FINAL REPORT

On the Road to Climate Neutrality 2050

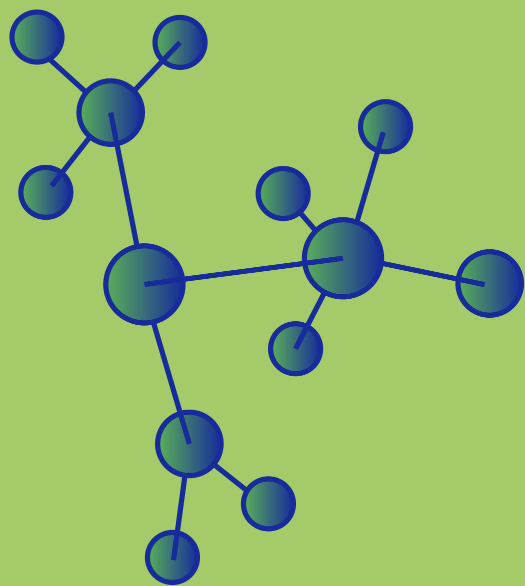
– the Role of Social Partners in the Decarbonisation of the Chemical, Pharmaceutical, Rubber and Plastics Industries

Authors:
Katharina Schöneberg, Birte Homann (wmp consult)
Julien Ballaire, Sarah Kessaria (Syndex)

March 2023

Please note

This report reflects the desk research and workshop results of the project and should not be seen as a policy statement. It describes the state of play at the time of desk research and does not necessarily include updated information keeping up with the fast-moving policy developments.



Content

0. Executive summary

With the European Union aiming to be climate neutral by 2050, the chemical, pharmaceutical, rubber and plastics industries, as important contributors to greenhouse gas (GHG) emissions, have committed to decarbonise their activities. In the framework of a quadruple transition where financial resources are needed for climate neutrality, circular economy, digitalisation and the implementation of the Chemicals Strategy for Sustainability, the ability of the sector to become climate neutral will depend on European and national policies and legislation, international competitivity and trade, development of demand and market requirements and public opinion. In addition, it will also depend on the availability and price of renewable energy, electricity, green hydrogen, Research and Development and innovation, investments and funding, cooperation among sectors, as well as infrastructure development.

Against this background, companies in the sector must choose between different technological pathways. Promising future-oriented technologies and production methods comprise the use of new raw materials and carbon sources, changes in own processes, including the enhancement of energy efficiency in the production process, the electrification of processes, the development of new processes, as well as sustainable business models and working methods. Also, alternative energy sources, the capture and storage or (re-)use of CO_2 and recycling methods play an important role. Finally, the idea of a circular economy combines several of the solutions for climate neutrality, such as renewable feedstock, efficient production, recycling and carbon utilisation. Companies will have to choose a technology mix that will ensure their future competitivity, also deciding on the regional focus of the undertaking, strategies and business models, and products.

Framework conditions and choices made by companies will have an impact both on companies and workers calling for actions. Companies are to engage in anticipation of change and risk management, increase cooperation and get engaged in strategic partnerships. They continue promoting R&D and innovation closely related to the need to secure access to financing and funding opportunities. Furthermore, to meet the above mentioned challenges, companies are to consider the potential reorganisation and/or change of their working methods, develop new organisational competences, and implement strategic personnel policy which will allow more active involvement of employees. From a workers' perspective, the impact on employment and the need to ensure job and social security, the prevention of negative effects on working conditions, as well as access to relevant training and education, will be important.

In this context, social partners can play an important role in accompanying the transition and shaping it in a way that is socially and economically viable. Throughout the project and in three different workshops, representatives of sectoral trade unions and employers' organisations from different EU Member States discussed framework conditions, different pathways and company choices, possibilities to ensure a successful and just transition. They also developed concrete practical tools for social partner involvement.

1. Introduction

1.1. Background and methodology

The European Union aims to be climate neutral by 2050 – an economy with net-zero greenhouse gas emissions. This objective is at the heart of the European Green Deal and in line with the EU's commitment to global climate action under the Paris Agreement to limit global warming to below 1.5 degrees Celsius. The chemical, pharmaceutical, rubber and plastics industries (henceforth: "the sector") have committed to contribute to this target by massively reducing their greenhouse gas (GHG) emissions, most notably carbon dioxide (CO_2). Strong social dialogue and collective bargaining are highly needed to find effective solutions for both workers and employers. Consequently, the European social partners of the sector, industriAll European Trade Union and the European Chemical Employers' Group (ECEG), initiated the joint project 'On the Road to Climate Neutrality 2050 – the Role of Social Partners in the Decarbonisation of the Chemical, Pharmaceutical, Rubber and Plastics Industries'.

The project consisted of a literature review, 23 interviews with experts from European and national social partner organisations and company representatives from seven countries, carried out by the external experts from wmp consult and Syndex between April and October 2021. The result thereof was a research report as a basis for, and input into, three interactive workshops, the development of the project toolbox and the final conference. This final project report summarises the overall project's results.

The background research was conducted and the first workshop held before the Russian invasion of Ukraine, exploding energy prices and the increased problems with access to raw materials.

1.2. The European chemical, pharmaceutical, rubber and plastics industries and their relevance for GHG emissions

In terms of production value in 2020, Germany and France are the two largest producers in the sector in the European Union, followed by Italy and the Netherlands. When including Spain, Belgium and Austria, these countries account for more than 80% of the production value of the sector. In 2018, the sector employed almost 3.4 million people (Eurostat 2022a). The sector is confronted with increasing competition, mainly from China, but also the USA, Japan, Russia, South Korea and India.

Fuel and power consumption in the EU27 chemical industry (including pharmaceuticals) decreased by 24% between 1990 and 2018, halving its energy intensity and greenhouse gas emissions while almost doubling production (Cefic 2021c). Together with the iron and steel, petrochemicals, cement and lime, and aluminium industries and three key transport sectors (road freight, aviation, and shipping), it could account for 38% of energy and process emissions and 43% of final energy use by 2050 without major policy changes (IRENA 2020).

In 2020, CO_2 emissions represented 86% of the GHG emissions of the chemical sector[1] in the EU-27, followed by nitrous oxide (N_2O) (9%). In addition, methane, hydrofluorocarbons (HFCs)[2] and perfluorocarbons (PFCs) accounted for 1-2% each. From 1990 to 2020, the European chemical industry had already reduced its GHG emissions by 67%. However, CO_2

[1] Comprising ammonia, nitric acid, adipic acid, caprolactam, glyoxal and glyoxylic acid, carbide, titanium dioxide, soda ash, petrochemical and carbon black and fluorochemical production; no comparable data available for the pharmaceutical, plastics and rubber industries.
[2] HFC is a type of gas used in refrigerators and aerosols.

emissions have only been reduced by 9%, whereas methane emissions have even increased by 10% (Eurostat, 2022b). Due to its large share in GHG emissions, as well as smaller progress in reductions so far, the focus in GHG emission reductions in the sector is on CO_2.

While the sector is a major energy user, it also helps to drive transformation, save energy and reduce GHG emissions. It is an "enabler" of hydrogen technologies, storage tanks, pipelines, and CO_2 reduction (for example, through lightweight construction, building insulation or electric motors). These effects on emissions' reduction can also be called the "carbon handprint" of the sector. The transformation in Europe is inconceivable without the sector's products and the companies' innovations (Cefic/Ecofys 2013). The contribution of the sector to reach climate neutrality across all sectors is very important. The present report however will focus on the sectors' own GHG emissions.

2. Framework conditions and company choices for climate neutrality in the sector until 2050

2.1. Framework conditions

The sector is confronted with a "double twin" or "quadruple" transition comprising the following four major challenges:

1. climate neutrality,
2. circular economy,
3. digitalisation and
4. implementation of the Chemicals Strategy for Sustainability.

As investments are needed for all developments, a coherent and consistent sectoral approach is indispensable (VCI/ Deloitte 2017; Cefic 2021b). All four aspects are closely linked and part of the EU's zero-pollution ambition, a key commitment of the European Green Deal. On the one hand, digital technologies are an enabler for climate neutrality in the chemical sector (for example, through measures for automated flexibilisation of industrial electricity demand, depending on the grid load or increased energy efficiency through automatisation and process analyses). On the other hand, increasing digitalisation itself leads to rising energy and resource consumption and thus greenhouse gas emissions (izt/Öko-Institut e.V. 2021). Interview partners estimated that digital transformation is the essential factor to meet the challenge of climate neutrality by 2050 as it will support control of costs and availability of scarce raw materials. Within the fourfold tension field, according to literature, interviews and workshop results, several influence factors will have an impact on the ability of the sector to become climate neutral until 2050, as shown in Figure 1.

Figure 1: Influence factors for climate neutrality of the sector

Source: own illustration

Enablers and barriers to climate neutrality related to these influence factors will be described in the following paragraphs.

• Policy and legislation

Several climate strategies and targets of the European Union have been adopted over the years[3]. While emissions reductions have already been a goal for companies, the process has been accelerated by the Paris Agreement and the provisions of the European Green Deal. Global, European and national policies and regulations can either inhibit development and investments or steer them in the "right" direction. Due to the more restrictive environmental laws, companies will have to make further investments and incur costs (see, for example, Pirelli 2021). With additional European legislation (Non-Financial Reporting Directive[4], Corporate Sustainable Reporting Directive[5], Regulation concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals-REACH[6], Corporate Sustainability Due Diligence Directive (CS3D)[7] and taxonomy[8]), there are multiple and complex sustainability related reporting requirements vis-a-vis companies. Planning security and a clear political and regulatory framework supporting the transition are of the utmost importance for the sector to remain competitive. A stable policy framework and technology-neutral support measures are key enabling elements for promoting low-carbon products and services. An integrated EU industry, energy policy and circular-focused public procurement practices also facilitate the transition to sustainability. There are several barriers that can impede progress towards a sustainable future, including the continuous adaptation of climate targets and isolated and fragmented policies that can exacerbate the problem by shifting GHG emissions elsewhere, rather than addressing them holistically.

[3] For example, the First Circular Economy Action Plan (December 2015), the European Strategy for Plastics in a Circular Economy (January 2018), Single Use Plastics Directive (July 2019), the European Green Deal (December 2019), the SME Strategy for a sustainable and digital Europe (March 2020), the Hydrogen Strategy for a climate-neutral Europe (July 2020), the Chemicals Strategy for Sustainability (October 2020), the Pharmaceutical Strategy for Europe (November 2020) or the European climate law (July 2021) (European Commission n.d., 2020a+b+c+d+e+f+g, 2019, 2021 a+c+d, 2018, 2018a, 2017, 2019c).
[4] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32014L0095
[5] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32022L2464
[6] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02006R1907-20140410
[7] https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52022PC0071&from=EN
[8] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32020R0852

• International competitivity and trade

The challenge of achieving climate neutrality in the industrial sector requires balancing competitiveness with climate protection to avoid carbon leakage. The European Commission introduced the Carbon Border Adjustment Mechanism (CBAM) as part of the Green Deal in addition to the EU Emissions Trading Scheme to contain the risk of emissions being shifted to non-European locations (European Commission 2019c; Kolev et al. 2021). However, some stakeholders fear that CBAM may not be effective for strongly export-oriented industries and could pose trade policy risks (BASF 2020). Other measures, such as capped industry electricity prices and carbon contracts for difference (CCfDs), are also being discussed (*Stiftung Arbeit und Umwelt* 2020).

• Demand and market requirements and public opinion

Major promoters for climate neutrality on the demand side are the social pressure and rising awareness for resource efficiency and sustainability issues (see, for example, Trelleborg 2021). Clients of the sector (especially transnational companies, such as Volkswagen) demand ecological efforts from their suppliers (see, for example, SNCP 2021 and Pirelli 2021). While developments such as electric vehicles, for example, offer a chance for growth for producers of certain rubber parts, there is a great deal of uncertainty about the development of the base materials industry (Fraunhofer 2013). The competitive position of Europe has suffered in recent years due to the efforts of many emerging countries to build up their own basic industries and their more favourable raw material conditions (Cefic 2013). As consumers are not necessarily willing to pay more for sustainable goods, demand-side measures (financial support and normative measures) can help to foster competitiveness of carbon- neutral products (High-Level Group on Energy-intensive Industries 2019).

• Availability and price of renewable electricity, energy and green hydrogen

To achieve the GHG neutrality goal for the sector by 2050, a strong increase in electricity demand and higher investment costs for electrification of processes is required (DECHEMA/FutureCamp 2019). Energy storage is crucial for uninterrupted production. A cost-effective and stable supply of renewable electricity is necessary, and the ability of European countries to decarbonise energy generation is important (IEA 2021a). Renewable energy is growing fast, but not fast enough to achieve net-zero by 2050 if current investment patterns continue (IEA 2021c). Hydrogen produced from decarbonised energy sources, or “green hydrogen,” is the main long-term solution for decarbonising hard-to-abate sectors (DNV 2021). However, the additional costs of renewable electricity-based hydrogen production require an adjustment of the levy and apportionment system to enable cost-effectiveness. Storage, transport, and distribution of hydrogen must also be addressed.

The development of a worldwide level playing field for energy costs, internationally competitive electricity prices, and solutions to use “surplus” electricity for hydrogen production, are all enabling elements for the adoption of hydrogen as a sustainable energy source. In addition, the installation of long-distance hydrogen transport pipelines and the development of local H_2 markets are also essential. However, the barriers include increasing electricity prices, high costs and energy needs for “green hydrogen” production, and intense competition for access to electrolysis potential within and between sectors.

• R&D and innovation

Interview partners highlighted that innovation is a main driving force for the sector. The timing of market maturity for new technologies is critical. The EU industrial strategy and sector-specific pathways promote chemical innovation (Cefic 2021a), and policymakers must support research and development for the industry to become climate neutral. Government support is likely necessary to drive technologies in the pilot or pre-commercial stages to scale (IEA/ICIS 2020). Academia and research organisations should undertake research on large-volume and high-energy use processes

(ICCA/IEA/Dechema 2013), and SMEs must be empowered to innovate more (ArGeZ 2021). Political instruments and international agreements must ensure competitiveness of domestic production as alternative process routes are less economical than conventional technologies (Neuwirth et al. 2020).

• Investments, funding and other incentives

To achieve greenhouse gas neutrality by 2050, decisions must be made now regarding investment in game-changing technologies for decarbonisation of industry. However, high research costs, enormous investment sums, and implementation risks are associated with these technologies (Nelissen 2019; IEA 2013). Public and private investment efforts will have to be significantly increased to achieve the goal of climate neutrality by 2050. Various funding programmes[9] already exist, and a transformation fund focusing on climate-friendly technologies, production processes, and products can provide significant support (Dullien et al. 2021). Other helpful funding mechanisms include Carbon Contracts for Difference (CCfDs) and transparent technology-oriented investment funds (Belitz et al. 2021; Cefic 2021).

• Industrial symbiosis and sector coupling

To achieve greenhouse gas neutrality, breakthrough technologies and increased cooperation across value chains will be needed, as a significant part of the chemical sector's emissions come from upstream activities in the value chain. There is a trend towards more collaboration between the chemical and other sectors, such as power, fuels, steel, and waste recycling, where chemical clusters will play an important role in reducing overall emissions. Extensive sector coupling and the integration of hydrogen across industries and energy sectors offer opportunities for optimum cost efficiency (WSP and Parsons Brinckerhoff/ DNV GL 2015; H_2 cluster Finland 2021). Also, for Carbon Capture and Storage (CCS), the capturing processes and infrastructure cannot be located on a single site.

• Infrastructure development

Workshop participants highlighted the importance of infrastructure development and modernisation. A comprehensive infrastructure is necessary to make technologies such as the use of hydrogen effective. Additionally, the distribution and infrastructure of hydrogen must be taken into consideration to make processes efficient. It is also essential to encourage the use of existing infrastructure in addition to developing new ones to collect and recycle materials. A centralised recycling infrastructure must be supported by industrial policy.

2.2. Corporate practices on the way to climate neutrality

To reduce their carbon footprint, companies in the sector must choose between a multitude of possible technologies and production methods. It will largely depend on framework conditions and the development of the influence factors named above which technological pathway they choose. The following chapter will present promising future-oriented technologies and production methods as well as possible strategic company choices.

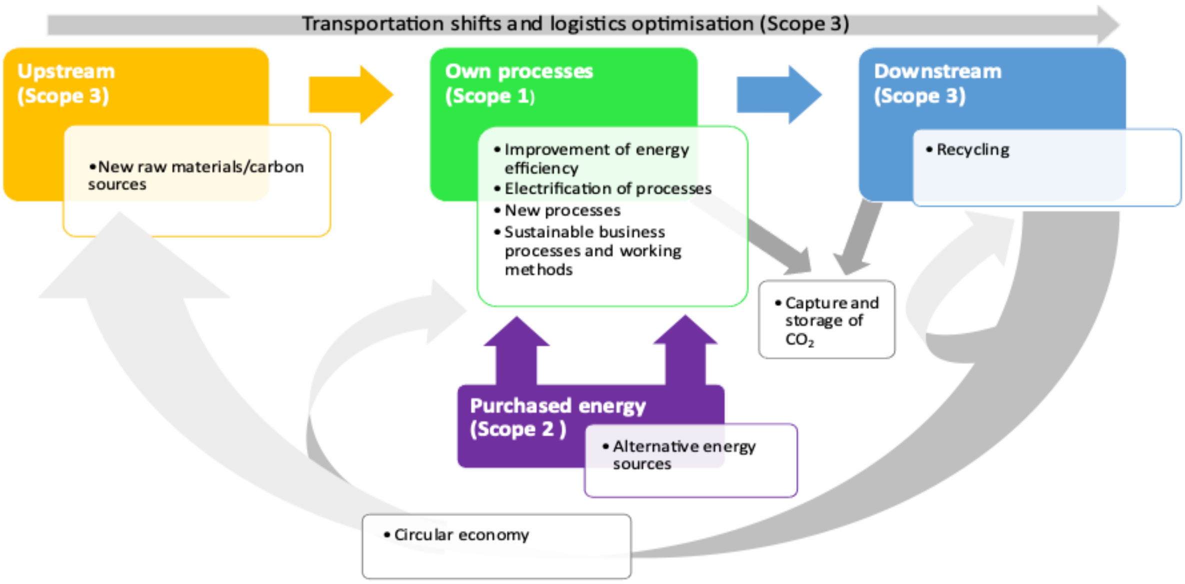
[9] Such as Horizon 2020 (2014-2020) / Horizon Europe (2021-2027) for research and innovation, the EU Recovery Plan (in response to the Covid-19 pandemic), the ETS Innovation Fund (for the commercial demonstration of innovative low-carbon technologies), the European Fund for Strategic Investment (EFSI), or under the EU cohesion policy. A Circular Economy Finance Support Platform was set up in 2017. Funding is also provided by the European Investment Bank (EIB), often in cooperation with national development banks, such as Private Finance for Energy Efficiency (PF4EE), supporting the implementation of National Energy Efficiency Action Plans or other energy efficiency programmes of the EU Member States, the Joint Initiative on Circular Economy (JICE), the investment programme InvestEU, the Just Transition Fund and the Just Transition Mechanism, the Connecting Europe Facility, EU Invest and Important Projects of Common European Interest (IPCEI), promoting the diversification of international supply chains and supporting new industrial alliances and Member States' efforts to pool public resources in areas where the market alone cannot deliver breakthrough innovation.

With the financial support of the European Union

Promising future-oriented technologies and production methods

While solutions differ from country to country, between sub-sectors and even from company to company, as highlighted by interview partners, some widespread approaches have been discussed in literature and interviews carried out during the project. There are several starting points for companies to reduce GHG emissions, including own upstream and downstream measures, as well as own processes and purchased energy (see Figure 2).

Figure 2: Scopes of GHG emissions[10] and possible starting points for their reduction



Source: own, based on Cefic 2013: 7

Upstream measures to reduce GHG emissions: New raw materials and carbon sources

Interview partners emphasised that the sector needs to convert its fossil feedstock to become greenhouse gas neutral by 2050. Sustainably produced biomass can contribute to additional emission reductions before 2030 (Cefic 2021d). However, competition for biomass with other sectors may drive up prices, and there are high opportunity costs of biomass use, including pressures on ecosystems and competition with food production (Green Chemistry & Commerce Council 2021; Hock 2021). CO_2 may play a role in the feedstock mix of the future, but cost-competitive access is a major challenge (Material Economics 2019). A few demonstration plants have already been

Funding of renewable methanol production within the Swedish Green Industrial Leap Programme

To reduce CO_2 emissions across the entire value chain, the Swedish chemical group Perstorp, in cooperation with Fortum and Uniper, plans to invest in a plant for renewable methanol production utilising residual streams and capturing and using CO_2 from production. Together with a new electrolysis plant and biogas, the plant will produce 200,000 tonnes of sustainable methanol annually. The project is supported by the Swedish Energy Agency by around 29 million Euros (Swedish Energy Agency 2021).

For further examples: see research report, Annex I.

[10] The GHG Protocol Corporate Standard classifies a company's GHG emissions into three 'scopes'. Scope 1 emissions are direct emissions from owned or controlled sources. Scope 2 emissions are indirect emissions from the generation of purchased energy. Scope 3 emissions are all indirect emissions (not included in Scope 2) that occur in the value chain of the reporting company, including both upstream and downstream emissions (http://www.ghgprotocol.org). Some examples of Scope 3 activities are extraction and production of purchased materials; transportation of purchased fuels; and use of products and services. These three scopes are also referred to as "carbon footprint", while a fourth scope, the contributions to emission reduction from the use phase of chemical products, are also named "carbon handprint".

built in Europe that convert CO_2 into high-quality plastics (Suschem 2018). Interview partners stated that the shift in the resource base is expected to be incremental, and that the use of CO_2 as a feedstock is not expected to be implemented on a large scale in the next ten years.

