the end of the value chain, the markets for CCU products must be created or improved. Last but not least, the competitiveness of the steel industry in Europe and worldwide must be ensured.

Caroline Henrotay, BAMP project

Title: "Buildings as materials banks - BAMB"

BAMB creates opportunities to increase the added value of building materials. Dynamically and flexibly designed buildings can be integrated into a circular economy. This will lead to a reduction in the amount of waste and the use of fewer new resources. The project funded by the EU under H2020 includes 15 partners from Europe, the project ended in February 2019.



The conclusion for the discussion is that a circular production and economics of segments for buildings allows great savings, these relate not only to the production and construction of buildings but also create enormous savings of CO_2 emissions.

Among the most important recommendations that should be taken into account when planning future policy and regulation for the circular economy are the following:

Existing EU legislation on energy performance, waste management and construction product legislation should be extended to support the implementation of dynamic and reversible buildings through the integration of material passports and principles for the design of reversible buildings. Clear and measurable objectives should be set. External environmental and social costs should be included in the value calculation of any new policy. Public procurement should be used to promote change and as a mechanism for internalising external costs. Public procurement should also support new types of business models and ownership that lead to other forms of cooperation.

The use of a mix of legislative, fiscal and budgetary measures should be considered in order to encourage the transition to dynamic buildings. Authorities should ensure that the space for experimentation is integrated into policy and regulation. Policy development should take a cooperative approach to ensuring that policy changes take into account the realities of stakeholders and that the objectives set for actors are appropriate and likely to be adopted.

Summary of the round table panel discussion - session 2

Moderator: Henning Wilts, Wuppertal Institute

Integration of Circular Economy in the building sector

The integration of Circular Economy into buildings will be a major challenge. Similar to the integration of renewable energies in buildings. Because the life cycles in buildings often last 20 years. The creation of a material passport for products in house construction is a very good idea. However, it must be clarified how the materials are treated in cross-border use; there are very many different national regulations here. It is therefore important that the material passport specifies exactly which materials are contained in the product. The organisation of dissemination can, for example, be achieved through digitisation.

A clear vision for the Circular Economy?

The construction sector must change significantly if it is to become less CO_2-intensive. These changes not only affect production, but also the subsequent use of the products. And this applies equally to all other industries. For the industry, however, it is not yet quite clear where the circular economy is heading. Not even the reduction targets for 2030 and 2050 are clear. But the message from the population to industry is clear: it must move towards CO_2 neutrality. The cement industry is aligning itself with this vision, and that will cost a lot of money. To reduce emissions, all available technical possibilities (e.g. CCS, oxyfuel) must be exhausted and alternative materials used (e.g. RESLAG project). But it is not only industry that is responsible for change; all actors must act and rethink their lifestyles, and society also needs this vision.

Regulations as trailblazers or ETS?

Laws and regulations will not help the cement and steel industries. For example, the cement industry already offers CO_2-neutral cement on the market, but there is no interest in it because it is too expensive. There must therefore be a price for CO_2. The actual price of CO_2 must now be paid by consumers. All internal and external costs must be integrated into the products (LCA) in order to develop a circular economy.

Closing remarks

Circular economy is a complex issue and there are many open questions to answer. Circular economy means different challenges for each industry, it also means different opportunities and barriers at local level than at national or international level. It will be important to work on a common framework and to arrive at a common understanding of what is meant by circular economy.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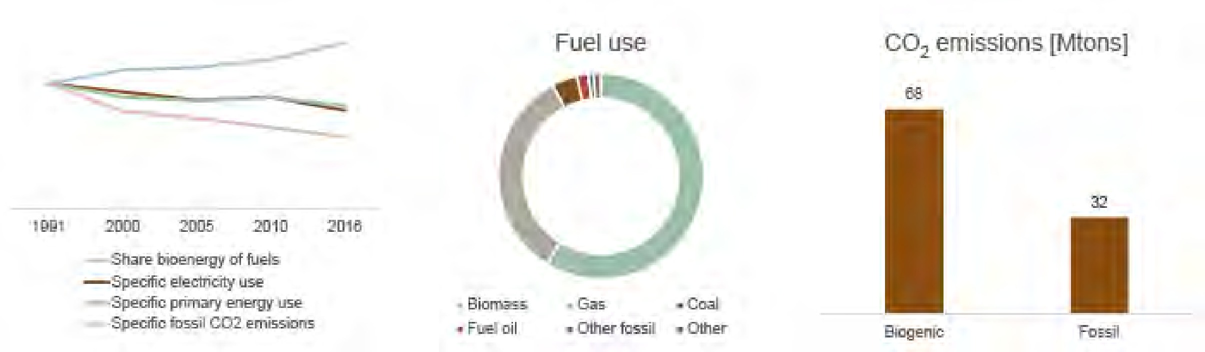
EU Industry Week

Session 3: Biogenic carbon economy, carbon utilisation and new interdependencies

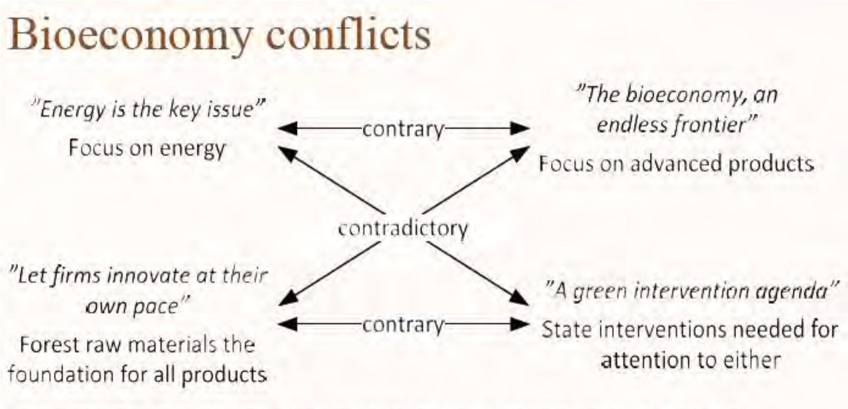
Fredric Bauer, Lund University

Title: “Identified pathways in the field of fuel change and energy efficiency, biorefineries, and bio-CCU”

The pulp and paper industry is the largest energy consumer in the European energy industry. Industry has a long history in Europe in terms of energy efficiency and innovation.



Basically, the share of bioenergy in fuels is increasing. It is obvious that the pulp and paper industry uses a lot of bioenergy, but a large amount of natural gas is still used. Eco-efficiency is already improving, but there is room for further improvement, particularly in Europe. Biorefineries are a possibility, but it is a complicated process to switch from oil to biomass and produce energy. Biorefeneries produces materials, chemicals and energy for the bioeconomy. At present, the focus is on biofuels, as policy mainly focuses on fuel. The CCU is an add-on for the integration of renewable energies from the industrial system into the economy. It is a complementarity pathway of gasification-based biorefeneries and CCUs. Conflicts will arise in connection with the bioeconomy, as examined in a 2018 study. Industry needs to show more interest in biogenic carbon and bio-CCU in order to further increase energy efficiency.