Changes in own processes

• Enhancing energy efficiency in the production process

Process intensification is crucial in improving the energy efficiency of chemical processes. This can be achieved through changes in equipment and methods, leading to a decrease in equipment-size/production-capacity ratio, energy and resource consumption or waste production. An efficient use of power and energy can be achieved by motor system optimisation and enhancement of boiler efficiency through improved or new process control methods, supply-demand optimisation, reduced flue gas quantity resulting from the combustion of fossil fuels, flue gas heat recovery, and regular maintenance (Cefic/Ecofys 2013, see also SPIRE 2012; Creative Energy 2017).

Steady progress in implementing incremental improvements and deploying best practice techniques (BPT) could provide substantial energy savings and emissions reductions in the sector compared to business-as-usual practice. As around 90% of chemical processes use catalysts (also called "reaction accelerators", a substance that increases the speed of a chemical reaction) to start the chemical reaction, catalyst improvements will play an important role (ICCA/IEA/Dechema 2013). However, due to the already achieved decline in energy consumption and associated GHG emissions, and physical and chemical limits to the reduction of energy input in many processes, for further substantial improvements new technological pathways will be necessary (Prognos 2011; ICCA/IEA/Dechema 2013; Agora Energiewende 2020).

Thermal groundwater utilisation for cooling

Gummiwerk KRAIBURG GmbH & Co. KG currently employs around 400 people producing rubber and silicone compounds. The KRAIBURG rubber plant uses thermal groundwater to cool buildings and processes. Overall, the installed system can reduce electricity consumption by an average of 30,000 kWh per month. After cooling, the groundwater seeps away on the primary side via two 500 kW heat exchangers and then back into the ground via an absorption well (wdk 2019).

Interview partners stated that advanced process modelling, control technologies, digitalisation, and artificial intelligence can reduce companies' carbon footprint and improve resource management. However, energy security is often overlooked in discussions about digitalisation, and the adoption of digital tools will increase energy demand and costs for the sector. Cooling systems for data storage and the use of big data, connected objects, blockchains and AI will contribute to this increase in energy consumption.

• Electrification of processes

Interviewees highlighted the significance of the electrification of processes, known as Power-to-X, for decarbonisation. Power-to-Heat, Power-to-Hydrogen, and Power-to-Chemicals, including specialities and commodities, are the main types of electrification. Power-to-Heat, such as waste heat upgrading and electrochemical production of fine chemicals, will be implemented on a large scale. Power-to-Hydrogen will expand from pilot scales to commercial scales and can be used as a feedstock for chemical processes or as energy storage. Applying Power-to-Hydrogen for local use on-site is already being applied by some companies on small scales, for specific cases. For example, a plant of Carbon Recycling International in Iceland, operating since 2011 and connected to the Svartsengi geothermal power plant, produces 5 million litres of completely renewable methanol per year and recycles 5.5 thousand tons of CO_2 emissions

With the financial support of the European Union

per year (www.carbonrecycling.is). Power-to-Chemical processes, such as plasma[11], microwave[12] and photocatalysis[13], have higher energy efficiencies and yields than conventional processes, but are still in earlier stages of development (VoltaChem 2016).

• New processes

Low-temperature processes and catalytic alternatives, such as the use of cleaner biocatalytic alternatives (for example, hormones or enzymes) to traditional process routes, can provide additional energy savings. Using membrane technologies to replace energy intensive distillation separation steps and, for chlor-alkali production[14], a further development of the membrane process[15] using an oxygen-depolarised cathode (ODC)[16], reduce the electrical power consumption considerably. The use of ODC technology will, given the existing energy mix, lead to considerable reductions in GHG emissions (Voß 2013a).

Reduction of power consumption by 30% with ODC

In 2011, a demonstration plant with an annual capacity of 20,000 metric tons of chlorine was commissioned at the Krefeld-Uerdingen Chempark. Following a successful two-year large-scale test operation, ThyssenKrupp and Bayer have been marketing the technology worldwide since 2013 and Bayer itself also gradually retooled its chlorine production. Bayer had developed this special type of electrode, while the design of the electrolytic cell comes from Thyssenkrupp Uhde / Uhdenora (chemietechnik.de 2013; chemie.de 2011).

Regarding ammonia[17] production, several new methods, such as biological nitrogen fixation using bacteria, electrochemical production of ammonia directly from nitrogen and water and chemical looping processes involving chemical or electrochemical reactions producing ammonia as a by-product (The Royal Society 2020), are being developed. Also, green e-methanol[18] may be synthesised from green hydrogen and CO_2. Emerging technologies, such as the replacement of the steam cracking process, currently run non-catalytically by a catalytic process and the methanol-to-olefin[19] (MTO) process would have to be applied in new plants (ICCA/IEA/Dechema 2013).

• Sustainable business processes and working methods

In addition to technological solutions, sustainable business processes and working methods will play an important role in reaching climate neutrality in the sector. These may include business processes (systematic green design approach for new products, implementation of a green fund and internal carbon price for all investments and business systems, changes in supply chains and transport, etc.) (EFPIA 2020) or the mobility of employees. Also, low-carbon transportation and the development of greener transportation routes and solutions play an important role in the reduction of GHG emissions (see, for example, Cefic/Smart Fright Centre 2021). In addition, the development of teleconferences and virtual meetings can be used to reduce the travelling emissions of employees, as stated by interview partners.

[11] Plasma technology is based on a simple physical principle. Matter changes its state when energy is supplied to it: solids become liquid, and liquids becomes gaseous. If even more energy is supplied to a gas, it is ionised and goes into the energy-rich plasma state, the fourth state of matter.
[12] Microwave processing is defined as the use of electromagnetic waves of certain frequencies to generate heat in a material.
[13] Photocatalysis, also known as ‘artificial photosynthesis’, is a technology for converting photonic energy from solar radiation to chemical energy. Photocatalysts are materials that change the rate of a chemical reaction on exposure to light.
[14] The chloralkali process is an industrial process for the electrolysis of sodium chloride solutions. It is the technology used to produce chlorine and sodium.
[15] The membrane acts as a very specific filter that will let water flow through, while it catches suspended solids and other substances.
[16] In ODC technology, gas and liquid are separated in the cathode compartment by a percolator, which enables the formation of a caustic film between the membrane and the ODC enabling a homogeneous oxygen and caustic pressure distribution over the compartment, leading to an optimum flow performance.
[17] Ammonia is a compound of nitrogen and hydrogen with the formula NH3. A stable binary hydride, and the simplest pnictogen hydride, ammonia is a colourless gas with a distinct pungent smell. Ammonia is one of the most highly produced inorganic chemicals. Ammonia, either directly or indirectly, is also a building block for the synthesis of many pharmaceutical products and is used in many commercial cleaning products. It is mainly collected by downward displacement of both air and water.
[18] Green methanol is a low-carbon fuel that can be made from either biomass gasification or renewable electricity and captured carbon dioxide (CO_2).
[19] Olefin is another name for polypropylene fiber. Chemically speaking, polypropylene sounds like a complicated process, but is in fact a greener fabric than cotton, wool, silk, or rayon. Olefin, or PP, is a synthetic based polypropylene fabric that was first created in Italy in 1957.

Alternative energy sources

While the sector is largely dependent on the availability and price of renewable energy to be purchased, the sector could make a greater contribution to the electricity transition through load management measures (Stiftung Arbeit und Umwelt der IGBCE 2019b) and heat source changes (Cefic/ Ecofys 2013). While hydrogen is not estimated to be widely used for industry heating in 2030, it may be part of a portfolio of decarbonisation measures in some industries in 2050 (DNV GL 2019). Availability of sufficient renewable energy or electricity, as well as hydrogen, at low prices will be a challenge (Rothermel 2020). International partnerships and cooperation with other sectors will be important, but according to interview partners, this issue is not being successfully addressed at the political level. Companies in the sector conclude supply agreements and power purchase agreements to secure low-carbon electricity and invest in new energy generation and storage capacity. To change the source of electricity, power purchase agreements (PPAs) to secure low-carbon electricity and joint ventures with energy companies to invest in new energy generation and storage capacity will be important.

Borealis Polymers: Reducing transportation routes

Borealis Polymers, a manufacturer of petrochemical products, streamlined its logistics and achieved significant emission reductions at its factories in Kilpilahti, Porvoo. Due to the small container field, some of the plastic granules produced by the company have had to be transported and stored at Vuosaari Harbor. The transport of containers within 30 kilometers was significantly reduced when the container field in the Kilpilahti factory area was doubled. The truck transportation route will be reduced by 10–15 per cent, cutting CO_2 emissions by 270 tonnes (Remes n.d.).

Capture and storage of CO_2

According to the International Energy Agency (IEA), the global climate goals can only be achieved if carbon capture and storage (CCS) and other negative emission technologies are researched and deployed on a large scale in a timely manner (Stiftung Arbeit und Umwelt der IGBCE 2019b). Cefic (2013) also expects these technologies to make a significant contribution to reducing emissions from the chemical industry in Europe. The EU also promotes the use of CCS technologies, for example through the InvestEU investment programme (Global CCS Institute 2020). Still, there is no consensus on the question whether CCS is needed to reach climate neutrality or not. By 2050, total carbon capture will only amount to 6% of all annual energy-related emissions (DNV 2021). Long-term technical feasibility, economic viability and actual storage capacities are difficult to determine. Fraunhofer Institute for Systems and Innovation 2019, Fraunhofer 2012 and CE Delft 2012 therefore do not include CCS technologies in their estimates. Emissions from individual plants are not of a sufficient scale to justify their own CO_2 pipeline and storage infrastructure. Collaboration both within the sector and externally is necessary to establish the networks, along with sources of funding to develop this shared infrastructure (WSP and Parsons Brinckerhoff/ DNV GL 2015).

Kiilto: Heating a large factory with waste heat

Kiilto will cut energy consumption by a fifth by 2025 and move to 100% renewable energy within a decade. At the Kiillo Lempäälä plant, the heat energy generated in adhesive production began to be recovered with the help of a new heat pump system. Waste heat is now used to heat factory properties. The plant has also introduced a geothermal system, which provides not only heat but also the cooling needed in production. The new heat pump system reduces the plant's energy consumption by 1,800 megawatt hours per year. CO_2 emissions will be reduced by about 310 tonnes per year when natural gas used for heating is replaced by renewable energy (Remes n.d.). *For further examples, see research report, Annex I.*

With the financial support of the European Union

Downstream measures to reduce GHG emissions: Mechanical and chemical recycling

Currently, only a small fraction of chemical product-based materials is recyclable, and an even smaller portion is being recycled (Kemianteollisuus et al. 2020). Today, mechanical recycling is the most widespread solution, but it has some limits, especially regarding the quality of output. While mechanical recycling methodologies must be further developed, chemical recycling, as interview partners emphasised, becomes more important. The first pilot plants are currently being built. Large-scale implementation is expected in the late 2020s. For example, through pyrolysis[20], the carbon can be used in crackers. This becomes even more important, as refineries will prospectively cease to be a source of raw materials when cars go electric and gasoline is no longer produced at large scale. The technology of pyrolysis plants needs to be further developed; the implementation is quite advanced. But if larger quantities are to be produced, larger plants are needed and there are still some issues to be solved in scaling up (e.g. regarding pollutant emissions), according to one interview partner.

BASF – ChemCyclingTM project

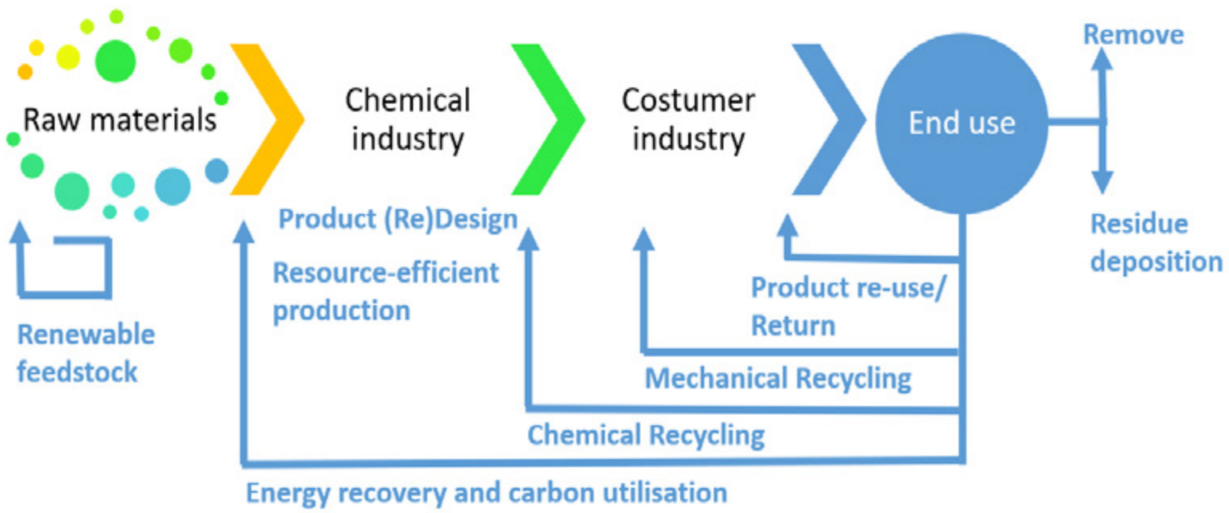
In 2018, BASF (primary producer) launched the ChemCycling project. It focuses on chemical recycling (through pyrolysis) of plastic waste that is not recycled mechanically for technological, economic, or ecological reasons today. Value chain cooperation is key to the project. The ChemCycling™ circle is described as follows: It starts with the disposal of plastic waste, which is then collected and sorted and delivered to BASF's technology partners (at present Quantafuel, Pyrum and New Energy) that convert the waste to pyrolysis oil. The pyrolysis oil is then purified and can be used as virgin-quality-feedstock at the beginning of BASF's "Verbund" production. Then, BASF allocates the recycled feedstock to all chemicals in the "Verbund" system via a certified mass balance approach (see Ellen MacArthur Foundation 2019). The chemicals obtained are then used by BASF's customers in their respective production processes. The project started on a pilot scale through to small commercial scale projects and it is supposed to be subsequently applied on an industrial scale. *For further examples, see research report, Annex I.*

Overarching topic: Circular economy

The idea of a circular economy combines several of the solutions for climate neutrality described above: renewable feedstock, efficient production, recycling and carbon utilisation. In addition, product re-use, such as the leasing model for solvents offered by SusChem, and (re)design is considered (Deloitte/VCI 2017). Product design may contribute to a circular economy by making components come apart easily, using 100% recyclable material or new primary and recycled materials that meet functional requirements without unwanted additives and contaminants (Green Chemistry and Commerce Council 2021). Figure 3 shows different aspects of circularity along the chemical value chain involving raw materials, the chemical industry, the customer industry, and end users.

[20] Pyrolysis is a thermochemical treatment, which can be applied to any organic (carbon-based) product. It can be done on pure products as well as mixtures. In this treatment, material is exposed to high temperature, and in the absence of oxygen goes through chemical and physical separation into different molecules. The decomposition takes place thanks to the limited thermal stability of chemical bonds of materials, which allows them to be disintegrated by using heat. Thermal decomposition leads to the formation of new molecules. This allows products to be received with a different, often more superior character than the original residue. Thanks to this feature, pyrolysis becomes an increasingly important process for today's industry – as it allows a far greater value to be created for common materials and waste.

Figure 3: Circularity of the chemical value chain



Source: own, based on Accenture 2017 and Deloitte/VCI 2017

The circular economy aims to improve material efficiency and sustainability by considering the full life cycle of products and processes. This requires increased cooperation among value chain partners and avoiding downgrading and contamination (ICCA 2021; cefic 2019; Wyns et al. 2019). The focus may shift from products to services, such as smart systems for stock management or leasing industrial tyres (Trelleborg 2021). Establishing a functioning circular economy requires investments in infrastructure and assets, partnerships and contractual agreements, and a central authority to coordinate and ensure synergies and transition speed (Accenture 2020).

CEFLEX – A Circular Economy for Flexible Packaging

CEFLEX is a European initiative bringing together more than 160 partners representing the entire flexible packaging value chain from raw material producers, to ink, coating and adhesive suppliers, film producers and converters, brand owners, waste management companies, recyclers, extended producer responsibility organisations and technology suppliers. Their common goal is to make all flexible packaging in Europe circular by 2025. This is to be achieved by a 5-step roadmap, endorsed by all stakeholders, together with a set of actions (Ceflex 2021).

Other GHG emissions

Generally, electrification will also reduce other GHG emissions besides CO_2. In the sector, nitrous oxide (N_2O) emissions result from the production of nitric acid (fertiliser production), adipic acid (nylon polymers) and glyoxylic acid (drug precursor). Technologies exist and have been implemented for many years to cut these emissions: 95% of the N_2O produced is now captured and destroyed. A rate of up to 99%, thanks to a doubling of the installations or through new catalysis technologies, may be reached in the next few years. Three cost-effective solutions already exist to abate N_2O emissions: breaking down the gas into nitrogen and oxygen using a catalyst, installing a thermal reduction unit at the end of a plant's exhaust pipes or capturing emissions to be used for other manufacturing processes such as flat screen displays (American Chemical Society 2021). A phaseout of HFCs is expected due to a European regulation that aims at developing new refrigerants with lower Global Warming Potential (GWP)[21].

[21] Global warming potential is the heat absorbed by any greenhouse gas in the atmosphere, as a multiple of the heat that would be absorbed by the same mass of carbon dioxide.

With the financial support of the European Union

Upstream, Scope 3[22] methane emissions related to sourcing of natural gas are still relevant, but inside the sector they are negligible (Conseil national de l'industrie 2021).

Examples of technologies in the four sub-sectors

The importance of respective technological pathways differs between sub-sectors. For example, circular economy approaches are particularly important for the plastics and rubber industry. Due to the nature of the pharmaceutical industry, adoption of other circular economy business models, such as product life extension, sharing platforms or product-as-a-service, present more of a challenge. The following figure shows examples of future-oriented technologies playing an important role in the four sub-sectors.

Figure 4: Examples of technologies in the four sub-sectors

Chemical industry	Pharmaceutical industry	Plastics industry	Rubber industry
New raw materials: steel mill flue gas valorisation for chemicals; CO2 as feedstock for methanol, polymers and specialty chemicals; biomass to methanol, bioethanol and BTX; bio naphtha to olefins; cameline oil to produce paints and varnishes/use of lignin; sugar surfactants for detergents, ethylene from bio-ethanol dehydration **Enhancing energy efficiency in the production process**: selective membrane filters in ethylene production; catalytic naphtha cracking **New processes**: ODC technology for chlor-alkali-electrolysis; methane pyrolysis-ammonia synthesis process chain for ammonia production; synthetization of "green e-methanol", methanol to olefins, water electrolysis for green hydrogen	**Enhancing energy efficiency in the production process**: improved leak control in the chillers and coolers and a change of refrigerant solution **New processes**: biological processes instead of chemical synthesis; reduction of the number of synthesis steps **Circular economy**: using vapor capture technology (VCT) to reuse the gas previously lost; replacing HFa inhalers with dry powder ones	**New raw materials**: plastics from biogenic carbon; bioplastics; thermoplastic lignin production **Recycling**: physical recycling of expanded polystyrene; high density polyethylene from advanced recycling; circular polyethylene derived from post-consumer recycled material; recycling of CFR-Composites; polymers out of plastic waste, PET and PS chemical recycling **Circular economy**: polyurethane based on a circular feedstock sourced from a waste product of the mobility sector; circular polypropylene solutions; plastic waste pyrolysis for circular naphtha	**New raw materials**: green butadiene from plants; peptizers and processing promoters for elastomer compounds from vegetable oil, CO2 as feedstock in elastomers; thermoplastic polyurethane based on CO2 technology **Enhancing energy efficiency in the production process**: vulcanizing agents and accelerators helping achieve vulcanization in a more efficient way at lower temperatures **Recycling**: decomposition of old tires in high-temperature process into carbon black, oils, gas and steel; granulation of scrap tires **Circular economy**: use of crumb rubber as infill in artificial football turf pitches; energy recovery; end-of-life tyre management

Sources: Interviews, EFPIA 2016 and 2020, ETRMA 2020, Abdallas Chikri/Wetzels 2019, Bauer et al. 2018, Chan et al. 2019, Cefic 2019, Cefic 2021e, VoltaChem 2016, Pöyry 2020

[22] For further information on different scopes of emission, see p.10

For further information on sub-sector specific developments and technologies, see research report, *Annex II.*

Companies' strategic choices

Several challenges and opportunities for companies arise from the general framework conditions and the need to implement future-oriented technologies, as described above, are shown in the following figure:

Figure 5: Opportunities and challenges for companies on the way to climate neutrality

Challenges

- Local environmental regulations impacting competitivity and leading to outsourcing and delocalisation
- Regulatory reuirements such as REACH and the Biocide Regulation can be innovation inhibitors especially for smaller companies and drive market consolidation
- Risk-intensive projects having an impact on the solvency of companies
- Determination of the right time for marketisation
- Lower demand for carbon-intensive products
- Change in capabilities / jobs needed to accompany the transition

Opportunities

- Growth and new business opportunities
- Resource, energy, CO_2 emissions and production cost savings
- Support to employer branding, employee engagement and retention and investor attraction through climate neutrality measures
- Enhanced value generation based on increased demand/ sales and extended product portfolios
- Value-to-society replacing shareholder value/investors increasingly orienting their investments to sustainability (sustainable finance)

Prognos 2019, Voß, 2013a

Small and medium-sized enterprises (SMEs) face greater challenges than larger companies in dealing with the impact of market changes, especially in terms of financial potential and resources for research and development. This can lead to SMEs being more vulnerable to risks, such as expensive tariffs on raw materials and surcharges for renewable energies, which can affect their competitiveness and survival. However, SMEs also have the potential to benefit from climate neutrality and may be more flexible in adapting to changes in the market. They are often innovative and focused on sustainable long-term investments, which could give them an advantage in the transition away from petrochemicals.