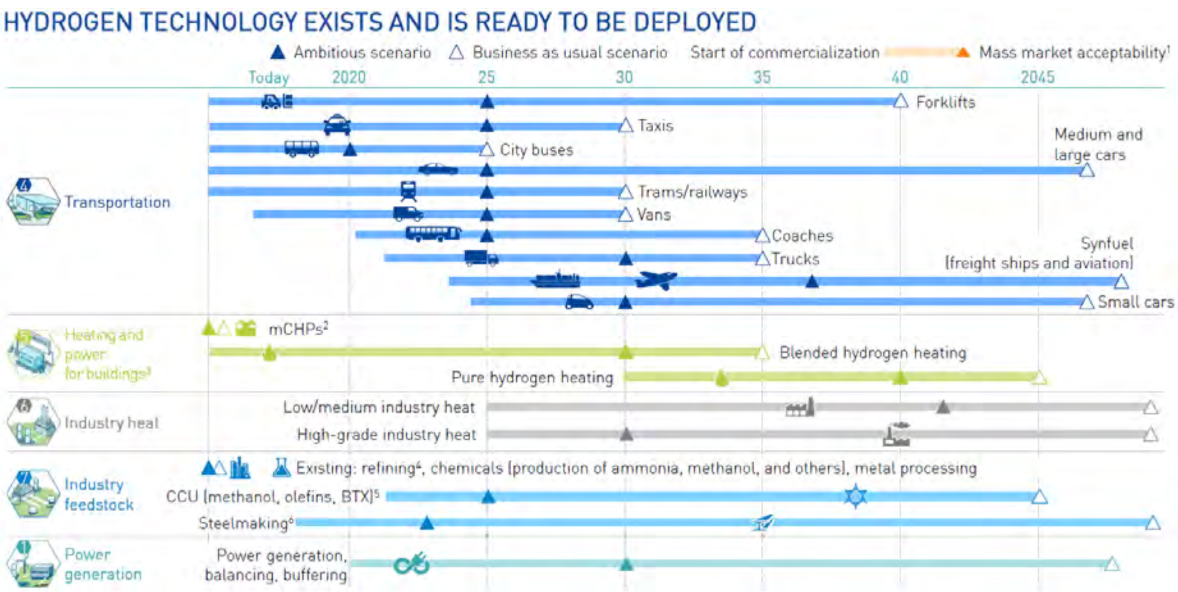


Bauer (2018) **"Narratives of biorefinery innovation for the bioeconomy: Conflict, consensus or confusion?"**

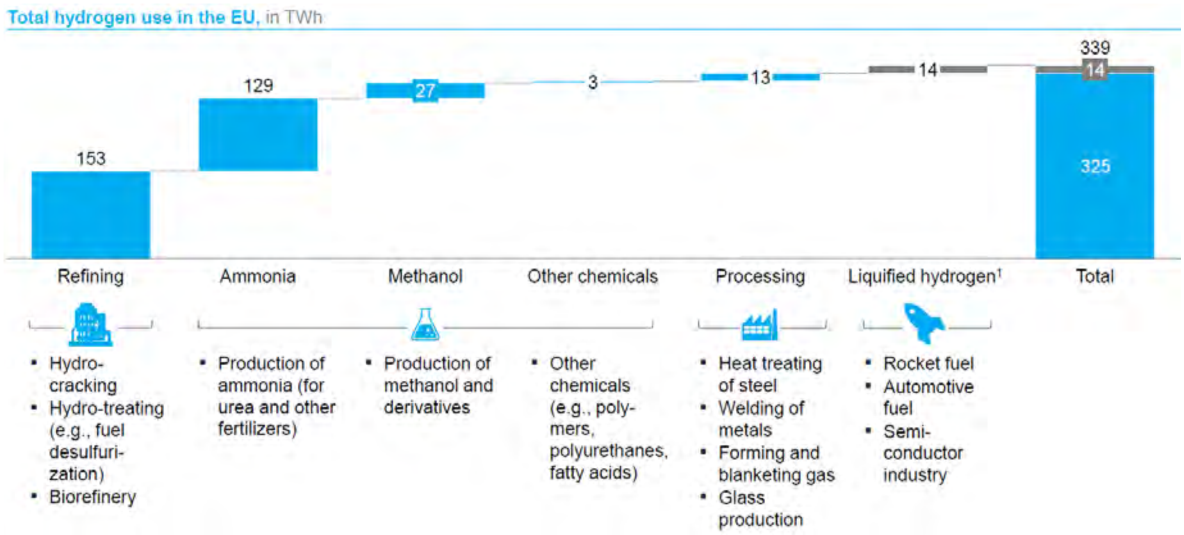
Jorgo Chatzimarkakis, Secretary General Hydrogen Europe

Title: "Hydrogen and CO_2 – what relationship?"

One way to solve decarbonization is to build a renewable energy system using hydrogen. Hydrogen helps to decarbonise transport, industrial energy use, building heating, energy supply and the supply of raw materials. The gas network has to be rebuilt and used for the transport of hydrogen. It is a cost-effective way to transport the hydrogen. According to a study by Forschungszentrum Jülich, the switch to a renewable energy system in Germany would cost five billion euros. 560 megatons of $C0_2$ would be reduced if the hydrogen vision became a reality, covering around 24% of energy requirements, reducing local emissions and creating new jobs in 2050. These objectives are in line with the European Commission's long-term strategy.



The roadmap above shows different hydrogen technologies, their current state of development and their future developments. It is necessary to make improvements in the areas of energy production and industrial raw materials in order to improve the areas of transport, heat and energy for buildings. Refining (153 TWh) and the production of ammonia (129 TWh) already consume around 182 TWh of hydrogen in Europe.