Due to insecurities related to the development of technological innovations (depending on which technologies will prevail), many strategic decisions are taken by companies under uncertainty. This includes decisions on the regional focus of the undertaking and on outsourcing, on business models and investments, on a technology mix appropriate to the individual company, on products and production processes. Companies are to respond to changes in the markets and pursue new opportunities to stay competitive (Cp. McKinsey 2018b, McKinsey 2020).

2.3. First workshop: Framework conditions and companies' choices

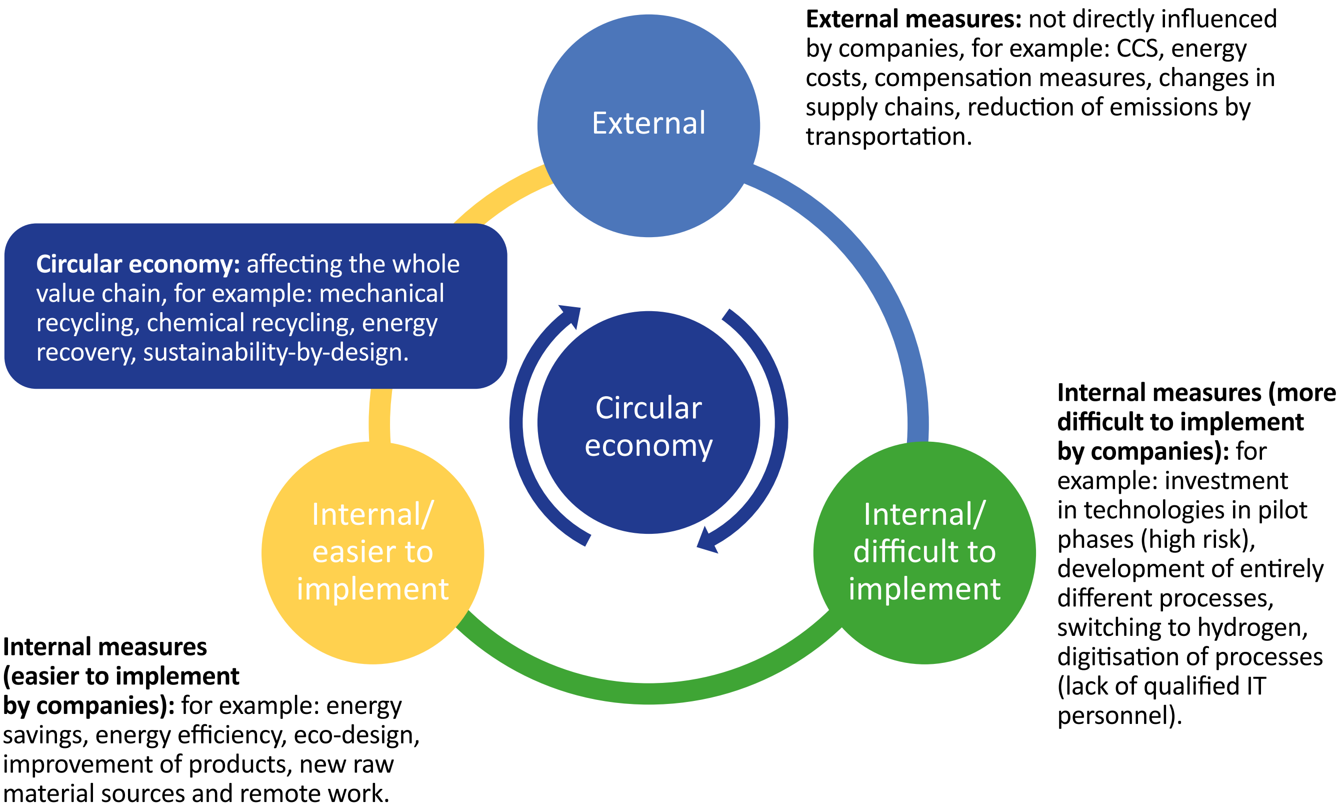
The first workshop was held online on 25 and 26 January 2022, due to the restrictions caused by the SARS-Cov2 pandemic situation. The objective was to discuss the framework conditions of companies' choices towards decarbonisation and to identify various scenarios.

With the financial support of the European Union

The workshop began with a roundtable discussion where participants shared their views on measures to reach climate neutrality and identified several focus areas. These included the need for new technologies to reduce greenhouse gas emissions, a Just Transition at a sectoral level, framework conditions to enhance decarbonisation, and additional measures at the company level. Wmp and Syndex then presented their [research report](), which sparked a debate on the necessity of massive investments in Carbon Capture and Storage (CCS) solutions and chemical recycling technologies, as well as the importance of market influence on corporate actions and the need for a common energy price.

Against this background, scenarios of measures that companies may choose to reach climate neutrality were developed:

Figure 6: Scenarios developed in the first workshop



Source: own illustration

- First, there are external measures that cannot directly be influenced by companies in the European chemical industry. These measures include, for example, Carbon Capture and Storage (CCS), where companies would depend on the development of storage sites and political support, but also energy costs, compensation measures, such as investment in forestation projects, changes in supply chains and the reduction of emissions by transportation.

- Second, there are internal measures that the companies may implement themselves. Here, participants differentiated between measures that are easier to implement and those that are more difficult to implement.

    - Internal measures that are easier to implement by companies in the chemical sector include energy saving and energy efficiency measures, choosing transition energies, eco-design and the improvement of products, new raw material sources and working online. These measures were already quite widespread.

- Other internal measures are more difficult to implement by companies due to several reasons: the solution is not ready from a technological point of view, the implementation is very cost intensive, or other factors are hindering its implementation, such as the lack of availability of renewable energy or qualified personnel. While electrification, the use of hydrogen and alkaline electrolysis, for example, are technically feasible and easy, they are difficult to implement because of electricity prices. Introducing sophisticated IT infrastructure may be difficult if IT personnel are not available.

- And finally, there are circular economy approaches affecting the whole value chain and including measures, such as mechanical recycling, chemical recycling, or energy recovery. A key element is sustainability-by-design. When designing a product, it must be considered that the product can be reused, repaired, recycled, etc.

In addition to the areas of focus mentioned, the workshop also highlighted the importance of collaboration and partnerships among stakeholders, including industry, policymakers, and civil society, to achieve climate neutrality. Participants noted the need for a clear regulatory framework and incentives to support investment in low-carbon technologies and processes. They also emphasised the importance of education and awareness-raising to encourage sustainable consumption patterns and behaviour change. Also, participants discussed the potential of circular economy models to reduce waste and emissions in the industry, highlighting the need for further research and development in this area.

The discussion was further explored in three working groups, where participants discussed changes necessary in companies' strategies and emphasised the need for concrete solutions and support for SMEs, national policy coordination, and public image improvement. Technological changes were also discussed, with a focus on the impact on working conditions, upskilling, and the importance of data management and cybersecurity. Structural changes were highlighted as well, with a need for an EU framework to implement the transition and prevent companies from being driven out of business, along with incentives to stay in Europe.

For further information, see summary of the first workshop.

3. Ensuring a successful transition

The transition of the sector to climate neutrality will only be successful if it is associated with industrial growth and good work. In this context, there are different starting points for companies to accompany the transformation, as well as for assessing and shaping the impact on workers. The following paragraphs give a non-exhaustive overview of possible starting points to ensure a successful transition collected throughout literature review and interviews.

3.1. Fields of action for companies

Anticipation of change and risk management

Companies are to anticipate and analyse technological, economic, and social disruptions to recognise opportunities and risks early on for future viability (Deloitte/VCI 2017). However, only 15% of chemical sector respondents in a PwC survey have assessed potential transition risks (PwC 2020). Larger companies have assigned board-level committees to oversee and manage climate-related risks (see for example Michelin 2020a).

With the financial support of the European Union

Increasing cooperation and strategic partnerships

Cooperation, and strategic partnerships between companies within the sector and along the value chain are gaining importance, be it in the form of acquisitions, networks, (innovation) clusters or competence centres, linking companies (R&D departments) with each other, or linking companies with research institutes and other stakeholders, including public-private partnerships. Risk sharing, financing, feedstock supply and the exchange of knowledge are among the advantages of such partnerships. Relocations, restructuring and organisational changes can also be part of it.

Often, "bigger players" invest in start-ups, that promise technology developments. This can also provide an opportunity for many small companies with a limited (financial) ability to adapt to transition requirements. Strategic partnerships for innovation are also being formed, for example between tyre producers and the automotive industry, to bring new solutions to the market faster. The European Innovation Council (EIC), a funding programme launched by the European Commission in March 2021, dedicated to disruptive technologies, promotes cooperation between chemical companies and start-ups (Cefic n.d.a). New partnerships are also required with digitalisation and tech companies, creating a broader value chain to include new services and solutions (PwC 2020).

ERRLAB- a European network of laboratories

"ERRLAB was established by the benchmark rubber laboratories of France, Germany and Italy (LRCCP, DIK, CERISIE), with the support of the rubber industry National Associations: respectively SNCP, wdk, Assogomma and the European Tyre and Rubber Manufacturers Association ETRMA. Its objective is to share resources and expertise to provide an ever better and complete service to the rubber manufacture industry, with a special attention to small and medium enterprises, in the field of research & development, testing and certification." (ERRLAB n.d.)

Dow and Shell: Joint project to develop lower CO_2 emission crackers

Supported by the Dutch government, Dow and Shell have developed a technology programme to electrically heat steam cracker furnaces by joining forces with The Netherlands Organisation for Applied Scientific Research (TNO) and the Institute for Sustainable Process Technology (ISPT). After having advanced electrification solutions for today's steam crackers, while also pursuing game-changing technologies for novel designs of electrified crackers in the longer-term, the companies are now evaluating the construction of a multi-megawatt pilot plant, with potential start-up in 2025. The project relies on a joint multidisciplinary team with competences in electrical design, metallurgy, hydrocarbon technology and computational fluid dynamics (Shell 2021).

Promoting research and development and innovation

For product innovation, new raw materials, process and productivity innovation research and development activities play an important role. In most sub-sectors this leads to an enhancement of own R&D functions. Also, joint developments of new technologies become more frequent, leading to a decentralisation of R&D in customer markets (VCI/ Deloitte 2017). In the pharma industry, the economic model of the industry relies more and more on the externalisation of R&D, via small, specialised start-ups . The promising technologies to reduce the carbon footprint will induce a pressure by the big pharma players on the small start-ups to incorporate those issues. Moreover, this will generate a greater need of transversal competences in the major corporations, to transform the R&D projects into low-carbon emission manufacturing processes.

Innovation at Pirelli: Regional technology centres and an open model

Twelve technology centres are located all over the world, allowing a direct relationship with markets and end users, and with the main vehicle manufacturers whose R&D centres and factories are in the same geographical areas. Pirelli's model for research and development, implemented in accordance with the Open Innovation model, is carried out through several collaborations with partners who are external to the Group - such as suppliers, universities and the said vehicle manufacturers - for the purposes of pre-empting technological innovations for the sector, to direct research and development activities, and to respond to and steer towards the needs of the end consumer (Pirelli 2021).

Securing access to finance and funding opportunities

Investments will be needed in new production equipment, for example when switching fuels for heat production (McKinsey 2018a) or for remodelling existing plants. Using hydrogen instead of natural gas in ethylene crackers, however, only causes minor retrofit costs, process setup changes and shifts in safety requirements. Gradually replacing existing fuels with hydrogen enables the reuse of current infrastructure (FCH 2019). Hence, the costs incurred depend on the technologies chosen. Very large projects will be financed externally, and the related risk level is a key consideration for financiers considering the return on investment. Interview partners stated that investor relations and sustainability reporting will become more important. To take the step from innovation to implementation, even larger companies need external financial support. Regarding internal funds, a key barrier is the limited availability of capital for projects' improvement, due to the high level of competition for internal funds in multinational companies, more easily dedicated to growing markets, such as Asia, which present a better business case, or other projects that are more closely related to the core business (WSP and Parsons Brinckerhoff/ DNV GL 2015).

Reorganisation and changes to working methods

The need to reorganise company structures and to adapt working methods depends on the technological pathway chosen. Investing in a circular economy approach might lead to complete reorganisation of the company, as it is for example the case for Covestro. Starting in July 2021, the company aligned its corporate strategy to the circular economy.

While one interviewee estimates that far fewer changes are required on the input side when switching from natural gas to electricity than is often assumed (since the subsequent value chain remains the same, as the same plant can produce the same products without natural gas), increasing energy efficiency in companies does have an impact on internal processes and structures. To exploit energy-saving potentials in companies as extensively as possible, the focus must not only be on improving plant technology, but also on organisational structures, such as operational processes or staff with their qualifications and motivation. Overall, the energy transition can promote the further development of internal processes and structures as well as transparency (e.g. regarding energy data and costs) and strengthen the

With the financial support of the European Union

role of employees (Löckener et al. 2016). For example, at Worlée-Chemie GmbH, an Energy and Environment working group deals with the topics of energy, environmental and climate protection, and waste management. Annual reviews are carried out as part of integrated management systems. Reports on energy development are published, as well as a sustainability report for the last four years.

Developing new organisational competences

To be successful on their way to climate neutrality, adjusting portfolios and implementing technologies, companies need organisational competences such as market intelligence, business development and strategic marketing (Roland Berger Strategy Consultants 2017). Strategic capabilities required for carbon neutrality can be divided into six groups that interact with each other:

1. Leadership (i.e. a vision of the company's role in society and sustainability as part of the strategy)
2. Management Processes (i.e. representation of all business units in sustainability activities, sustainability as part of reporting and emission measurement and calculation)
3. Company culture (i.e., sustainability as part of everyone's job description, innovative work environment)
4. Expertise in various fields (i.e. multidisciplinarity, permit and grant application, lobbying, data analytics, marketing, communication)
5. Innovation (new business models, customer-orientation, holistic management of technology development, etc.)
6. Influencing business environment (i.e. cooperation with external research organisations, legislation and standards, network, identification of funding opportunities) (Kemianteollisuus et al. 2020)

As mentioned under the strategic capability 'Management Processes', to reduce their carbon footprint, companies in the sector need to assess their processes and products, identifying how they contribute to emissions. The result is highly relevant for the company's image, customer relations and for capital markets. Companies are advised to develop databases for the assessment of the portfolio, collecting all data relevant to emissions. For example, Evonik - together with seven other chemical companies - has developed a method based on the Portfolio Sustainability Assessment of the World Business Council for Sustainable Development (WBCSD)[23]. The PARC (Product Application, Region Combination) assesses how products perform in different applications in regions and how this can be quantified. Next Generation Solutions will be used to further develop and grow the portfolio. This also goes along with organisational changes. For example, five years ago, Evonik established a dedicated functional area for sustainability. It is also to be viewed across all management processes and is anchored there. Other companies, such as BASF, Bayer, Covestro, Clariant and Merck, also have entire staff departments with 10-30 employees who deal with the topic of climate neutrality.

[23] https://www.wbcsd.org/contentwbc/download/5870/80216/1

Establishing a strategic personnel policy and strategic workforce planning

Interview partners agreed that a major task for the sector will be to secure skilled workers. The challenges related to this task are diverse: starting with the mitigation of the effects of demographic change, to the organisation of training, further education of the existing workforce, up to the recruitment of new, qualified personnel. Considering both the sometimes-negative public image of the industry and the general competition for skilled workers, it might be very challenging to recruit people. The efforts in internal and external personnel marketing must be ramped up. Offering (more) apprenticeship positions and dual studies could also be an opportunity to secure the supply of young professionals (Stiftung Arbeit und Umwelt der IG BCE 2021).

In-company education and training programmes that enable innovation and the testing of new ideas are crucial for entrepreneurial innovation and transformation processes (Stiftung Arbeit und Umwelt der IGBCE 2019b). Leaders will need to assess and identify skills gaps and mismatches and compare workforce capabilities and needs, as well as to motivate employees to participate in qualification schemes (PwC 2020).

Skills development and strategic workforce planning at Michelin

Against evolving skills requirements, in 2018, Michelin established a new 'Managing and Developing People and Skills' process being sustained by a strategic workforce planning process (SWP), updated in 2021. The process is managed by the Group Competency Managers, each of whom is in charge of one skills-set (competency) leading to the creation of two new positions, Development Partner and Skills Manager. The SWP consists in identifying the potential risks involving the Group's skills and workforce needs over the next five years and recommending solutions to address them, covering job families for which the Group Competency Managers have identified issues requiring a response (due to a new organisation, significant changes in a job family or skill needs, etc.) (Michelin 2020b).

Involving employees

A company's workforce plays an important part in the adaption and diffusion of technological and organisational change (Toner 2011). Interviewees agreed that it is important to adapt the mindset of employees to the changes. To involve employees and raise awareness, communication to employees on climate-related issues is of utmost importance. For example, at the Finnish tyre-producing company Nokian, regular training and environmental communication are implemented to increase environmental awareness among the personnel (Nokian tyres 2021). Employees may also be involved in energy saving exercises through idea management and made aware of the issue. Social innovations in companies, e.g. new opportunities for participation around the use of resource-saving measures, can contribute to the transformation. An expansion of the in-house suggestion scheme, innovation prizes or bonuses can strengthen corporate innovation systems alongside R&D departments (Bollen et al. 2020). In this context, works councils and trade unions need to become more involved, for example, in the issue of training. It must be clarified how the works council can support the process. [24]

The French legal framework: ensuring that environmental consequences are a social dialogue topic

In the French legal framework, works councils are joint bipartite bodies composed of representatives appointed by employers from among managerial staff and of representatives elected by workers in the enterprise. Works councils are informed and consulted on the economic and financial situation of their company; the social policies (training, employment, working conditions, inclusivity, etc.) and the strategic objectives and plans, including their social consequences (needs and risks in training, workforce level, skills development, etc.). The company management discusses new propositions with works' council's representatives.

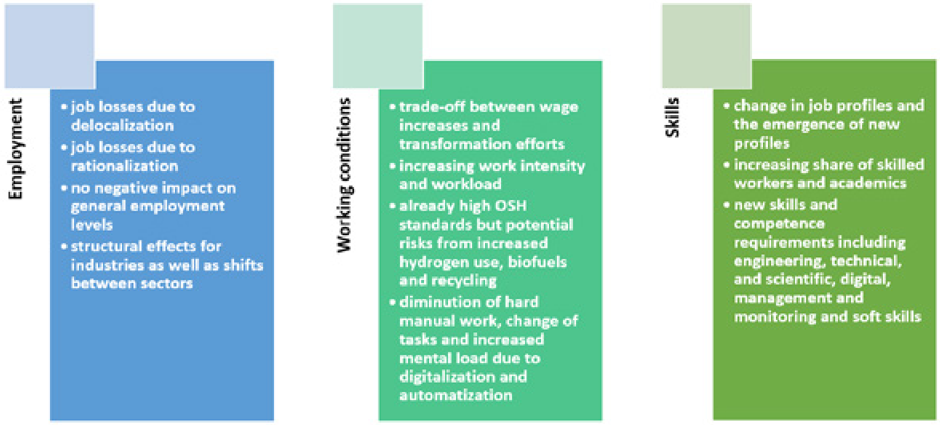
The Climate and resilience Act of June 2021 added the "environmental consequences" to the already existing fields of information and consultation. That new law also entitles the works councils to address the impact of activities on the climate, pollution, resources, animal life, etc. It entitles them to address, discuss and challenge the roadmaps to decarbonation in their companies, and to clarify the risks and needs on investments, skills, work conditions, etc. The law also enlarged the right to training for the workers' representative, to include environmental policies and the way to address them in social dialogue.

3.2. A workers' perspective

The transition will profoundly reshape the labour market in ways that create both new risks and new opportunities for workers: new jobs but also, in some cases, destruction of jobs, replacement of some existing occupations by new ones, along with the need for new competencies and skills. The transition may also impact the quality of jobs and working conditions (OECD 2012). Figure 7 gives a non-exhaustive overview of the possible impact of climate neutrality measures on employment, working conditions and skills considered in literature and interviews. It is followed by a consideration of relevant topics for social partners, including the assessment of the impact on employment, ensuring job and social security, the prevention of negative effects on working conditions, skills forecasting, and the assessment of competence needs, as well as the promotion of training and education.

[24] For further information on information and consultation, social dialogue at different levels and collective bargaining, see chapter 4.

Figure 7: Overview of impact on employment, working conditions and skills



Source: own

Assessing the impact on employment

According to interviewees, one major concern is that moving production to countries outside Europe or the purchase of parts and services abroad due to better economic conditions will cause job losses in European countries. Quality of jobs will depend on which part of the value creation will still take place in Europe. One of the major causes of such developments is the growing regulatory burden on EU-based companies, which reduces competitiveness vis-à-vis international counterparts in addition to investment requirements to meet 2050 climate goals. There is also the question of the relocation of certain jobs (administration/accounting/production) to places where labour is cheaper. While measures taken by the industry to increase energy efficiency can contribute to increasing the competitiveness of companies and thus to securing locations and jobs, works councils - especially from energy-intensive companies - point out that such investments can also lead to rationalisation effects reducing the volume of work (Löckener et al. 2016).

However, if delocalisation can be prevented, it is often assumed that measures taken to transition to a new, lower-emission economy will not have a negative impact on overall employment levels. Either they are considered to have no relevant impact (see, for example, Großmann et al. 2020 or OECD 2012), or to create employment due to investments in clean energy, energy efficiency in construction and electric vehicles that outweigh negative impacts in the fossil fuel industry (see, for example, IEA 2021b). However, studies agree that there are far-reaching structural effects for industries, as well as shifts between sectors. To counteract potential employment losses, new value-added structures, as well as training and further education offers, must be developed in parallel.

An analysis commissioned by the Foundation for Work and the Environment of the trade union IG BCE, based on three scenarios for achieving Germany's climate targets and resulting economic consequences presented in the study 'Climate Paths for Germany' (BDI/Boston Consulting Group/Prognos 2018), concludes that for the German chemical industry, negative effects of climate protection measures are more than offset by various positive effects. The chemical industry is estimated to benefit from the additional investments made by the economy in the climate scenarios, e.g. insulation materials or basic materials for lightweight construction and composites. While the study states that employment is increasing between 0.3% and 0.4% in the scenarios in which an 80% reduction in greenhouse gases is to be achieved, in the case of a reduction of 95% t of GHG emissions, the number of people in employment is 1% lower, as the pressure to modernise is significantly higher here than in the other scenarios. Stronger investment activity and a higher degree of automatisation are the result. As to the pharmaceutical industry, employment effects are estimated to be low, with reductions between 0.08% and 0.2%. In contrast, the study states that higher product prices lead to a decline in private consumption demand for rubber and plastic goods, which is noticeably below the reference level in all three climate

Restructuring in the rubber and tyre industry

The technology shift in the automotive industry may lead to sales and earnings problems and cause restructuring in the rubber and tyre industry. This, for example, was the case for the Freudenberg Group, where 170 jobs were affected in the Oil Seals Industry, Damper & Steering and Powertrain & Driveline Divisions and the Components unit. In addition, the radial shaft seals business at the factories in Kecskemét, Hungary, and Langres, France, was realigned. Production had to be adjusted in response to significantly lower demand for internal combustion engines and adapted to meet present and future market requirements. Some 250 jobs were affected (Freudenberg Group 2021). Confronted with decreasing demand in the automotive sector, further aggravated by the pandemic, to secure growth with relevant future technologies, Continental decided to bundle production, research and development tasks at the most competitive locations worldwide, as well as on portfolio adjustments under the transformation 2019 to 2029 structural programme. According to a preliminary analysis, up to 30,000 jobs worldwide are expected to be affected over the next 10 years by modification, relocation or reduction. In close cooperation with employee representatives, the company is trying to prepare the employees affected for the technological changes with structured training measures promoting employment (Continental 2020).

pathways. A reduction of employees in the sector of 0.5%, 0.9% and 1.8% in the different scenarios is the result stated by the study (Stiftung Arbeit und Umwelt 2019a).

Furthermore, a study commissioned to CETA, the Centre for Economic and Market Analysis, by the Czech social partners in the chemical sector, SCHP ČR and ECHO trade union, found that severe negative impacts can be expected on employment in chemical industry in the Czech Republic, decreasing by around 17% because of the implementation of the European Green Deal. It is estimated that countries with a bigger share of employment in energy-intensive industries will suffer from a more negative impact on employment (CETA-Centrum ekonomických a tržních analýz, z. ú. 2020).

It is still difficult to predict the quantitative development of employment and this report can only give a first hint of possible developments. However, there seems to be a broad agreement on certain qualitative developments linked to the structural change to employment in the sector. The crucial question is how and when an upscaling of new technologies in production will take place. The technology switch offers great opportunities for R&D jobs. However, jobs in production will depend on new technologies being scaled up.

Regarding employment development in the hydrogen economy, experts estimate that the expansion of the use of “clean” hydrogen will at least secure jobs and even lead to job creation (see, for example, Hydrogen Council 2017; FCH 2019; Deutscher Wasserstoff- und Brennstoffzellen- Verband e.V. 2018). Job creation potential is estimated to be more important where hydrogen is used for energy creation production (Jepma et al. 2019). The transport sector and vehicle maintenance have a larger potential for job creation than industry (CE Delft 2018). Clean hydrogen is estimated to be part of a Just Transition and good for job creation, as it may avoid the need to restructure existing industrial processes or phase out production along with fossil fuels (Stelpstra 2020; Renssen 2021).

Considering effects on social security and working conditions

The European social partners believe that the global transition towards a low-carbon energy production includes vital opportunities for businesses and can be achieved without compromising growth and jobs (ECEG/industriAll Europe 2015). IndustriAll Europe demands that the transition must be carefully monitored to ensure nobody is left behind. It is important to avoid mass redundancies, ensure a smooth transition to another job for each worker affected, establish safety nets of social protection for workers whose jobs will be at risk and invest in human capital at all levels (industriAll Europe 2019). Confronted with the uncertainty of how labour markets will evolve, policy measures must enhance their adaptability, at the same time providing adequate social protection for workers (OECD 2012), reducing the insecurity due to job displacement and making the tax and benefit systems more supportive of employment. Possible measures to tackle negative effects on job and social security, named by interview partners, include, for example, tax breaks, both for companies and workers, financial support measures for those losing their jobs. In addition, other measures include assistance to transfer to a different but similar field of work, retraining for qualifications in new occupational fields, promoting educational institutions and innovation projects and implementing a socially acceptable structural transformation programme (see also Hoch et al. 2020) . Measures also include promotion of internal mobility, job search assistance, provision of income security and identifying vulnerable regions and support for re-development plans (Nelissen 2019).

Companies in the coming years will need to invest massively in the transition in a context of limited access to capital. They might be forced to engage in cost-cutting programmes and restructuring in different areas that might affect the current working conditions of workers in the industry. Narrowing margins and increasing investment needs may lead to lower wage increases. There is a possible trade-off between wage increases and transformation efforts as companies are confronted with a multitude of investment needs and regulations to comply with. An OECD study suggests that policies which significantly reduce GHG emissions may depress real wages and workers can risk bearing a disproportionate share of the costs of the transition in the absence of compensating policies (OECD 2012). Interview partners highlighted that increasing work intensity and workload are observed as the energy transition has created the need for employees to constantly familiarise themselves with new regulations and topics.

Interviewees stated that occupational health and safety is already very much developed in the sector. Very high standards are already implemented in most companies and countries. Consequently, they do not expect any important changes due to climate neutrality measures and new technologies. Still, some potential risks concerning the increased use of hydrogen, bioenergy, as well as mechanical and chemical recycling, are mentioned in the literature. A more widespread use of bioenergy may lead to higher physical, chemical and biological risks for workers. High temperatures, and sometimes high pressures, are used in pyrolysis and gasification, resulting in risks from fire and explosion. Biofuels have the potential to give rise to new biological risks (European Agency for Safety and Health at Work 2013).

So far, the quantity and composition of the process emissions are not recorded and the impact of the actual emissions on the health of the staff can often only be estimated. Chemical recycling comprises processes which are still far from being ready for the market and whereof risks for employees are still unclear and must be investigated as early as possible (IFA, 2020). Still, working conditions are likely to improve with each investment, resulting in cleaner air and fewer carbon emissions.

Regarding digitalisation and automatisation, a positive impact includes a diminution of hard manual work. In addition, tasks are changing. As predictive maintenance becomes more important, workers no longer accompany the whole process, but must use a specific knowledge on special occasions. Worker's health and safety is an important priority for the chemical industry supported by Cefic, for example partnering with the European Agency for Safety and Health at Work (Cefic 2020). To anticipate and prevent psychosocial and physical risks, assuring healthy and secure working conditions is not a new issue for companies and social partners in the sector (see, for example, the joint initiative of the German Chemical Employers' Federation, BAVC, and the trade union, IGBCE, on good and healthy work in the chemical sector[25]). Based on an assessment and analysis of risks related to digitalisation or other technological advances, preventive health measures may be taken. Cefic and ECEG are also 'friends' of the Roadmap on Carcinogens, which was launched under the Dutch presidency in 2015[26] and were part of the EU-OSHA healthy workplaces campaign on

[25] https://www.bavc.de/service/pressemitteilungen/1774-gutes-und-gesundes-arbeiten-in-der-chemie-branche-chemie-sozialpartner-starten-gesundheitsinitiative
[26] https://roadmaponcarcinogens.eu

managing dangerous substances at work (2018-2019). They showcased good practice examples, but also pledged to decrease exposure to CM substances at workplaces.[27]

Skills forecasting and assessing competence needs

As stated by the Industry 2030 high-level round table, anticipating and developing skills is very important (European Commission 2019b). Also, interview partners agreed that a precise inventory of needs in terms of job profiles must be drawn up. Some interviewees do not consider the impact on skills and competences to be very important, since energy efficiency measures are incremental for plants operating over the long term (25-30 years) and even a modified process is still a chemical process. Others see changes in, for example, improved monitoring and control of the heating process. Training in the use of electrically heated systems may also be needed. However, systems already run largely automatically, so changes will be minimal.

A change in job profiles and the emergence of new profiles is likely. For example, retreading of tyres and the use of recyclable materials, the job profile of a "material planning analyst" will require additional competences as the supply chain becomes more complex and integrated (ESCA 2016). In the pharmaceutical industry, the global trend of switching from chemical molecules to biological ones leads to the need to recruit more biologists and fewer chemists in the R&D teams. With electrification of processes, there will be an increased need for electrical engineers. While electrification does not change the processes themselves, other competences are needed for maintenance. Further occupations that are becoming more important are, for example, energy managers, climate change analysts, sustainability specialists, chief sustainability officers, sales engineers, transportation planners, compliance inspectors, nuclear monitoring technicians or emergency management directors (Arthur 2021). As found by the Future Skills Forecast initiated by German social partners, BAVC and IGBCE, preventive maintenance, process control engineering, computer vision/image processing, virtual collaboration, additive manufacturing, Computer Aided Design (CAD), good automated manufacturing practices (GAMP), continuous improvement, process simulation and machine-learning, artificial intelligence and advanced statistics have become more important (BAVC/IGBCE/HR Forecast n.d.). It is estimated that the share of unskilled and semi-skilled workers will further decrease, whereas the share of skilled workers and academics is likely to increase.

New jobs and new processes require new skills (see Table 1). The general trend is towards increased demand for cross-cutting competences, such as problem solving and communications (European Commission 2018c).

Table 1: Overview of skills and competence needs on the way to climate neutrality

Engineering, technical and scientific skills	Digital skills
• applied biology, chemistry and electromechanics • applied thermodynamics, mechanics, and aeronautics • scientific and mathematical skills • (renewable) energy technologies and design • energy-saving • process optimization, with an environmental focus • product design ("safe and sustainable-by-design") • materials science • technical-scientific interface competencies • research and development expertise	• industrial IoT technologies (e.g., connectivity, smart metering, predictive maintenance) • robotic process automation technologies • cyber & application security technologies • augmented reality • programming • data science: artificial intelligence and big data • principles of process simulation / digital twins • machine learning • data processing and analytics

[27] https://healthy-workplaces.eu/en/previous-campaigns/dangerous-substances-2018-19

Management and monitoring skills	Soft skills
• lobbying and influencing • permit and grant application • sales and marketing • managerial agility • life-cycle management and analysis, lean production and cooperation with external actors, including customers • sustainable energy management (demand vs. supply) & monitoring • technical standards and legal aspects • environmental impact quantification and monitoring • economic and financial modeling • social impact analysis • leadership • change and transformation management • stakeholder management • quality management • energy management • sustainable & customer-oriented product and material design	• design thinking • creativity • adaptability, resilience and flexibility • ability to work in a team • ability to cooperate and communicate • analytical understanding and ability to abstract • responsibility • critical & ethical thinking • decision-making skills (based on data / assistive technologies) • systems thinking / process thinking throughout the different steps of the production process • creative and innovative thinking • entrepreneurship • willingness to learn • scenario thinking • flexible planning & organisation • (agile) project operation • coaching & training • participative techniques • multidisciplinary collaboration • intercultural and language skills, international experience • communications and media expertise • self-development

Sources: Arthur 2021, Roland Berger 2021, Löckener et al. 2016, Cefic 2019, Kemianteollissus 2021, Interviews

Regarding changed skills and competence needs in the hydrogen economy, the future hydrogen economy will require additional, well-trained specialists (Kaiser et al. 2020). Several US American research studies focused on the analysis of hydrogen economy jobs are finding that the jobs created are disproportionate for highly skilled, well-paid, technical,

New job profiles at Yara: Technical expert - Ammonia Product carbon footprint and certification schemes

Yara International headquartered in Oslo, Norway, is a manufacturer and supplier of chemicals and industrial gases such as fertilisers, urea, nitrates and ammonia. The Energy & Environment Department presently consists of 12 persons in various locations, who drive and manage Yara's decarbonisation and non-GHG environmental efforts, including both project portfolio management and operational excellence initiatives globally in Yara's production system. The department is closely following up energy and climate related regulations and the development of carbon markets to assess the impact on Yara's carbon footprints. The technical expert will participate in initiatives set up for the developing of Yara's internal carbon footprint schemes, influencing the development of international standards and certifications for low-carbon products (Yara International 2021).

With the financial support of the European Union

and professional workers. Still, emerging hydrogen industries do not exclusively require highly educated workers, but a wide variety of occupations at all skill levels. Many of these jobs do not currently exist and require different skills and education than current jobs, and training needs must be determined. Because of constantly evolving technologies, forecasting skills and training needs is quite difficult. Higher education and vocational training programmes need to be assessed to understand where the opportunities lie and what additional curricula may be required (Bezdek 2019). Locally differentiated education and training strategies need to be developed, as the demand for skilled workers for project development and construction of new facilities can vary greatly at the local or regional level and can quickly lead to shortages (Krichewsky-Wegener et al. 2020).

Promoting training and education

As ECEG and industriAll European Trade Union state in a joint declaration on the European Commission's Green Paper 'A 2030 framework for climate and energy policies' "the chemical industry can only be competitive with a highly skilled and qualified workforce. Training and education therefore also require investment to ensure a Just Transition and the best possible skilling for European industrial workers to handle new technologies" (ECEG/industriAll Europe 2013). Confronted with a general shortage of skilled labour and many advertised positions still vacant, the need for qualified employees in the sector is increasing (IFA, 2020; see also European Commission 2019a). Workers in the sector are already highly skilled. Still, acquisition of new skills and training is essential. Continuing education is a necessity.

Training for sustainability at Evonik

Methodological competence training is offered at Evonik. There are tutorials, online training courses and digital "Evonik Learning Hours" in which up to 2,000 employees participate. The topics of sustainability and climate are also integrated into standard management training courses. New works councils are encouraged to address the issue. Actors, such as employee representatives on the supervisory board, must be qualified so that they can participate in internal and external discourse (Source: interview).

International training network at Pirelli

As "to innovate is to keep learning", Pirelli has established an extensive training network across all countries where the company is present. Ten Professional Academies - among others the Manufacturing Academy and R&D Academy - play an important role in the company's technological development. Sustainable Management elements are transversal throughout the Academies, with a focus for example on environmental efficiency of the process, health and safety, sustainable management of the supply chain, risk management and diversity management (Pirelli 2020).

Regional training alliances in which large and small companies join forces would be one solution put forward by interview partners. Interview partners and workshop participants highlighted that training structures need to be created where they do not yet exist. While many large companies already provide training, with SMEs playing an important part therein, the latter are a very heterogenous group and a number of small companies do not have the opportunity train their workforce. Interaction between businesses and educational institutions must be increased. International cooperation is highly important. Policies, such as increased university marketing and talent programmes, can help individual companies attract skilled workers (Kemianteollissus 2021).

A certain willingness to change is required from employees. Uncertainty about how their jobs and tasks may evolve in the future may negatively affect employees. Here, the works councils and trade unions could play a role in involving employees. Apprenticeships and training need to already prepare employees for change and give them the resources to adapt.

3.3. Second workshop: The impact of transition towards carbon neutrality on companies and workers and the role of social partners

The second workshop took place on 14 and 15 June 2022, in Zagreb (Croatia). The aim was to discuss the impact of the transition towards carbon neutrality, both on workers and companies, as well as to identify the role of social partners in the process.

The first day started with the presentation of the results of the research report by wmp and Syndex and of the different scenarios on how to reach carbon neutrality by 2050, identified during the first workshop. The focus was on the impact of the transition on employment, working conditions and skills, which depend respectively on the impact and speed of each identified scenario. Several fields of action were distinguished for the social partners to address at company level. A round-table helped to specify the actions needed to be taken at company, regional, national or European levels in the fields of health and safety, employment and skills regarding the transition and its implications. The participants identified the need for cooperation and planification, both at local and national levels, constructive social dialogue to elaborate on strategies to decarbonise, ensuring social and work conditions' standards of the future green jobs. It has been specified that there is a need to associate the workers' representatives to the definition of the new competences, skills and qualifications required for the transition, and therefore the need to equip the social partners with knowledge in that field.

A presentation by SME United[28] addressed the issue of the impact of the transition on SMEs, keeping in mind that SMEs in Europe are a very heterogenous group. The major needs presented are:

- the facilitation of access to already existing financial support, data, etc.
- simplification of application procedures requesting/acquiring financial or technical assistance
- massive investments in R&D to enhance new technologies
- information at local level to share good practice examples and technologies
- specific incentives for SMEs to help them to implement massive changes on a limited scale (e.g. specific tax rebates to invest in green equipment)
- a better forecasting and planification of upskilling, reskilling and developing new skills at a global level

The second day focused on the concrete actions to ensure a just and successful transition, namely:

1. Policy demands, with a need for legislation to shape practices and support efforts on waste management, circular economy, development of green energy, and protection of the European market against less decarbonated economic actors. The participants also clarified the need for local and national framework agreements to enhance transition plans and pathways co-created by the social partners. Those pathways should include guidelines for investments fostered by political incentives.
2. Skills and training: participants identified the need for mapping of existing and anticipated skills, better planning and engagement with the education system (authorities, VET and training providers, etc.), companies and workers.
3. Employment: participants emphasised the need for more information, data and foresight of the development of workforce. Commitment to securing a skilled workforce.
4. Working conditions: participants highlighted the need to renew the framework conditions (such as legislation and collective bargaining) to adapt to the decarbonisation demands. Information sharing with workers, such as objectives, potential changes in work organisation, tools, and technologies that the transition will entail.

28 For more information about SME United, please visit the official website: https://www.smeunited.eu.

With the financial support of the European Union

These changes might come with a set of new risks that the legal and collective framework need to address to ensure that already existing high standards in health & safety, working conditions, and policies at the workplace remain unchanged.

Participants were finally encouraged to share further examples and ideas to fuel the discussion of the third workshop and to develop concrete tools for social partners. For further information, see summary of the second workshop.

4. The role of social partners

4.1. The importance of and the possibilities for social partners' involvement

As stated in a study commissioned by the European Economic and Social Committee (EESC) regarding the future of work and a general more human-centred approach to managing change, a key component in the form of social dialogue, including collective bargaining and tripartite cooperation, was identified (EESC 2020). Establishing a culture of social dialogue at all levels (company, sector, regional, national) is an important element for timely anticipating the change and for avoiding potential social disputes, promoting retraining, upskilling and job-to-job transitions alongside accompanying policies (ETUC/BusinessEurope/SMEUnited/SGIeurope 2022; see also European Commission 2021b; Nelissen 2019). Social dialogue can also play a key role in managing the balanced adoption of new technologies (ILO/OECD 2020).

Ideally, social partners should accompany and support their members in this transformation process and help shape it in a way that is socially and economically viable. This could encompass measures and projects at all levels, such as:

- From works councils' initiatives to professional training plans
- Provision of further training measures and the monitoring of existing ones
- Negotiations of relevant company level or site agreements
- Information and consultation mechanisms to better anticipate strategic, economic and technological changes and their impact on competences and skills
- National measures and collective agreements
- Transnational social partner cooperation, including joint projects, but also transnational and European framework agreements

Relevant aspects for a successful transition, such as training, health & safety and management of change, may be subject to cross-border collective bargaining and transnational social dialogue (IZA 2011). Furthermore, European social partners could engage in communication and education campaigns related to the transition, as well as seeking dialogue with experts, policy representatives, and consumers. Generally, the participation in, or setting up of concrete stakeholder initiatives or workshops can, on the one hand, ensure that social partners' interests are represented and, on the other hand, actively help shape the transformation. Social partners may exert a formative influence on the advancement of the creation of incentives to implement the transformation (including electricity prices, support for research and development). A joint discourse of the social partners with policy representatives is necessary. They shall promote an assessment of industrial policy consequences. A joint identification of framework conditions to keep companies and production in Europe or in the country is very useful. Acceptance of the entire transformation cannot be achieved only via mere acceptance management and involvement, but also through co-determination and democracy.

However, social partners are faced with growing challenges on the way to climate neutrality. Both trade unions and employers' associations could be faced with an erosion of the social partnership and a declining importance of co-determination in the years to come. The transition might imply a shift towards a more fragmented economic system, where collective agreements and trade union representation are weaker (ETUC 2018). Also, differences in countries due to relevance of the sector for the economy and the shape of national industrial relations and social dialogue, as well as the impulses given by the government, will have an impact on social partners' approaches.