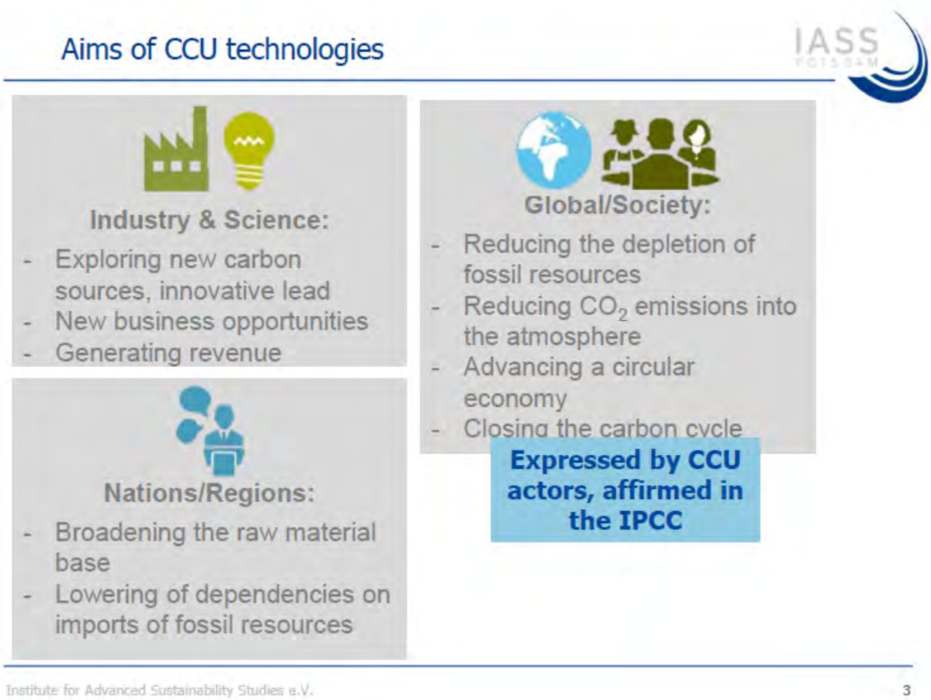


The Netherlands is one of the first countries to convert its gas network to a hydrogen network by 2050. If deep decarbonisation is desired, Europe needs system efficiency like hydrogen and no further technological efficiency. The electricity grid is too small to cover the electricity demand for heat pumps, cars or buses. It should be emphasised that hydrogen can use the gas grid and thus offers a much cheaper and more efficient option than the expansion of the electricity grid.

Barbara Olfe-Kräutlein, IASS Potsdam

Title: "CCU technologies: possible societal contributions and policy needs"

Basically, CCU processes include the capture and compression of CO_2 and its transport (if necessary). In a Circular Economy approach, however, the functional use of CO_2 and the end of life must also be taken into account.



With regard to the implementation of SDGs, CCU technologies could make a possible contribution. CCU aims to achieve affordable and clean energy, decent work and economic growth, industrial development and aspects of innovation and infrastructure, as well as responsible production and reduction of greenhouse gases. CCU promotes a more sustainable use of resources.

With regard to energy and environmental policies, CCU needs clear incentives to reduce industrial emissions and specific tools for assessing the environmental impacts of CCU technologies should be developed. From an economic point of view, CCU needs incentives. The regulatory conditions are not sufficient to ensure investment security. CCU continues to require financing activities at various levels and incentives for successful market introduction, e.g. tax benefits, product mix quotas.

CCU also needs CO_2-based fuels: this means developing hydrogen production from renewable sources. The development of a CCU approach requires support in overcoming the challenges in the area of infrastructure.

Nevertheless, CCU could create hurdles with regard to social acceptance; there are recommendations for improved social acceptance: The CCU debate must separate from CCS. It is important to highlight the potential of CCU technologies that go beyond climate protection, for example support for energy transition processes and the replacement of fossil resources. In the discussion about CCU, realistic figures have to be dealt with when considering the potential. In addition, it is advisable to create certification options for products manufactured with CO_2 in an understandable and internationally applicable manner.

Florie Gonsolin, CEFIC

Title: "CCU in the context of a long-term GHG emission reduction strategy"

CO_2 emissions in the chemical industry will be greatly reduced by 2050. In addition, the sector is developing into a carbon sink, reducing CO_2 emissions by 100 %. The carbon sink is made possible by CSS/CCU, so CO_2 is returned to the plastic and produced by a biobased raw material. So far, the chemical sector has reduced its greenhouse gases by around 60 % since 1990. However, the chemical value chain must be redesigned to reduce CO_2 emissions and achieve the goal of reducing emissions.