4.2. Examples of social partner initiatives at company, regional, national and transnational level

Company level

At the corporate level, the issue of climate neutrality is a big challenge for the management. As interviews and workshop results have highlighted, to ensure a successful transition, joint actions of the management and employee representatives are needed. Social partners need to be aware of each other's actions. Climate neutrality may also become a topic for works councils and for employee representatives on the supervisory board. Exchange of information, the implementation of change management and communication are key. Joint approaches for skills development are also very important. In general, employees and co-determination bodies have a major role to play alongside management in unlocking potential energy and resource efficiencies, as employee participation has a positive effect on the optimisation of processes and cross-cutting technologies. For example, the works council can be involved in idea management. Co-determination and co-design are to be considered.

The internationalisation of companies is placing industrial relations on a new footing. Both Europeanisation and capacity building in Asia and Arab countries are increasing the pressure and the need to create new forms of social dialogue and coordinate collective bargaining. Transnational company agreements have become an important tool to regulate working conditions, health protection, environmental responsibilities, and other aspects of corporate policy on a transnational and supranational level (Voß 2013b).

Some companies included climate neutrality goals and their consequences in company level agreements. For example, the *accords d'intéressement* (compensation and benefits agreements) in France. These agreements are mainly local, site-level ones, mobilising small-size initiatives and objectives. At Worlée, a German producer of chemical, natural and cosmetic raw materials, a joint goal-setting agreement was concluded with the works council. A common vision was developed, from which a mission was created, and a mission statement formulated. Worlée held meetings with employees to jointly develop values and principles in townhall meetings. Issues such as energy, the environment and resource conservation play a central role, among others, in the joint paper. Companies in the sector "contribute to improving carbon circularity and minimising greenhouse gas emissions by revolutionising materials, production processes and services across all sectors"[29] (see also chapter 2.2.).

Regional level

Industrial cluster areas are most affected by climate neutrality goals, regional policies and measures. In Belgium, for example, social partners are involved in the Social and Economic Council of Flanders (SERV), the main advisory body to the Flemish Government on Flemish socio-economic policy. To accelerate the transition to a circular economy, the Flemish social partners in the Social Economic Council of Flanders (SERV) have drawn up a policy agenda with 40 concrete recommendations. In preparation of the document 'The transition to a circular economy:

[29] https://cefic.org/a-solution-provider-for-sustainability/chemistrycan/going-climate-neutral/

With the financial support of the European Union

policy agenda and recommendations', the SERV organised four round tables with different sectors, including the chemical industry.

National sectoral level

Employers' associations and trade unions have developed their own projects aiming at getting a better picture of the industrial transformation ahead.

Employers' associations are important enablers of the transition to climate neutrality, assisting companies in the transformation. As most of the companies are micro- or medium-sized enterprises, the employers' associations can support them with sharing best practice examples and offering opportunities to exchange with other companies. In several countries, employers' associations have developed roadmaps for the chemical industry to become climate- or carbon neutral. While France Chimie presented a roadmap for the decarbonisation of the chemical sector by 2030, the roadmap of the Chemical Industry Federation of Finland (Kemianteollisuus ry) refers to carbon neutrality by 2045 and the German Chemical Industry Association (Verband der Chemischen Industrie-VCI) to GHG neutrality by 2050. All the roadmaps compare different quantitative scenarios, examine different solutions and measures and the impact thereof on GHG emissions.

In addition to the above, the German trade union IGBCE started a Transformation Camp in 2021 to take place every year, and launched a process called "Perspectives 2030+" in 2019. Based on four different scenarios, members are discussing possible solutions for the upcoming challenges linked to the industry's transformation. The aim is to develop a strategy for a future-oriented industrial policy by the end of 2021 (IG BCE 2021).

Table 2: Roadmaps published by the chemical industry associations in Finland, Germany and France

	Roadmap to reach carbon neutral chemistry in Finland 2045	Roadmap Chemistry 2050 - On the way to a greenhouse gas-neutral chemical industry in Germany	Roadmap for the decarbonisation of the Chemicals sector by 2030
Initiated by	Chemical Industry Federation of Finland (Kemianteollisuus ry)	German chemical industry association (Verband der Chemischen Industrie-VCI)	Chemicals and Materials strategic committee[30]
Scope of GHG emissions considered	Scope 1-3+ "handprint"	Scope 1-3	No definition
Scenarios	• Business as usual (BAU) • Fast development • Carbon neutral chemistry	• Reference pathway • Technology pathway • GHG neutrality 2050 pathway	Mature solutions Less mature solutions • Minimum • Medium • Maximum
Methodology	Quantitative calculations of GHG emissions, power use, investments, feedstock	Quantitative calculations of GHG emissions, power use, investments, feedstock	Quantitative calculations of GHG emissions reduction potential

[30] The committee brings together the federations of the Chemicals (France Chimie, FEBEA, FIPEC and FNCG), Plastics and Composites (Polyvia), Paper and Cardboard (COPACEL) and Rubber (SNCP) industries representatives of the CFDT and CFE-CGC and the signatory Ministries (Economy, Ecological Transition and Labour)

Technologies/ solutions examined	Power-to-Chemicals Energy efficiency Electrification and power-to-heat Raw material changes CCS/CCU Process development Synthetic biology Digitalisation	Chlor-Alkali-Electrolysis Production of hydrogen Ammonia synthesis Methanol synthesis Production of olefins and aromatics	Mature: • Energy efficiency • Decarbonated heat source • Reduction of N_2O emissions • Reduction of HFC emissions Less mature: • Hydrogen • CCS • Electrification

Source: Pöyry 2020, DECHEMA/FutureCamp 2019, Conseil national de l'industrie 2021

In addition to the roadmaps, the Chemical Industry Federation of Finland, together with Accenture, the Finnish Innovation Fund SITRA and Business Finland, a Finnish public actor that provides innovation financing and internationalisation services, and promotes tourism and investment in Finland, have developed a 'Circular economy playbook for chemical companies'. It is to provide a good understanding of the importance of the chemical industry in accelerating the broader transition to a sustainable and circular economy across industries (Kemianteollisuus et al. 2020).

Responsible Care Project - implemented and monitored by social partners in Finland

Central themes of the Responsible Care Programme include sustainable use of natural resources, sustainability and safety of production and products, well-being of the work community and open interaction and co-operation. In Finland, 98 companies have committed to the programme, representing some 80% of all production in the chemical industry and some 60% of its employees. The Chemical Industry Federation of Finland coordinates the implementation of the programme in Finland. Members participating in the monitoring and development of the programme include The Industrial Union, Trade Union Pro and the Federation of Professional and Managerial Staff (YTN) (Kemianteollissuus n.d.).

As part of the Responsible Care Project within the project 'Climate-Neutral Chemistry', the Association has been working with member companies since 2018. Two major goals are set: 1) to reduce the footprint of operations and 2) provide solutions to society to reduce its emissions to increase the carbon handprint. In the last two years, preparatory work has been carried out, creating technology roadmaps, playbooks, figuring out what strategic capabilities are needed and what the framework conditions are. Trade unions have been involved right from the beginning of the process.

Future skills needs were addressed by the Dutch Chemical Employers' Association, VNCI, that coordinates a human capital agenda for a better coordination of education and necessary qualifications on the labour market (labour market monitoring, talent programmes, broad networks). In a memorandum for the 2019 regional, federal and European elections, Essenscia, the Belgian Employers' Federation of the Chemical Industry and Life Sciences highlighted the importance of strengthening education and training (essenscia 2019).

Joint projects and initiatives from social partners are growing. For example, the German social partners, BAVC (the German Federation of Chemical Employers' Associations), and IG BCE (the Mining, Chemical and Energy Industrial Trade Union), are in constant dialogue, among others, on climate neutrality. Some of the initiatives include the Chemie³ sustainability initiative founded by the German Federation of Chemical Employers' Associations, BAVC, IGBCE and the German Chemical Industry Association, VCI, to develop sustainability guidelines for the chemical industry in Germany. Another example includes the future forum for a sustainable plastics industry, initiated by IG BCE (the Mining, Chemical and Energy Industrial Trade Union) and the German Association of Plastics Converters (Gesamtverband Kunststoffverarbeitende Industrie GKV) in 2011 for exchange and communication towards public and politics (GKV

With the financial support of the European Union

Feasibility and impact study of the European Green Deal and of industry decarbonisation on the chemical sector of the Czech Republic with a focus on employment

In 2020, a study commissioned by the Czech social partners in the chemical industry, SCHP ČR, and the trade union ECHO was published, describing a wide range of issues related to meeting the objectives of the European Green Deal and the green transition of the economy. It analyses the impact of the Green Deal on employment and the planned sources of funding for measures to minimise its negative impact, including spending on wages and investments related to the creation of alternative jobs.

In the Czech Republic, industry is a significant part of the economy and accounts for a large share of employment. Therefore, the transition is more threatening than in countries where the share of industry in employment is lower. Economic actors will have to deal with significant negative cost pressure and declining demand. An approximation of the impact of the European Green Deal on the labour market in the chemical industry in the Czech Republic is carried out on the basis of models predicting the development of employment in three different scenarios between 2020 and 2030, showing that without an adequate response from the Czech Republic or the EU, jobs in the chemical industry will disappear.

A survey conducted in August 2020 among 30 members of the Association of the Chemical Industry of the Czech Republic found that about 89% of respondents perceive the European Green Deal as a threat, about 2/3 of companies plan to freeze their current headcount out of prudence, regardless of economic developments, and slightly more than half of companies expect that they will not have enough funds for wages and investment in human capital (CETA 2020).

2011). The Social Partner Workshop for Innovation and Sustainability So.WIN (Chemie3 n.d.) and a qualification offensive for the chemical industry, signed by German chemical industry's social partners as part of the 2019 collective bargaining agreement. 'Future Skills Report' a qualification advisory service developed by the German Federation of Chemical Employers' Associations, BAVC, IG BCE and the German Federal Employment Agency, also includes an analysis tool to better map the skills available in companies (BAVC 2020). Joint recommendations for action for the chemical and pharmaceutical industry were drawn up by the German Federal Ministry of Economics, resulting from an intensive dialogue with BAVC, IG BCE and VCI (VCI/BAVC/IGBCE/BMWi 2021).

As the above examples showcase, a close cooperation among social partners and an enhanced dialogue between employers' associations and trade unions could increase the success and visibility of their activities.

European/transnational level

At the transnational level, 13 trade unions from Denmark, Finland, Germany, Iceland, Norway and Sweden, represented by the Council of Nordic Trade Unions (NFS), the Friedrich-Ebert-Stiftung (FES), and the German Trade Union Confederation (DGB), carried out a project in 2021 entitled 'The Road Towards a Carbon-Free Society'. A Nordic-German Trade Union Cooperation on Just Transition is based on six country reports, analysing national climate policies and the respective national instruments, as well as economic and social consequences. This synthesis report gives political recommendations covering both national and European levels to support the transition towards a carbon-free society in a just and sustainable way. It highlights the importance of education, training and better work environment, social protection and collaboration (FES 2021).

At the end of 2019, the European Chemical Industry Council, Cefic, developed a scenario modelling tool of the chemical industry for climate neutrality by 2050. It adopts a cradle-to-gate approach, producing four illustrative scenarios comprising electrification, circularity, biomass, and Carbon Capture and Storage (CCS). Technologies are considered in relation to their contribution to climate neutrality as well as their technological readiness. These are grouped in four categories:

1) Alternative processes enabling the use of low-carbon energy (such as electric crackers playing a central role in the production of basic chemicals and requiring a significant amount of energy to break down hydrocarbons into olefins and aromatics or ammonia from green hydrogen produced by electrolysis using electricity from renewable sources)

2) Low-carbon heat and steam supply, for example through electric or hydrogen boilers

3) Alternative processes enabling the circular use of carbon (plastic waste pyrolysis or gasification, CO2 as feedstock, etc.)

4) Carbon capture, transport and storage technologies (Source: Interview)

Furthermore, a joint trade union project funded by the European Social Fund started in 2021, named *'Werknemers als hefboom voor een circulaire economie*' ('Employees as leverage for a circular economy'), and initiated by the Flemish trade unions cooperating with trade unions across Europe to gather concrete examples and guidelines for supporting the transition in terms of training, sector consultation, studies, mobilising communication and events.

In October 2020, the European Tyre and Rubber Manufacturers' Association proposed, in cooperation with DRIVES (Development and Research on Innovative Vocational Educational Skills project funded by the Erasmus+ Sector Skills Alliances Programme, 2018-2021) and the Alliance for Batteries Technology, Training and Skills' (ALBATTS), a strategy for the implementation of the European Commission's Pact for Skills, for the Automotive ecosystem. The aim is to put in place an up-/re-skilling framework which maximises industry competitiveness, job retention and new job opportunities, paving the way to a skills partnership for the whole automotive ecosystem. The initiative is supported by industry, educational and training institutions, as well as the European social partners, Ceemet and industriAll Europe (ETRMA 2020a; DRIVE 2020).

4.3. Third workshop: Good practices of social partners' involvement and development of tools

The third project workshop took place on 26 and 27 October 2022 in Budapest (Hungary). Its aim was to exchange good practices and to develop tools based on the results from the previous workshops.

The first day was dedicated to presentations of examples of activities by industrial associations and social partners at the European and national level. Firstly, the European Chemical Industry Council (Cefic)'s Director of European Public Affairs, George Kapantaidakis, presented the role and activities of Cefic in reaching 2050 climate goals. He focused on Cefic's vision, structure, role and advocacy priorities. He presented the state of play, the major parts of the EU Green Deal and elaborated on the chemical industry's double-twin transition which the sector is currently undergoing. He also referred to the Transition Pathways for chemical sector, a transformation roadmap co-created by the European Commission and the European level stakeholders. Cefic's priorities are to:

- Establish a credible timeline for investments
- Ensure regulatory predictability
- Monitor sustainable competitiveness
- Attain financial support to de-risk investments, resource availability and infrastructure requirements

With the financial support of the European Union

- Remove hurdles for cooperation
- Have solid REACH registration dossiers, promotion of animal-free New Approach Methodologies (NAMs)[31]
- Acknowledge chemical recycling of plastic waste in the Regulation

The presentation by Mr Kapantaidakis was followed by the representatives of the European Chemical social partners, industriAll Europe and ECEG, who shared activities focused on climate neutrality. IndustriAll Europe presented the Just Transition Manifesto[32], referring to skills and employment mapping. The ECEG presented the Blueprint project proposal for sustainable skills in the chemical sector, aiming at developing sector-specific green and digital skills alongside competences to produce safe and sustainable by design chemicals.

The representative of the Danish trade union 3F, Jannie Bunk, presented the approach of the Danish tripartite system, i.e. the Danish Government representatives and social partners, highlighting the need for the right skills and training for green transition. In this context, the government and the social partners entered into tripartite agreements to deliver on vocational and labour market education and developed new training courses and vocational training programmes (see toolbox).

Finally, the external experts from wmp and Syndex gave a short overview of their research study, by giving examples of social partner initiatives at company, regional, national and European levels.

The second day was dedicated to the development of tools and helpful materials by participants. Five of the topics that were identified during the second workshop and considered manageable by social partners were jointly developed in the setting of a 'World Café': The participants discussed the topics in small groups during three rounds of conversations at different tables. Each participant chose three topics. The results were collected on table cloths:

1. Storytelling
2. Checklist for social partners at company level
3. Project Glossary
4. Environmental coordinator

Kick-off event for regional coordination (for further information, see chapter 5)

During the discussions in the World Café setting, participants welcomed the opportunity to learn about practice examples from other countries and agreed that concrete tools would help to tackle the subject of climate neutrality within social partner organisations and at the regional and national level. It was agreed that the results from the third workshop would be developed further by the project team to feed into the project toolbox expected as one of the main results of the project. For further information, check the summary of the third workshop.

[31] https://cefic.org/app/uploads/2021/11/Joint-letter-Animal-Testing-CSS-1.pdf
[32] https://news.industriall-europe.eu/p/justtransition

5. Project toolbox

Five items were identified and developed in the third workshop and afterwards:

- „Storytelling“: aims at creating short “stories” which can be told to paint a positive image of the chemical industry. A set of guidelines was sketched out, including potential addressees (future employees and general public) of the story, that can be easily used to contact and brief an agency/copywriter.

- Checklist for social partners at the company level, developed by the project team, included joint approaches of social partners regarding project preparation, definition of goals, and ideas on employees’ involvement. Participants agreed that communication, information, and transparency are key.

- A project glossary is based on existing definitions and contains a list of key words to make the terms and concepts often mentioned in discussions on climate neutrality understandable to all involved actors.

- Possible roles and tasks for environmental coordinators at the company level to develop statistics on energy use and emissions, as well as other data relevant for achieving climate neutrality. It is based on the Flemish Government’s example and considers future developments, including training needs.

- Exemplary agendas for kick-off events for regional cooperation to be used by national social partners. The agendas have been developed involving local authorities, sectoral and cross-sectoral social partners, VET providers and school representatives and energy producers and suppliers. There are agendas for a conference and thematic workshops on training and skills, innovation and R&D, energy and infrastructure, as well as for regular follow-up events.

In addition to the tools developed during the project, information and links to other publications on training courses in Denmark, on the Italian analysis of the impact of the chemical industry on innovation, economic growth and society named ’The growth formula‘, and on the European social partners’ recommendation on circular economy in the framework of social dialogue, are included in the toolbox.

With the financial support of the European Union

5.1. Storytelling

To whom should the story be told?	To the public in a context of fear and uncertainty about climate change and its effects • Lack of information about the chemical industry and what it actually does • Most people are not aware how many products of the chemical industry they regularly use The young generation • Wants to be more involved and is more engaged in climate policies • Is attracted to “green jobs” Children, grammar and elementary schools • Working with school programmes to change the narrative about chemistry
By whom should the story be told?	The young generation within the industry, including: • Young researchers, engineers, mechanics, etc. • Role models and influencers One joint message to be spread by different companies Involving workers, employers and national governments • All aligned in one simple message
How should the story be told?	The accusation of “greenwashing” to be overcome Not starting from a defensive position, but telling the story with a: • Positive message • Informative message: facts and figures • Simple message: complex information made simple • Relatable message, connected to people’s lives An example of a punch line: • Today, we may be part of the problem (emitting CO2) but we are solving it (CO2 = feedstock for the industry)
Where should the story be told?	To reach out to young people: • On social media • On TED Talks and conferences • In collaboration with the art world (musicians): e.g. essencia’s initiative “the sound of a factory” To reach out to a wider public • Through TV, campaigns, advertisements • During festivals and cultural events: providing concrete examples (recycling plastic, etc.) Locally, in the factories themselves, via: • Open door days Family days.
What story should be told? Main messages:	No climate neutrality without chemicals Chemicals are the solution Chemicals are the key for climate neutrality • Show what a world without chemicals would look like, i.e. no toothbrushes, no soaps, cleaning detergents, etc. Address every problem and show how chemicals can provide a solution • Energy → green energy, solar panels • Plastic pollution → recycling plastic, circular economy

5.2. Towards climate neutrality and sustainability: Checklist for a joint social partner approach at the company level

The workshop participants recognised and highlighted the importance of early worker involvement to ensure a company's successful transition towards climate neutrality and sustainability. Effective communication, information sharing, and transparency were identified as crucial factors in this process. Social partners at the company level could use the following tentative list considering employee involvement and joint approaches of social partners.

Project preparation/ Defining a goal		Check?
	A project steering group has been created.	
	All relevant stakeholders are involved (management, works councils/ shop stewards, persons responsible for occupational health and safety, environmental coordinators, etc.).	
	Responsibilities have been clarified.	
	Following the agreement among all stakeholders at the company level, the works council/shop stewards are involved from the beginning and go along with the measures.	
	The management, works councils/shop stewards and the management and/or project team have agreed on the goal and the procedure and work together in a cooperative manner.	
	The goal of climate neutrality has been communicated to all employees.	
Assessing the initial situation		**Check?**
	The management has set up a GHG accounting system.	
	Structured data collection has been implemented by the management.	
	Data on GHG emissions is complete and available to the management.	
	Managers and employees have been interviewed to record the starting situation.	
	Workshops or interviews with employees or surveys have been carried out to determine the need for change.	
	In case any data management tools are used in assessing the initial situation, employees have been informed and trained in how to use the tool.	
Developing a climate strategy		**Check?**
	A long-term climate emission target has been set by the company.	
	The management has formulated and published a climate strategy.	
	Workers have been involved and informed about any strategy changes.	
	Employees understand the reason for changes.	
Developing solutions and planning implementation steps		**Check?**
	GHG reduction potentials have been identified.	
	Suggestions from all company levels have been collected and discussed.	
	Measures have been assessed and selected jointly.	
	Consequences for employees have been considered (H&S, working conditions) based on the existing evidence.	
	Project steps, activities and a timeline have been set jointly.	
	Small steps have been planned (e.g. not introducing all production changes at once).	

With the financial support of the European Union

Implementation of measures		Check?
	Management follows up with employees on implementation status.	
	The implementation progress has been monitored jointly.	
	Necessary skills adaptions have been considered.	
	A reskilling roadmap has been agreed upon.	
	Employees have been trained accordingly based on the existing company level policies.	
	A strategic personnel policy and strategic workforce planning have been established.	
	Occupational safety and health issues have been taken into consideration.	
	Employees are made aware of risks and have the possibility to report on any.	
Controlling and Evaluation		**Check?**
	Key performance indicators (KPI) have been defined and are regularly assessed by the management.	
	Feedback from employees has been recorded.	
	Management, based on the company level policies, informs employees how their feedback will be taken into consideration.	
	A communication strategy has been defined.	
	Evaluation results have been communicated.	
	Next steps are explained.	

Further information on steps towards climate neutrality at company level and change management can be found here:

- The Global Compact Network Germany has developed a Step-by-step guide for companies regarding corporate climate action. It provides companies with concrete instructions on how to analyse and reduce GHG emissions.

- Change management is, for example, defined in Kotter's 8 steps. The World Economic Forum puts forward a new, sustainable approach to change management.

- The Technology Consulting Centre, TBS, developed "participation tools" that made it possible to integrate the topic of "more climate protection through participation" into (consulting) processes in companies.

  A manual (in German) provides steps and project ideas for more worker participation in climate protection at the company level, as well as basic approaches for (more) participation, including workshops, group work, enabling (regular) exchange on climate protection and action days or weeks (p. 37). It also provides suggestions for how to provide incentives and rewards, continuous training and education, as well as suggestion schemes and idea management (pp. 47-73).

All documents developed by the project can be found here (in German) (p. 37).

5.3. Project glossary

2050/ respective national deadlines	The European Union (EU) aims to be climate neutral by 2050 – an economy with net-zero greenhouse gas emissions. This objective is at the heart of the European Green Deal and in line with the EU's commitment to global climate action under the Paris Agreement. All parts of society and economic sectors will play a role – from the power sector to industry, mobility, buildings, agriculture and forestry. As part of the European Green Deal, the Commission proposed on 4 March 2020 the first European Climate Law to enshrine the 2050 climate-neutrality target into law. EU Member States are required to develop national, long-term strategies on how they plan to achieve the greenhouse gas emissions reductions needed to meet their commitments under the Paris Agreement and EU objectives.[33]
All shades of hydrogen[34]	**White** hydrogen is a naturally occurring version that can be found underground, but is difficult to extract. **Grey** hydrogen is generated from natural gas, or methane, through a process called "steam reforming". The process to create **black** hydrogen uses black (bituminous) coal, **brown** hydrogen uses brown (lignite) coal. This method emits carbon dioxide and carbon monoxide. Hydrogen is called **blue** whenever the carbon generated from steam reforming is captured and stored underground (carbon capture and storage, CSS). 10-20% of the generated carbon cannot be captured. Hydrogen can also be generated through gasification from biomass.[35] **Green** hydrogen – also referred to as "clean hydrogen" – is produced by using clean energy from surplus renewable energy sources, such as solar or wind power, to split water into hydrogen oxygen. The process is called electrolysis. (Sometimes, "yellow" is used to describe the hydrogen that is produced with solar power.) **Pink** hydrogen is also created through electrolysis of water, but powered by nuclear energy rather than renewables. **Turquoise** hydrogen describes a way of creating hydrogen through methane pyrolysis, which generates solid carbon that can be used in other applications. This is still at pilot stage.
Biofuels	Biofuels are liquid or gaseous transport fuels, such as biodiesel and bioethanol, made from biomass. Today, the production typically takes place on cropland that was previously used for agriculture. Most biofuel makers today use microbes to synthesise ethanol from either cornstarch or sugar produced from sugarcane. Hence, biomass production competes with agricultural land use or extends into areas with potentially high-carbon stock, such as forests, wetlands and peatlands.[36] However, biofuel can also be produced from plants or from agricultural, domestic or industrial biowaste.[37] These are first- or second-generation biofuels. Third generation biofuels are made from algae. A fourth generation - photobiological solar fuels and electro fuels - is currently being developed.[38]
Biomass-based chemicals	Biomass refers to the mass of living organisms, including plants, animals, and microorganisms, or - from a biochemical perspective - cellulose, lignin, sugars, fats, and proteins.[39] While direct combustion of dry biomass to generate energy is already in practical use, the use of biomass as a material still needs further development. In the chemical industry, biomass for example can be used for the production of basic chemicals by completely degrading biomass into so-called 'C1' units by using the synthesis gas process or the production of, in some cases, more complex functional compounds, by exploiting upstream natural synthesis processes.[40]

[33] https://climate.ec.europa.eu/eu-action/climate-strategies-targets/2050-long-term-strategy_en
[34] https://www.weforum.org/agenda/2021/07/clean-energy-green-hydrogen/
[35] https://www.energy.gov/eere/fuelcells/hydrogen-production-biomass-gasification
[36] https://energy.ec.europa.eu/topics/renewable-energy/bioenergy/biofuels_en
[37] https://en.wikipedia.org/wiki/Biofuel
[38] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4678123/
[39] sciencedirect.com/topics/agricultural-and-biological-sciences/biomass
[40] https://www.ifeu.de/fileadmin/uploads/VCI_IFEU_Biomass_Chemical_Industry.pdf

With the financial support of the European Union

Carbon Border Adjustment Mechanism (CBAM)	On 14 July 2021, the Commission presented its proposal for a regulation establishing a Carbon Border Adjustment Mechanism (CBAM). CBAM targets **imports of products in carbon-intensive industries.** The objective of CBAM is to prevent – in full compliance with international trade rules – that the greenhouse gas emissions reduction efforts of the EU are offset by increasing emissions outside its borders through relocation of production to non-EU countries (where policies applied to fight climate change are less ambitious than those of the EU) or increased imports of carbon-intensive products.[41] A provisional agreement on CBAM was reached in December 2022.
Carbon footprint	Is the "amount of carbon dioxide (CO_2) emissions associated with all the activities of a person or other entity (e.g. building, corporation, country, etc.)". It includes direct emissions, such as those that result from fossil-fuel combustion in manufacturing, heating and transportation, as well as emissions required to produce the electricity associated with goods and services consumed. In addition, the carbon footprint concept also often includes the emissions of other greenhouse gases, such as methane, nitrous oxide, or chlorofluorocarbons (CFCs). [...] Rather than the greenhouse gas emissions associated with production, carbon footprints focus on the greenhouse gas emissions associated with consumption. They include the emissions associated with goods that are imported into a country but are produced elsewhere, and generally consider emissions associated with international transport and shipping, which is not accounted for in standard national inventories."[42]
Carbon handprint	It is a concept created by the Climate Leadership Coalition (CLC), the technical research centre of Finland (VTT), and Lappeenranta-Lahti University of Technology. Carbon handprint refers to the positive climate impact that using a product or service has compared to other products or services in the same category.[43] VTT defines it in its Carbon Handprint Guide as: "An indicator of climate change mitigation potential. It describes the GHG emission reduction in a customer's activities that occurs when the customer replaces a baseline solution with a handprint solution."[44]
CCR-Carbon Capture and Recycling or Re-Use	See CCU
CCS-Carbon Capture and Storage	"Carbon Capture and Storage (CCS) is an important component of many national, European and worldwide strategies to tackle climate change. CCS can reduce greenhouse gas emissions by capturing the carbon dioxide (CO_2) generated by large point sources before it is released into the atmosphere, and then transporting it to a secure underground storage facility."[45]
CCU-Carbon Capture and Utilisation	"Carbon Capture and Utilisation (CCU) technologies allow to reuse captured carbon, increasing its circularity and potentially reducing its emissions to the atmosphere.[46] CO_2 is separated out from one (industrial) process or captured directly from the air (direct air capture, DAC) and reused as an input stream for another industrial application. The captured CO_2 is turned into a carbon source and therefore a feedstock for chemical or biotechnological processes. It can be used to make plastics or synthetic fuels for aviation and shipping, for example, or the CO_2 can be sequestered (stored) in building materials. The primary aim of CCU is to sequester CO_2 for as long as possible or use it within a closed-loop system."[47]
Chemical	"A chemical is any basic substance that is used in or produced by a reaction involving changes to atoms or molecules."[48]

[41] https://www.consilium.europa.eu/en/press/press-releases/2022/12/13/eu-climate-action-provisional-agreement-reached-on-carbon-border-adjustment-mechanism-cbam/?s=08
[42] https://www.britannica.com/science/carbon-footprint
[43] https://clc.fi/key-targets/#carbon-handprint-and-footprint
[44] https://cris.vtt.fi/ws/portalfiles/portal/22508565/Carbon_Handprint_Guide.pdf
[45] https://easac.eu/fileadmin/Reports/Easac_13_CCS_Summary_Web.pdf
[46] https://energy.ec.europa.eu/topics/oil-gas-and-coal/carbon-capture-storage-and-utilisation_en
[47] https://www.klimaschutz-industrie.de/en/topics/ccu/
[48] https://dictionary.cambridge.org/de/worterbuch/englisch/chemical

Circular economy	The traditional linear economic model was based on a ‘take-make-consume-throw away’ pattern. A circular economy is based on sharing, leasing, reuse, repair, refurbishment and recycling.[49] Circular economy models can be divided into different and sometimes complementary processes: • service-based systems, “collaborative consumption”, “sharing economy” models • industrial symbiosis, meaning that the process by which waste or by-products of an industry or industrial process become the raw materials for another one • (re)designing of products to make them more durable, reusable, repairable • recycling and waste management systems[50]
Climate neutrality/ carbon neutrality, net-zero	**Carbon neutrality** is a state of **net-zero** carbon dioxide emissions. This can be achieved by eliminating emissions or by balancing emissions of carbon dioxide with its removal. The term **climate-neutrality** goes beyond carbon and includes other greenhouse gases. If the total greenhouse gases emitted is equal to the total amount removed, then the two effects cancel each other out and the net emissions are ‘neutral’.
Direct/indirect emissions	In industry, direct GHG emissions come from sources that are owned or controlled by the company in question. Most notably, these emissions are created by manufacturing goods. Indirect emissions come from outside sources but are related to the company’s activities, e.g. emissions caused within the supply chain, but also other outsourced activities, as well as the travel and commute of employees.[51]
Electrification	“Electrification means replacing technologies and services that run on fossil fuels with ones that run on electricity from renewable sources.”[52] “Electrification holds great potential to reduce final energy demand because the efficiency of electric technologies is generally much higher than fossil fuel-based alternatives with similar energy services.”[53]
Energy (blue, green, grey)	**Blue energy** Rarely used expression, it sometimes refers to energy production by means of water or any energy form that can be transformed in electric energy without material consumption.[54] **Green energy** Green energy is energy that is produced in a way that protects the natural environment, for example by using wind, water, or the sun.[55] It often comes from renewable energy sources. Both terms are often used interchangeably, however, some argue that not all sources of renewable energy are green. For example, “power generation that burns organic material from sustainable forests may be renewable, but it is not necessarily green, due to the CO_2 produced by the burning process itself”. Also, “a hydroelectric dam which may divert waterways and impact the local environment might not be called green.”[56] **Grey energy** Grey energy, as opposed to green energy, is produced by polluting sources, e.g. using fossil fuels.[57] The term may also refer to “the hidden energy associated with a product, meaning the total energy consumed throughout the product’s life cycle from its production to its disposal.”[58]

[49] https://www.europarl.europa.eu/RegData/etudes/BRIE/2016/573899/EPRS_BRI%282016%29573899_EN.pdf
[50] https://news.industriall-europe.eu/documents/upload/2022/12/638055883130940811_Adopted_-_More_and_fair_circular_economy_-_towards_strategic_autonomy_for_industrial_jobs_and_a_cleaner_environment_-_EN.pdf
[51] https://ecochain.com/knowledge/scope-1-2-and-3-emissions-overview-to-direct-and-indirect-emissions/
[52] https://corporate.enelx.com/en/question-and-answers/what-is-electrification
[53] https://www.iea.org/reports/electrification
[54] https://blog.paradigma.de/blaue-energie/
[55] https://dictionary.cambridge.org/de/worterbuch/englisch/green-energy
[56] https://www.twi-global.com/technical-knowledge/faqs/what-is-green-energy#WhatisGreenEnergy
[57] https://en.wikipedia.org/wiki/Gray_energy
[58] http://www.educapoles.org/assets/uploads/teaching_dossiers_files/05_swift_fact_sheet_grey_energy.pdf

With the financial support of the European Union

Energy-Intensive Industries	There is no exact definition. In a masterplan with recommendations to build the policy framework needed to manage the transition to climate neutrality, the High Level Group on Energy-Intensive Industries, advising the Commission on policies relevant to energy-intensive industries since 2015, includes the following industries: Cement, Ceramics and Refractory, Chemicals, Ferro Alloy and Silicon, Fertilisers, Glass, Lime, Non-Ferrous Metals, Pulp and Paper, Refining and Steel.[59]
EU Emissions Trading System (EU ETS)	The EU Emissions Trading System (EU ETS) was set up in 2005 and is a cornerstone of the EU's policy to combat climate change and its key tool for reducing greenhouse gas emissions cost-effectively. The EU ETS works on the 'cap and trade' principle. A cap is set on the total amount of certain greenhouse gases that can be emitted by the installations covered by the system. The cap is reduced over time so that total emissions fall. Within the cap, installations buy or emissions allowances, which they can trade with one another as needed. The limit on the total number of allowances available ensures that they have a value.[60]
EU Fit for 55 Package of EU Directives	In July 2021, the European Commission adopted a package of proposals to make the EU's climate, energy, land use, transport and taxation policies fit for reducing net greenhouse gas emissions by at least 55% by 2030, compared to 1990 levels.[61] This massive package contains an unprecedented amount of policy proposals to revise the entire EU climate policy framework. The Emission Trading System (ETS) Directive; the Effort Sharing Regulation; the Renewable Energy Directive; the Energy Efficiency Directive; the Energy Tax Directive; the Regulation setting CO_2 Emissions Performance Standards for Cars and Vans, will all be revised. A Strategic Plan for the quick deployment of the alternative fuels infrastructure and a new Forest Strategy have been proposed, building on existing instruments. In addition, the package contains a proposal to set up a Carbon Border Adjustment Mechanism (CBAM), as well as a proposal to establish a Climate Action Social Fund to accompany the creation of an ETS for the fuels used in road transport and heating. Lastly, two initiatives called 'ReFuelEU Aviation' and 'FuelEU Maritime' have been launched to accelerate the uptake of green fuels in aviation and shipping sectors.[62] For industriAll Europe'position regarding the Fit for 55 package see: **The Fit-for-55 Package - Position of industriAll Europe December 2021. For the employers' position issued by Cefic, please check: https://cefic.org/policy-matters/welcoming-fit-for-55/**
Fuels from waste	"Waste-to-energy technologies physically convert waste matter into more useful forms like bioethanol, biobutanol, biogas, biohythane, CNG, and syngas, through various processes such as combustion, pyrolysis, gasification, or biological treatments."[63]
GHG protocol	Is an organisation that establishes global standards and frameworks to measure and manage greenhouse gas emissions and mitigation activities[64]. "The GHG Protocol Corporate Standard classifies a company's GHG emissions into three 'scopes'. Scope 1 emissions are direct emissions from owned or controlled sources. Scope 2 emissions are indirect emissions from the generation of purchased energy. Scope 3 emissions are all indirect emissions (not included in Scope 2) that occur in the value chain of the reporting company, including both upstream and downstream emissions."[65]
Green Deal	"The European Green Deal, presented by the European Commission in December 2019, sets out how to make Europe the first climate-neutral continent by 2050, boosting the economy, improving people's health and quality of life, caring for nature, and leaving no one behind. The European Green Deal provides a roadmap with actions to boost the efficient use of resources by moving to a clean, circular economy and stop climate change, revert biodiversity loss and cut pollution. It outlines investments needed and financing tools available and it explains how to ensure a just and inclusive transition. The European Green Deal covers all sectors of the economy, notably transport, energy, agriculture, buildings, and industries such as steel, cement, ICT, textiles and chemicals."[66]

[59] https://op.europa.eu/en/publication-detail/-/publication/be308ba7-14da-11ea-8c1f-01aa75ed71a1/language-en
[60] https://climate.ec.europa.eu/eu-action/eu-emissions-trading-system-eu-ets_en
[61] https://ec.europa.eu/commission/presscorner/detail/en/IP_21_3541
[62] https://agenda.industriall-europe.eu/uploads/documents/2022/1/637781861870019034_Adopted-TheFit-for-55Package-Position-iAE-EN.pdf
[63] https://link.springer.com/chapter/10.1007/978-981-10-7518-6_10
[64] https://ghgprotocol.org/about-us
[65] https://ghgprotocol.org/sites/default/files/standards_supporting/FAQ.pdf
[66] https://ec.europa.eu/commission/presscorner/detail/en/ip_19_6691

Greenhouse gas (GHG)	"Any gas that has the property of absorbing infrared radiation (net heat energy) emitted from Earth's surface and reradiating it back to Earth's surface, thus contributing to the greenhouse effect. Carbon dioxide, methane, and water vapour are the most important greenhouse gases. (To a lesser extent, surface-level ozone, nitrous oxides, and fluorinated gases also trap infrared radiation.)"[67]
Green jobs	In general, green jobs can be found in all sectors of the economy building the basis for a successful energy transition and promote climate and environmental protection. The European Commission refers to jobs related to renewable technologies (wind, solar), heat/energy saving, energy management, waste management, environmental protection, wastewater/water management. A wider definition also includes other sectors making intermediate goods for the eco-industry, organic farming or eco-tourism.[68]
Green mindset	No agreed definition exists. Generally taken to refer to taking environmental sustainability aspects into consideration in every private and commercial activity. When used in the context of a company, a green mindset would involve "greening" all operations, plus providing comprehensive information thereof and training employees accordingly.
Green skills	"Green skills are the knowledge, abilities, values and attitudes needed to live in, develop and support a sustainable and resource-efficient society. The transition to a low-carbon, resource-efficient economy requires systemic changes that will result not only in new products and services, but also in changes in production processes and business models. This greening of the economy will inevitably change the skills required and the tasks involved in many of the existing occupations." Green skills, among others, comprise engineering and technical skills, science skills, operation management skills and monitoring skills. [69] Concrete skills needed vary from sector to sector. On 07/03/2023, Member States adopted in the Council the conclusions on skills and competences for the green transition.[70]
Lifecycle assessment	"Life-cycle assessment (LCA) is a process of evaluating the effects that a product has on the environment over the entire period of its life, thereby increasing resource-use efficiency and decreasing liabilities. It can be used to study the environmental impact of either a product or the function the product is designed to perform. LCA is commonly referred to as a "cradle-to-grave" analysis. LCA's key elements are: (1) identify and quantify the environmental loads involved; e.g. the energy and raw materials consumed, the emissions and wastes generated; (2) evaluate the potential environmental impacts of these loads; and (3) assess the options available for reducing these environmental impacts."[71]
Nature positivity	The use of this term is…that no credible entry can be made here. ScienceDirect provides an overview of the many different definitions.[72]
Paris Agreement + follow-ups + "translation"	The Paris Agreement is the first-ever universal, legally binding global climate change agreement, adopted at the UN Climate ChangeConference (COP21) in Paris in December 2015 with the objective to keep the global temperature increase to well below 2°C and pursue efforts to keep it to 1.5°C. The EU and its Member States are among the (close to) 190 Parties to the Paris Agreement.[73] The Katowice package adopted at the UN Climate Change Conference (COP24) in December 2018 contains common and **detailed rules, procedures and guidelines** that operationalise the Paris Agreement. The EU submitted its long-term strategy to the United Nations Framework Convention on Climate Change (UNFCCC) in March 2020.

[67] https://www.britannica.com/science/greenhouse-gas
[68] https://ec.europa.eu/environment/enveco/pdf/FACT_SHEET_ii_Green_Growth_Jobs_Social_Impacts.pdf
[69] https://www.unido.org/stories/what-are-green-skills
[70] https://data.consilium.europa.eu/doc/document/ST-7089-2023-INIT/en/pdf
[71] https://www.eea.europa.eu/help/glossary/eea-glossary/life-cycle-assessment
[72] https://www.sciencedirect.com/science/article/pii/S0959652622043700
[73] https://climate.ec.europa.eu/eu-action/international-action-climate-change/climate-negotiations/paris-agreement_en

With the financial support of the European Union

Safe and sustainable by design	"Safe and sustainable by design can be described as an approach that focuses on providing a function (or service), while avoiding onerous environmental footprints and chemical properties that may be harmful to human health or the environment."[74] "Within the European Green Deal, the Chemicals Strategy for Sustainability (CSS) identified a number of actions to reduce the negative impacts on human health and the environment associated with chemicals, materials, products and services commercialised or introduced into the EU market. In particular, the ambition of the CSS is to phase out the most harmful substances and substitute, as far as possible, all other substances of concern, and otherwise minimise their use and track them."[75]
Recycling, reuse and incineration of waste	Recycling is a resource recovery method involving the collection and treatment of a waste product for use as a raw material in the manufacture of the same or a similar product. The EU waste strategy distinguishes between: reuse meant as a material reuse without any structural changes in materials; [76]recycling meant as a material recycling, only, and with a reference to structural changes in products; and recovery meant as an energy recovery only. Incineration of waste is the process of burning solid waste under controlled conditions to reduce its weight and volume, and often to produce energy.[77]
Renewable fuels	"The main difference between renewable fuels and fossil fuels is where they come from. Fossil fuels are made from non-renewable fossil resources and release the carbon from these fuels into the atmosphere. Renewable fuels are made from previously used materials (waste and residues) or from oil extracted from plants that can re-absorb CO_2 from the air through photosynthesis."[78]
Sustainable development	"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."[79] There are three connected pillars of sustainability: social, economic and environmental. Social sustainability refers to "human well-being and equity, access to basic needs, fair distribution of income, good working conditions and decent wages, equality of rights, inter-and intragenerational justice, access to social and health services and to education, social cohesion and inclusion, empowerment, and participation in policy-making."[80] Economic sustainability is the practice of conserving natural and financial resources to create long-term financial stability. Environmental sustainability involves the conservation of land, freshwater, oceans, forests and air.[81]
Waste-based chemicals	Wastes, and in particular municipal solid waste, represent an untapped source of carbon (and hydrogen) to produce a large range of chemicals from methane to alcohols (as methanol or ethanol) or urea.[82] For example, Waste to Methanol (WtM) is a technology converting urban waste and non-recyclable plastic into methanol through a process based on high temperature gasification, syngas purification and conditioning up to methanol synthesis.[83] By chemical recycling, plastic waste may be converted into pyrolysis oil that can then be used as a raw material for chemical products.[84]
Waste management	"Waste management is responsible for the entire waste cycle: from waste prevention, re-use and recycling to recovery and disposal. Tasks included are collection, transport, sorting and treatment of waste."[85]

74 https://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=ENV-CBC-MONO(2022)30%20&doclanguage=en#:~:text=Safe%20and%20sustainable%20by%20design%20(SSbD)%20can%20be%20described%20as,human%20health%20or%20the%20environment
75 https://op.europa.eu/en/publication-detail/-/publication/eb0a62f3-031b-11ed-acce-01aa75ed71a1/language-en
76 https://www.indeed.com/career-advice/career-development/what-is-economic-sustainability
77 https://www.eea.europa.eu/help/glossary/eea-glossary
78 https://www.neste.com/media/sustainable-mobility/what-are-renewable-fuels#515f9a9c
79 http://www.un-documents.net/ocf-02.htm
80 https://www.europarl.europa.eu/RegData/etudes/STUD/2020/648782/IPOL_STU(2020)648782_EN.pdf
81 https://sustainability-success.com/environmental-sustainability-examples/
82 https://pubmed.ncbi.nlm.nih.gov/29939452/
83 https://onepetro.org/OMCONF/proceedings-abstract/OMC21/All-OMC21/OMC-2021-087/473117
84 https://www.basf.com/global/en/who-we-are/sustainability/we-drive-sustainable-solutions/circular-economy/mass-balance-approach/chemcycling.html
85 https://www.umweltbundesamt.de/en/topics/waste-resources/waste-management

5.4. Environmental coordinators

Environmental coordinators at the company level can be appointed to implement legislation and environmental standards, to develop statistics on energy use and emissions as well as other data relevant to becoming climate neutral, and to consider future developments, including training needs. They should be responsible for environmental safety and cooperate with health and safety representatives. They are to be involved in every project with a potential impact on climate and environmental issues, be engaged in internal and external communication guaranteeing interaction at all levels.