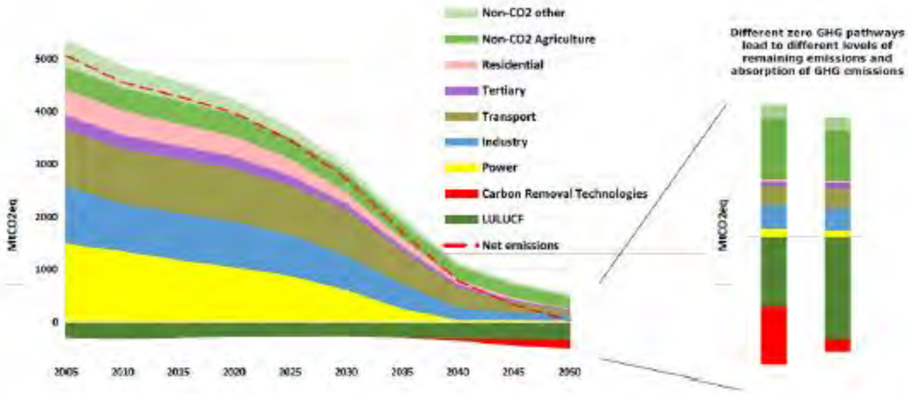


Table 34: Total CO_2 emissions reduction in Chemicals by 2050 compared to 2015

Chemicals	Baseline	ELEC	H2	P2X	EE	CIRC	COMBO	1.5 TECH	1.5 LIFE
Total CO_2 Emissions	-43%	-67%	-69%	-64%	-65%	-70%	-71%	-143%	-118%

Source: PRIMES.

The reduced use of fossil raw materials, which is replaced by the use of hydrogen, bio-based materials and recycled materials, shows a strong potential to reduce emissions. Switching to a CO_2 raw material source brings with it the problem of energy loss of your current raw material. Accordingly, the import of energy in the form of green hydrogen, for example, is necessary to compensate for the loss of energy. The $C0_2$ emission drops by around minus 80 %. The demand for green electricity is around 1900 TWh. It is important to distinguish between cradle-to-gate and gate-to-grave CO_2 emissions. The CCU is a method of reducing emissions from the chemical industry itself. The chemical industry will have to absorb CO_2 emissions in the future. With the CCU, emissions from the chemical sector will now be reduced, but no further emissions. End-of-life emission describes the process by which carbon remains in the cycle and is to be reused. An appropriate policy framework is needed to develop the technology. The framework would recognise the value of the use of CO_2 as an alternative source of carbon. Support, in particular financial support for technology, would increase.

Summary of the round table panel discussion - session 3

Moderator: Lars J. Nilsson (Lund University)

A business model for Europe?

In the future, a lot of electricity generated from renewable sources will be needed to reduce CO_2 emissions from industrial processes. Whether for electrification, hydrogen or CE. At present it seems unclear whether the electricity generated from renewable sources comes primarily from Europe or from other countries in the world. Traditionally, Europe has been heavily dependent on the development and export of innovative technologies and the import of energy. Whether a business model can be developed from this concept in the future is still unclear.

CCU and H2FCV as niche concepts

The CCU is useful for technology areas where industrial emissions are unavoidable. CCU is advantageous when the CO_2 goes into long-lived products. Nevertheless, the technology is likely to remain a bridge and will not lead to the decarbonisation of the energy-intensive industry. It is also unclear whether the market for hydrogen fuel cells will develop and how this will affect the demand for hydrogen or vice versa electricity.

A long-term industrial strategy

A fully collaborative and long-term industrial strategy is needed to bring together all these diverse technological approaches, where it is necessary to find out which will establish themselves in the market and in what way. This is of utmost importance in order to bring together the individual technology paths for decarbonisation. Many stable political and also economic cooperations are needed worldwide.

Keep thinking, what about services?

To help industries develop a wide range of technologies, they need competitive electricity prices. It is also important to consider specific incentives for a circular economy, which do not yet exist. In addition to these incentives, potential services that are needed to integrate the technologies into the market are already being considered.