The role of environmental coordinators should best be taken over by a joint team of workers and management representatives and/or by an external expert taking independent decisions. Required competences for environmental coordinators are, for example, technical knowledge, knowledge about the relevant legislative framework, communication skills and emotional and social intelligence.

To effectively carry out their tasks, environmental coordinators need sufficient time, budget and access to information. Regular meetings between the management and the environmental coordinators should be organised.

Trade unions and employers/industrial representatives can support environmental coordinators, for example through training, exchanges of experience or networks. A definition by law (as in Flanders/Belgium) or by collective agreement (as in Spain) can be helpful to promote the work of environmental coordinators.

The Flemish example

In Flanders (Belgium), environmental coordinators have a wide range of duties in which they can act objectively and independently, contributing to environmentally conscious and friendly business operations:

1. They contribute to the development, introduction, application and evaluation of environmentally friendly production methods and products;
2. They monitor compliance with environmental legislation, by monitoring workplaces, purification plants and material flows at regular intervals. They report observed shortcomings to the management and make proposals to remedy them;
3. They monitor or they are responsible for carrying out the prescribed emission measurements and for recording the results;
4. They shall keep a waste register and comply with the reporting obligation on waste prevention and waste management;
5. They shall communicate internally and externally about possible consequences of the company's activity for people and the environment, its products, its waste substances, and about the facilities and measures to limit these consequences;
6. They advise management on environment related investments;
7. They prepare an annual report on their activities and advise on the basis of what is provided the previous year and the follow-up given to them. This is for the benefit of the management and of the works council and the committee for safety, health and improvement of workplaces.

With the financial support of the European Union

5.5. Exemplary agendas for regional events building the basis for regional cooperation between relevant stakeholders

Kick-off conference: Regional cooperation for climate neutrality

First step: to reach out to mayors or regional ministries of economy or employment or other suitable public authorities' representatives to explain the idea and need for joint actions.	
Organisation	Regional social partners in the chemical industry in cooperation with regional authorities (ministers, mayors, etc.)
Approx. 80 participants	
	· Ministers, representatives of local authorities
	· Trade unions' and employers' organisations' representatives in the chemical industry from the regional level
	· Representatives from chemical companies (management, works council or other employee representation bodies)
	· VET providers and school representatives
	· Energy producers and suppliers
	· Cross-sectoral employers' and trade unions' organisations
Duration 2-3 hours	**Agenda: possible topics**
	Welcome by social partners and regional authorities' representatives *Presentation of the aim of the conference*
	Panel discussion: "Becoming climate neutral - Where do we stand and what are our goals? + discussion in plenary *Social partners at regional, sectoral and company levels from the chemical sector, representatives from the energy sector and public authorities.*
	Plenary discussion: "What do we need to reach climate neutrality? Who needs to be involved?" *e.g. skills needs, innovation and technology, energy and infrastructure, etc.*
	Joint commitment to follow-up and outlook/next events *e.g. regular exchange on different topics.*

Kick-off workshops for different topics

Focus on training and skills	
Organisation	Jointly organised by regional social partners
Approx. 30-40 particip.	
	· Representatives from trade unions and employers' organisations in the chemical industry from the regional level
	· Representatives of chemical companies (management, works councils or other employee representation bodies + employees)
	· VET providers
	· Head of science departments at local schools
	· Representatives of relevant public authorities, e.g. regional ministry for education
Duration 2-3 hours	**Agenda: possible topics**
	Welcome by social partners *Presentation of the aim of the workshop*
	Skills needs for climate neutrality: current framework and approaches *Input/Presentation by research institution/VET expert/authority*

	Joint discussion and collection of skills needs + comments on framework conditions and related topics
	Breakout sessions (in parallel): 1. Framework conditions needed for successful training and education in the regional chemical industry 2. Cooperation between companies: where and how to work together in training 3. VET providers: Matching companies'/employees' needs and offers 4. School curricula: current state and additional needs 5. And/or any other topic coming up during joint discussion
	Reporting on results of the breakout sessions in plenary + discussion
	Presentation of the EU, national and regional funding opportunities and financing possibilities. *Input including information on how to apply for the existing funding opportunities*
	Joint commitment to follow-up and agreement on next steps

Focus on innovation and R&D

Organisation	Jointly organised by regional social partners
Approx. 30-40 particip.	
	· Representatives of the trade unions and employers' organisations in the chemical industry from the regional level
	· Representatives of chemical companies (management, works councils or other employee representation bodies)
	· Representatives of research institutes
	· Representatives of relevant public authorities
Duration 2-3 hours	**Agenda: possible topics**
	Welcome by social partners *Presentation of the aim of the workshop*
	Innovation and technology for climate neutrality *Input/Presentation by research institution/companies*
	Joint discussion and collection of innovation and research needs + comments on framework conditions
	Breakout sessions (in parallel): 1. Framework conditions needed for successful innovation in the regional chemical industry 2. Cooperation between companies: where and how to work together in R D&I? 3. Cooperation with research institutes 4. And/or any other topic(s) coming up during joint discussions
	Reporting on results of breakout session in plenary + discussion
	Presentation of the EU, national, regional funding opportunities and financing possibilities *Input including information on how to apply for existing funds*
	Joint commitment to follow-up and agreement on next steps

With the financial support of the European Union

Focus on energy and infrastructure

Organisation	Jointly organised by regional social partners
Approx. 30-40 particip.	
	· Representatives from trade unions and employers' organisations in the chemical industry from the regional level
	· Representatives of chemical companies (management, works councils or other employee representation bodies)
	· Energy producers and suppliers
	· Representatives of other industrial sectors or of a cross-sectoral industry association · Representatives of relevant public authorities, e.g. regional ministry for energy
Duration 2-3 hours	**Agenda: possible topics**
	Welcome by social partners *Presentation of the aim of the workshop*
	Energy supply and infrastructure: current state, future needs and plans to bridge the gap between current infrastructure in place and the one needed for future production *Input/Presentation by research institution/regional authority/ energy companies*
	Joint discussion and collection of energy and infrastructure needs + comments on framework conditions
	Breakout sessions (in parallel): 1. Framework conditions needed for regional energy supply and infrastructure 2. Cooperation between companies: where and how to work together on energy production, supply and infrastructure development 3. Synergies: possibilities of cross-sectoral cooperation 4. And/or any other topic(s) coming up during joint discussions
	Reporting on results of breakout sessions in plenary + discussion Presentation of the EU, national, regional funding opportunities, and financing possibilities *Input including information on how to apply for existing funds* Joint commitment to follow-up and agreement on next steps

Follow-up: regular exchange (1-2 x/year)

Organisation	Jointly organised by regional social partners in cooperation with regional authorities
Approx. 60 participants	
	· Representatives from trade unions and employers' organisations in the chemical industry from the regional level
	· Representatives of chemical companies (management, works councils or other employee representation bodies + employees)
	· VET providers and school representatives
	· Energy producers and suppliers · Cross-sectoral employers' and trade unions' organisations
Duration 2-3 hours	**Agenda**
	Welcome by social partners
	Presentation of implementation status *Workshop results: what has been implemented regarding training and education, innovation, energy, infrastructure, etc.*
	Discussion of further steps

5.6. Training for climate neutrality in Denmark

The Danish tripartite system is based on the collaboration between the government and the social partners whose influence on employment policy, wages and working conditions is special for the Danish labour market model.

The government and the social partners also enter into tripartite agreements on vocational and labour market education. The state ensures that everyone in the labour market can achieve good basic skills including providing education at all levels of high quality and with relevant content for the labour market. The state also plays a central role in vocational and training programmes which are part of the overall flexicurity model: combining a high flexibility for movement between jobs and reorganisation of workforce with the security of support for the unemployed.

In 2000, two trade unions (The Danish Metalworkers' Union and The United Federation of Danish Workers), together with the Danish employers' association, The Confederation of Danish Industry (Dansk Industri), established the educational secretariat "Industriens Udannelser (IU)" an independent institution.

The tasks of the Educational secretariat (IU) are:

- to uncover and communicate educational needs within vocational and labour market education
- to approve apprenticeships and special conditions in training agreements
- to handle apprenticeship administration
- to handle complaints about school training and settlement cases

Within IU, there are 27 professional education committees with representatives from trade unions and employers. IU supports the committees in their work to determine the vocational content, duration, structure and aim of the different vocational, education and training programmes (VET) and Continuing Vocational Training Programmes (CVT) in the Danish industry.

Based on an analysis (desk study, interviews and survey) of skills needs for the green transition, a new vocational training programme starting in 2024 upon approval from the Ministry of Education, as well as three training courses, have been developed:

New Process Operator Vocational Training Programme[86]

The Professional Committee wishes to create a new vocational training programme with the working title "*speciale i grøn energiomstilling*" (specialisation in Green Energy Conversion). The aim is to be able to meet the future needs for new green production skills in traditional process companies, as well as in new energy and process companies. In the green energy transition, process operators must be trained to have clear skills in all aspects of the green transition.

The specialisation will also match young people's desire for an education with a greener image, where they can make a difference. The programme targets the whole industry, ranging from established companies that want to convert their production to a greener version, where electrification and resource consumption are the focus, to energy producing companies that want to work with green energy. Examples include Power-to-X (P2X), the conversion of green-generated electricity into chemical energy carriers for electricity storage, and into electricity-based fuels for mobility or raw materials for the chemical industry. There is currently no training coverage in this area.

The need for the new specialisation has been identified by the professional committee through a dialogue with the industry representatives and by conducting analysis of future competence needs in the field of green transformation in the process in metal and manufacturing industries. The analysis was carried out in collaboration with MI and Cowi[87].

[86] https://iu.dk/uddannelser/erhvervsuddannelser/erhvervsuddannelser-og-specialer/procesoperator/
[87] Industrien Uddannelser og Cowi; Tværgående kompetencebehov som følge af grøn omstilling i industrien; august 2022

With the financial support of the European Union

The green specialisation has a duration of 10 weeks, which is added to the school periods of the level 2 Process Operator. These 10 extra weeks of schooling replace 10 weeks of the training period, so the total training for the process operator specialising in green energy conversion is not extended. The model is the same as that of the process operator specialising in pharma and food ingredients.

The programme is expected to consist of five modules of two weeks each, with the following titles:

- CO_2 neutrality
- Energy-optimised production
- Electrification
- Biogas and fuel and thermal energy
- Power-2-X

The content of the five modules is qualified in a collaboration between the Development Committee for Process Industry, the Knowledge Centre for Process Technology, a wide range of companies approved to train process operators and process operators specialising in pharma and food ingredients, and the schools approved for the training.

The specialisation is relevant to apprentices in all industries that train process operators, but will be particularly attractive to apprentices who do not have the opportunity to take the pharma and food ingredient specialisation. Due to the interest from industry, the Committee also expects a greater interest in retraining already trained process operators and transferring already started apprentices from the process operator speciality to the process operator with green energy conversion speciality.

As the specialisation covers all sectors of industry that want to work purposefully with green transition and/or produce new forms of energy, and at the same time there are increasing demands for documentation and compliance with environmental requirements, there is great potential to attract new companies in all areas where the process operator is relevant and more young people who want to take a green education and make a difference.

According to the analysis 'Employment effects in industry of investments in the green transition'[88], investments in the green transition are expected to create additional demand of 116,000 full-time jobs or even more in the industry of the future. Process operators will be an important part of this additional demand, as they are both in the industry that will supply new and existing equipment for greener production and will also be the group of employees that will operate the new plants. There is a projected increase in demand for apprentices compared to the 2020 intake for process and industrial operator apprenticeships of 97%. For process operator apprentices, the green specialisation will meet the need for new skills demanded by industry.

Training courses

Introduction to Sustainable Transition[89]

Description of the course: After the course, the participant will be able to actively propose and assess sustainability in their own practice and job function, based on knowledge of the concept of "sustainability". The participant can contribute to the redesign of a process, a product or a service in the company, with a view to developing a company's sustainability objectives and areas of activity.

[88] Industriens Uddannelser og Cowi; Beskæftigelseseffekter i industrien af investeringer i den grønne omstilling; juni 2022
[89] https://hakl.amukurs.dk/Kursusside.aspx?CourseID=10201

Target group: The course is aimed at skilled and unskilled employees in large or small companies, who need to start converting a given process, product or service to be more sustainable.

Objectives: The participant, based on knowledge of the concept of "sustainability" in relation to, e.g. environmental requirements, labelling schemes and/or certifications, can actively make suggestions and assess sustainability in his/her own practice and job function. The participant can, in cooperation with others, help to redesign a process, product or service in the company with a view to developing the company's sustainability objectives and areas of action.

Duration: 2 days

Sustainable production[90]

Description of the course: Participants will learn about sustainable production and how to identify improvement and optimisation opportunities and develop idea proposals within their own job function/company/industry.

Target group: The course is designed for unskilled and skilled employees in large or small industrial companies, working in the job areas where adult vocational training (AMU) is offered.

Objectives: On completion of the course, the participants will have knowledge of sustainability in relation to production and the 17 UN Sustainable Development Goals, with a particular focus on the goals of sustainable consumption and production. They will be able to contribute to developing and maintaining sustainable behaviours and processes in production and to support the green transition with a focus on waste sorting, recycling, energy efficient production, waste management, reduction of resource consumption and compliance with environmental standards and requirements.

Duration: 2 days

For information on the experiences of the company MAN Energy Solution with regard to the training course, please see the article: "Virksomhed sender alle 400 medarbejdere på grønt AMU-kursus: - Det er en god forretning" (in Danish) (p.49).

Partner in the green transition[91]

Description of the course: In this course, participants will learn about the link between CO_2 emissions, resource consumption and climate change and will gain an understanding of why it is necessary for employees to contribute to the green transformation of production in the industry.

Target group: The course is designed for unskilled and skilled workers who have been, or are looking for a job in manufacturing companies.

Objectives: On completion of the course, the participants shall be motivated to be an active contributor to the company's strategy for green transformation in manufacturing. They will have a basic knowledge of the links between CO_2 emissions, resource consumption and climate change and will understand why it is necessary for employees to contribute to the green transformation of production in industry. They will know about their own possibilities to contribute to green transition in the production. They will be able to distinguish between fossil fuels and sustainable

[90] https://iu.amukurs.dk/Kursusside.aspx?CourseID=10035
[91] https://iu.amukurs.dk/Kursusside.aspx?CourseID=10416

With the financial support of the European Union

energy sources, and have a basic understanding of where these are used in industry. They can carry out a CO_2 calculation using a simple web-based CO_2 calculator and can make concrete suggestions on how to reduce carbon footprint and resource consumption in their own job area.

Duration: 3 days

5.7. The growth formula: real, fair and sustainable (Italian Federation of the Chemical Industry, Federchimica, Piano Lauree Scientifiche, 2016)

Intended for the young generation, with the objective of attracting it to the chemical industry, the book analyses how chemistry can have a positive impact on the following aspects:

- Innovation: chemistry innovates and makes others innovate
- Environment and how helpful chemistry is in solving climate and energy problems and in preserving natural resources
- Economy: chemistry generates wealth (example of the pharmaceutical sector)
- Society:
    1) Many chemical products are essential to protect health, although some chemicals can be dangerous for human health
    2) Chemistry produces safety (reduction of workplace accidents)
    3) Chemistry provides jobs

Quoting from the introduction, "The three dimensions of sustainability - environmental, social and economic - need each other, and they all need chemistry".

For further information see: https://www.federchimica.it/docs/default-source/dati-e-analisi/formula-della-crescita-navigabile-2016.pdf (in Italian).

6. Final Conference

Luc Triangle (industriAll Europe) and Csaba Szabó (ECEG) delivered keynote speeches addressing issues strongly linked to each other, such as climate neutrality and gender equality. Both stressed the need for raising awareness and dialogue between social partners to achieve the goals of the Green Deal and to ensure a Just Transition for all. The chemical industry is at the beginning of a challenging and complex pathway towards climate neutrality.

The external experts, wmp consult and Syndex, provided an overview of the project results, focusing on: 1) the measures to reach climate neutrality in the chemical, pharmaceutical, rubber and plastics industries; 2) the fields of action for companies; 3) the impacts on employment, working conditions, skills, 4) the role of social partners in the decarbonisation process; and 5) the project toolbox.

The first panel discussion focused on the political framework, decisions, and support measures with Roman Mokry (DG GROW), Jitka Hrudova (DG EMPL), Maike Niggemann (industriAll Europe) and Emma Argutyan (ECEG) and a video message by MEP Patrizia Toia. The group discussed various topics related to the transition to climate neutrality, including the initial motivation for the project, the challenges in implementing initiatives, the importance of social dialogue, and the regulatory burden on companies. They also talked about the need for a clear roadmap, including upcoming legislation and the involvement of different sectors and stakeholders in the co-implementation of the Transition Pathway[92] for the chemical industry. The group discussed the interplay between national and European levels, and the importance of capacity building and collaboration in achieving the goals of the transition. Roman Mokry (DG GROW) informed the participants that the Transition Pathway[93] was published in January 2023, aiming at providing a roadmap for the overall industry to incorporate, among others, sustainable practices into their daily operations.

In their presentation "A green skills roadmap for the climate transition in the energy-intensive industry", Helena Van Langenhove and An Katrien Sodermans (Department of Work and Social Economy – Flanders, Belgium) presented results of a study conducted by the Flemish Government in 2021, which identified the skills challenges faced by energy-intensive industries (chemicals, petrochemicals, primary metals, rubber and plastics) in Flanders by 2035. The roadmap focused especially on the green and digital transitions. The study created a new competence framework, which includes technical knowledge, technical skills, and soft skills for the green transition. It identifies three key areas of training needed: 1) efficient and circular production, 2) renewable energy, and 3) digital innovation.

According to the study, apprenticeships are seen as a solution for upskilling employees and training students in green, digital, and soft skills. A case study focusing on the chemical industry suggests that collaboration between education and industry is necessary to include sector-specific sustainability cases in course materials. The importance of identifying and addressing green skills is emphasised, together with financial support from governments needed to stimulate training providers. Apprenticeships provide a good opportunity for developing a green attitude at the workplace, but strong partnerships between educational providers, companies, sectoral players, and regional players are necessary.

Questions and remarks from the audience showed that the definition of green skills, identification of skills needs and skills development are a key topic in the transition to climate neutrality.

During a second panel discussion, Laure Lamoureux (FCE-CFDT, France), Andreas Ogrinz (BAVC, Germany), Taru Reinikainen (Pro, Finland) and Nicolas Rega (Cefic) discussed organisations' activities, opportunities, and challenges. They covered the role of social partners in the transition, the role of employers in maintaining competitiveness of the industry, and how to address potential negative effects on employment due to transformation. The panellists also talked about the need for involving social partners in political discussions, the importance of leadership in large-scale transformation, and the challenges of identifying skills for the future. Other issues discussed included the commitment of organisations to national transition pathways, the need to ensure competitiveness, also by addressing regulatory burden, the importance of attracting skilled workers, and the need for strong social dialogue. The panellists also referred to the importance of considering the employment aspect in every transition and the need for new creative ideas to make the sector more attractive.

Finally, the presentation by Diana Chillón from BASF Spain discussed managing the transformation through regional cooperation. The key points included implementation of the Transition Pathway, by involving all actors of the value chain, calculating the carbon footprint of the latter, presentation of the training centre built by BASF for employees.

7. Conclusion and outlook

This Final Report summarises research results from literature review, interviews, the three workshops and the conference results. It highlights the framework conditions and corporate practices on the way to climate neutrality, as well as fields of actions to ensure a successful transition and the role of social partners. It presents the project toolbox

[92] https://ec.europa.eu/docsroom/documents/53754
[93] https://ec.europa.eu/docsroom/documents/53754

With the financial support of the European Union

developed together with national social partners in the framework of the project.

The sector still finds itself at the beginning of an important transformation, even if a lot has been done since the commencement of the project. During 2022, the European Commission Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs (DG GROW) developed a Transition Pathway for the chemical industry[94] to climate neutrality within a co-creation process involving European social partners and other European level stakeholders in the sector. At the time of writing this report, a co-implementation process has just begun.

The project has made it very clear that skills forecasting, and development are important tasks on the way to climate neutrality. The European social partners will engage in the Blueprint project funded by the EU to develop digital, green skills and competences to produce safe and sustainable by design chemicals in addition to developing training/courses for all levels of education - from VET, upskilling and reskilling of the current workforce to highly qualified, i.e. Masters. It will also cover Lifelong Learning. The objective of the latter is to identify gaps between the industry needs and the currently offered curricula across the EU.

8. Interview partners

Representatives from the following organisations and companies have been interviewed for this report: 3F (Denmark), ACV-CSC (Belgium), BASF Personal Care and Nutrition GmbH (Germany), BASF SE (Germany), BAVC (Germany), BÜFA GmbH & Co. KG (Germany), Cefic (Europe), Covestro Deutschland AG (Germany), Evonik Industries AG (Germany), France Chimie (France), IGBCE (Germany), Kemianteollisuus ry (Finland), Reset Vlaanderen (Belgium), SIMA (Portugal), Stiftung Arbeit und Umwelt der IGBCE (Germany), Trade Union Pro (Finland), Unite the Union (UK), VCI (Germany), Worlée-Chemie GmbH (Germany).

[94] https://ec.europa.eu/docsroom/documents/53754

9. Literature/Sources

Abdallas Chikri, Yasmine, Wetzels, Wouter (2019), Decarbonisation options for the Dutch tyre industry, 21 November 2019, https://www.pbl.nl/sites/default/files/downloads/pbl-2019-decarbonisation-options-for-the-dutch-tyre-industry_3819.pdf

Accenture (2017), Taking the European chemical industry into the circular economy, https://cefic.org/library-item/taking-the-european-chemical-industry-into-the-circular-economy/

Accenture (2020), Winning in a circular economy. Practical steps for the European chemical industry, https://www.accenture.com/_acnmedia/PDF-117/Accenture-Winning-In-A-Circular-Economy-Executive-Summary.pdf

Agora Energiewende (2020), Klimaneutrale Industrie. Schlüsseltechnologien und Politikoptionen für Stahl, Chemie und Zement, https://static.agora-energiewende.de/fileadmin/Projekte/2018/Dekarbonisierung_Industrie/164_A-EW_Klimaneutrale-Industrie_Studie_WEB.pdf

American Chemical Society (2021), Chemical plants combat nitrous oxide emissions, News release, https://www.eurekalert.org/news-releases/767617

ArGeZ (2021), Lastenheft der Zulieferindustrie zur Bundestagswahl 2021, https://argez.de/2021/04/12/lastenheft-der-zulieferindustrie-zur-bundestagswahl-2021/

Arthur, Charles (2021), What are green skills?, UNIDO, https://www.unido.org/stories/what-are-green-skills

BASF (2020), Outlook for the Chemical Industry. BASF Online Report 2020, https://report.basf.com/2020/en/managements-report/forecast/economic-environment/chemical-industry.html

BASF (2021), Trinseo and BASF jointly announce Business Collaboration on Circular Feedstock, Joint News Release, 29 march 2021, https://www.basf.com/fi/en/media/news-releases/20201/03/p-21-170.html

BASF / ChemCycling™, https://www.basf.com/global/en/who-we-are/sustainability/we-drive-sustainable-solutions/circular-economy/mass-balance-approach/chemcycling.html

Bauer, F., Ericsson, K., Hasselbalch, J., Nielsen, T., & Nilsson, L. J. (2018). Climate innovations in the plastic industry: Prospects for decarbonisation. (IMES/EEES report series; Vol. 111). Miljö- och energisystem, LTH, Lunds universitet, https://portal.research.lu.se/portal/files/53800825/Climate_innovations_in_the_plastic_industry_IMES_report_111.pdf

BAVC (2019), Tarifrunde #Chemie2019: Kein Lohnplus in der Rezession, https://www.bavc.de/service/pressemitteilungen/1881-pi-19-09-2019

BAVC (2020), Kooperation mit der Bundesagentur für Arbeit: Gemeinsam für bessere Qualifizierung, https://www.bavc.de/aktuelles/2002-kooperation-mit-der-bundesagentur-fuer-arbeit-gemeinsam-fuer-bessere-qualifizierung

BAVC/IGBCE/HR Forecast (n.d.), Future jobs and skills. Analysis of the most important changes in the skill architecture of the global chemical and pharmaceutical industry, https://future-skills-chemie.de/en/jobs-skills/

BDI/Boston Consulting Group/Prognos (2018), Klimapfade für Deutschland, https://bdi.eu/publikation/news/

klimapfade-fuer-deutschland/

Beesch, Simon (2020), Welche Beschäftigungs- und Qualifizierungstrends sind zu erwarten? Wasserstoffwirtschaft. Technologie, Wirtschaft & Perspektiven, Hans-Böckler-Stiftung, https://www.mitbestimmung.de/html/wasserstoffwirtschaft-16358.html

Belitz, Heike, Gornig, Martin (2021), TECHNOLOGIEFONDS – Anschub für die digitale und ökologische Transformation der Industrie, 02/2021 WISO direkt, Friedrich-Ebert-Stiftung, https://library.fes.de/pdf-files/wiso/17915.pdf

Bezdek, Roger H. (2019), The hydrogen economy and jobs of the future, IN: Renewable Energy and Environmental Sustainability, Volume 4 (2019), https://doi.org/10.1051/rees/2018005

Bollen, Yelter, Beys, Olivier (2020), D'une politique climatique industrielle défensive à une politique offensive. La politique de soutien à l'industrie à forte intensité énergétique sous la loupe, https://www.researchgate.net/profile/Yelter-Bollen/publication/342262078_D'une_politique_climatique_industrielle_defensive_a_une_politique_offensive/links/5eeb4ecd458515814a676d9c/Dune-politique-climatique-industrielle-defensive-a-une-politique-offensive.pdf

Brown, Trevor (2018), Small-scale ammonia: where the economics work and the technology is ready, https://www.ammoniaenergy.org/articles/small-scale-ammonia-where-the-economics-work-and-the-technology-is-ready/

CE Delft (2012), Identifying breakthrough technologies for the production of basic chemicals. A long term view on the sustainable production of ammonia, olefins and aromatics in the European region, https://cedelft.eu/wp-content/uploads/sites/2/2021/04/CE_Delft_finalreport_1329899563.pdf

CE Delft (2018), Werk door groene waterstof. Eerste verkenning naar behoud van werkgelegenheid en creëren van nieuwe banen door grootschalige uitrol groene waterstof in Nederland, https://cedelft.eu/wp-content/uploads/sites/2/2021/03/CE_Delft_180015_Werk_door_groene_waterstof_DEF.pdf

Cefic (n.d.a), European Innovation Council: Making Science Fiction Reality, https://cefic.org/media-corner/newsroom/european-innovation-council-making-science-fiction-reality/?utm_campaign=Chemistry%20Matters%20-%2027%20May%202021-News%20Subscriber&utm_source=email&utm_mc&enedium=post-organic&utm_content=News---EIC&utm_term=Europe_cefic_News-Subscriber___Chemistry_Matters_-_27_May_2021___post-organic_News---EIC_27/05/2021

Cefic (n.d.b), Future Chemistry Network, https://cefic.org/thought-leadership/future-chemistry-network/

Cefic (2013), European chemistry for growth. Unlocking a competitive, low carbon and energy efficient future, https://cefic.org/app/uploads/2019/01/Energy-Roadmap-The-Report-European-chemistry-for-growth_BROCHURE-Energy.pdf

Cefic (2019), Molecule managers. A journey into the Future of Europe with the European Chemical Industry, https://cefic.org/app/uploads/2019/06/Cefic_Mid-Century-Vision-Molecule-Managers-Brochure.pdf

Cefic (2020), Cefic Partners Again With The European Agency For Safety And Health At Work, https://cefic.org/media-corner/newsroom/cefic-partners-again-with-the-european-agency-for-safety-and-health-at-work/

Cefic (2021), Carbon Contracts For Difference: The Urgent Boost Needed To Deploy Breakthrough Green Deal Technologies, https://cefic.org/media-corner/newsroom/carbon-contracts-for-difference-the-urgent-boost-needed-to-deploy-breakthrough-green-deal-technologies/?utm_campaign=Chemistry%20Matters%20-%2012%20May%202021-News%20Subscriber&utm_source=email---mailjet&utm_medium=post-organic&utm_content=Digital-Dialogue---Carbon-Contracts&utm_term=Europe_cefic_News-Subscriber___Chemistry_Matters_-_12_May_2021___post-organic_Digital-Dialogue---Carbon-Contracts_05/12/2021

Cefic (2021a), Industry data confirms green shoots of recovery but reveals highly challenging times remain for industry, Chemical Quarterly Report (CQR). Quarterly Summary, 11 May 2021, https://cefic.org/app/uploads/2021/05/Cefic-Chemicals-Quarterly-Report-May-2021.pdf

Cefic (2021b), Sectoral Pathways Will Be Key To A Successful Industrial Transition Cefic Director General Says Welcoming The Update Of The EU Industrial Strategy, https://cefic.org/media-corner/newsroom/sectoral-pathways-will-be-key-to-a-successful-industrial-transition-cefic-director-general-says-welcoming-the-update-of-the-eu-industrial-strategy/?utm_campaign=Chemistry%20Matters%20-%2012%20May%202021-News%20Subscriber&utm_source=email---mailjet&utm_medium=post-organic&utm_content=News---Welcome-Welcoming-The-Update-Of-The-EU-Industrial-Strategy&utm_term=Europe_cefic_News-Subscriber___Chemistry_Matters_-_12_May_2021___post-organic_News---Welcome-Welcoming-The-Update-Of-The-EU-Industrial-Strategy_05/12/2021

Cefic (2021c), The European Chemical Industry. A vital part of Europe's future. Facts&Figures 2021

Cefic (2021d), The European chemical industry wants to boost its Bioeconomy sector: platform chemicals and polymers for plastics as promising opportunities, https://cefic.org/app/uploads/2021/04/Cefic-view-paper-BioEconomy-and-BBPs.pdf

Cefic (2021e), Walking the sustainability talk, ChemistryCan Newsletter, 13 July 2021.

Cefic/Ecofys (2013), European chemistry for growth. Unlocking a competitive, low carbon and energy efficient future, April 2013, https://cefic.org/app/uploads/2019/01/Energy-Roadmap-The-Report-European-chemistry-for-growth_BROCHURE-Energy.pdf

Cefic/Smart Fright Centre (2021), Calculating GHG transport and logistics emissions for the European Chemical Industry, https://cefic.org/app/uploads/2021/09/Calculating-GHG-transport-and-logistics-emissions-for-the-European-Chemical-Industry-Guidance.pdf

Ceflex: A circular economy for flexible packaging, https://ceflex.eu/

CETA-Centrum ekonomických a tržních analýz, z. ú. (2020), Feasibility and impact study of the European Green Deal and of industry decarbonisation on the chemical sector of the Czech Republic with focus on employment.

Chan, Y.; Petithuguenin, L.; Fleiter, T.; Herbst, A.; Arens, M., Stevenson, P. (2019): Industrial Innovation: Pathways to deep decarbonisation of Industry. Part 1: Technology Analysis. ICF and Fraunhofer ISI, https://www.isi.fraunhofer.de/content/dam/isi/dokumente/cce/2021/industrial_innovation_part_1_en.pdf

Chemie3 (n.d.), Sozialpartner-Werkstatt So.WIN, https://www.chemiehoch3.de/branche/so-win/

Chemie,de (2011), Bayer MaterialScience: Clevere Technologie erhöht Energieeffizienz, https://www.chemie.de/news/133777/bayer-materialscience-clevere-technologie-erhoeht-energieeffizienz.html

Chemietechnik,de (2013), Bayer und Thyssenkrupp vermarkten SVK-Technik für Chlor-Produktion, https://www.

With the financial support of the European Union

chemietechnik.de/markt/bayer-und-thyssenkrupp-vermarkten-svk-technik-fuer-chlor-produktion.html

Conseil national de l'industrie (2021), Decarbonisation de l'industrie. Feuille de route de la filière chimie, https://www.ecologie.gouv.fr/sites/default/files/2021.05.07_Annexe_au_cp_feuille_de_route_decarbonation_chimie.pdf

Continental (2020), Continental to Expand Structural Program and Save More than One Billion Euros Per Year, Press release September 01, 2020, https://www.continental.com/en/press/press-releases/expansion-structural-program/

Creative Energy (2007), European roadmap more process intensification, https://efce.info/efce_media/-p-531.pdf

DECHEMA (2017), Low-carbon energy and feedstock for the European chemical industry, technology study, commissioned by Cefic, https://cefic.org/app/uploads/2019/01/Low-carbon-energy-and-feedstock-for-the-chemical-industry-DECHEMA_Report-energy_climate.pdf

DECHEMA/FutureCamp (2019), Roadmap Chemie 2050, Auf dem Weg zu einer treibhausgasneutralen chemischen Industrie in Deutschland. Eine Studie von DECHEMA und FutureCamp für den VCI, https://www.vci.de/vci/downloads-vci/publikation/2019-10-09-studie-roadmap-chemie-2050-treibhausgasneutralitaet.pdf

Deloitte/VCI (2017), Chemistry 4.0. Growth through innovation in a transforming world, https://www.vci.de/vci/downloads-vci/publikation/vci-deloitte-study-chemistry-4-dot-0-short-version.pdf

Dialog Basis/VCI (2019), Stakeholder-Dialog Dekarbonisierung, Dialogbericht, https://www.vci.de/vci/downloads-vci/publikation/2019-04-30-stakeholder-dialog-dekarbonisierung-zwischenfazit.pdf

DNV GL (2019), Hydrogen as an energy carrier, Research Review 2018, https://www.dnv.com/research/review2018/featured-projects/hydrogen-energy-carrier.html

DNV (2021), Energy transition outlook 2021. A global and regional forecast to 2050, executive summary, https://eto.dnv.com/2020/what-is-energy-transition-report

Drive (2020), The Pact for Skills. Skills Partnership for the Automotive Ecosystem, 15 November 2020, https://drivescloud.vsb.cz/index.php/s/2nA4EwAT5cLB6a6#pdfviewer

Dullien, Sebastian, Rietzler, Katja, Tober, Silk (2021), Ein Transformationsfonds für Deutschland, Stiftung Arbeit und Umwelt der IG BCE / Institut für Makroökonomie und Konjunkturforschung (IMK), Hans-Böckler- Stiftung, Berlin, https://igbce.de/resource/blob/179390/593129ff28b077f280efaa6b2c590dca/gutachten-zum-transformationsfonds-data.pdf

ECEG/IndustriAll Europe (2013), Joint declaration on the European Commission's Green Paper 'A 2030 framework for climate and energy policies', https://news.industriall-europe.eu/content/documents/upload/2019/3/636891176977234095_climate-energy-common-position_en-fin.pdf

ECEG/IndustriAll Europe (2015), Joint Declaration of the Social Partners of the European Chemical Industry. Common position on energy and climate policy ahead of the 21st Conference of the Parties (COP 21) of the United Nations Framework Convention on Climate Change (UNFCCC) to be held in Paris 30 November - 11 December 2015, http://ec.europa.eu/social/BlobServlet?mode=dsw&docId=11586&langId=en

EESC (2020), An EU legal framework on safeguarding and strengthening workers' information, consultation and participation, Study, https://www.eesc.europa.eu/sites/default/files/files/qe-02-20-818-en-n.pdf

EFPIA (2016), EFPIA White Paper on Circular Economy, https://www.efpia.eu/media/554663/circular-economy.pdf

EFPIA (2020), EFPIA White Paper on Climate Change, https://www.efpia.eu/media/554662/white-paper-climate-change.pdf

Ellen MacArthur Foundation (2019), Enabling a circular economy for chemicals with the mass balance approach, White Paper.

Energy Transitions Commission (2018), Mission Possible. Reaching net-zero carbon emissions from harder to abate sectors by mid-century, November 2018, https://www.energy-transitions.org/wp-content/uploads/2020/08/ETC_MissionPossible_FullReport.pdf

ERRLAB (n.d.), About us, http://www.errlab.eu/

ESCA (2016), European Sector Skills Council Automotive Industry. Report, https://www.etrma.org/wp-content/uploads/2019/09/skill-council-automotive-report-2016-stampa4.pdf

essenscia (2019), Chimie & sciences de la vie: la formule par excellence pour plus de prospérité et de bien-être. Mémorandum d'essenscia pour les élections régionales, fédérales et européennes 2019, https://essenscia.be/wp-content/uploads/2019/01/181122_Memorandum_essenscia_2019.pdf

ETRMA (2020), Recycled rubber infill material has a role to play in a Circular Economy, Updated, Brussels, 1st September 2020, https://www.etrma.org/wp-content/uploads/2020/09/20200901-Recycled-rubber-has-a-role-to-play.pdf

ETRMA (2020a), Bringing forward-looking skills to the rubber and tyre industry via a Pact for Skills is key to accompany transformation in the automotive ecosystem. Press release, https://www.etrma.org/wp-content/uploads/2020/10/ETRMA-Automotive-Skills-Alliance.pdf

ETUC (2018), A guide for trade unions, Involving trade unions in climate action to build a just transition, https://www.etuc.org/sites/default/files/publication/file/2018-09/Final%20FUPA%20Guide_EN.pdf

ETUC/BusinessEurope/SMEUnited/SGIeurope (2022): European Social Dialogue WORK PROGRAMME 2022 – 2024, https://www.businesseurope.eu/sites/buseur/files/media/reports_and_studies/2022-06-28_european_social_dialogue_programme_22-24_0.pdf

European Agency for Safety and Health at Work (2013), Green jobs and occupational safety and health: Foresight on new and emerging risks associated with new technologies by 2020. Report, https://eur-lex.europa.eu/resource.html?uri=cellar:001663c8-c1af-40ef-ab21-72ae030ca858.0001.02/DOC_1&format=PDF

European Commission (n.d.), European Climate Law, https://climate.ec.europa.eu/eu-action/european-green-deal/european-climate-law_en#formal-adoption

European Commission (2017), Investing in a smart, innovative and sustainable Industry. A renewed EU Industrial Policy Strategy, COM(2017) 479 final, https://eur-lex.europa.eu/resource.html?uri=cellar:c8b9aac5-9861-11e7-b92d-01aa75ed71a1.0001.02/DOC_1&format=PDF

With the financial support of the European Union

European Commission (2018), A Clean Planet for all. A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52018DC0773&from=EN, COM(2018) 773 final.

European Commission (2018a): A European Strategy for Plastics in a Circular Economy, COM(2018) 28 final. https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1516265440535&uri=COM:2018:28:FIN

European Commission (2018b), Final Report of the High-Level Panel of the European Decarbonisation Pathways Initiative, https://publications.europa.eu/en/publication-detail/-/publication/226dea40-04d3-11e9-adde-01aa75ed71a1

European Commission (2018c), Impacts of circular economy policies on the labour market. Final report, https://circulareconomy.europa.eu/platform/sites/default/files/ec_2018_-_impacts_of_circular_economy_policies_on_the_labour_market.pdf

European Commission (2018d): Questions & Answers: A European Strategy for plastics. Strasbourg, 16 January 2018. https://ec.europa.eu/commission/presscorner/detail/fi/MEMO_18_6

European Commission (2019a), 2050 long-term strategy, https://ec.europa.eu/clima/policies/strategies/2050_en

European Commission (2019b), A vision for the European Industry until 2030, Final report of the Industry 2030 high-level industrial roundtable, https://op.europa.eu/de/publication-detail/-/publication/339d0a1b-bcab-11e9-9d01-01aa75ed71a1

European Commission (2019c), The European Green Deal, COM(2019) 640 final, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2019%3A640%3AFIN

European Commission (2020a), A hydrogen strategy for a climate-neutral Europe, COM/2020/301 final, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020DC0301

European Commission (2020b), A new Circular Economy Action Plan. For a cleaner and more competitive Europe, COM(2020) 98 final, https://eur-lex.europa.eu/resource.html?uri=cellar:9903b325-6388-11ea-b735-01aa75ed71a1.0017.02/DOC_1&format=PDF

European Commission (2020c), A New Industrial Strategy for Europe, COM(2020) 102 final, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020DC0102&from=EN

European Commission (2020d), An SME Strategy for a sustainable and digital Europe, COM(2020) 103 final, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0103

European Commission (2020e), Chemicals Strategy for Sustainability. Towards a Toxic-free Environment, COM(2020) 667 final, https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52020DC0667&from=EN

European Commission (2020f), Pharmaceutical Strategy for Europe, COM(2020) 761 final, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020DC0761&from=EN

European Commission (2020g), Powering a climate-neutral economy: An EU Strategy for Energy System Integration, COM (2020) 299 final, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020DC0299&from=EN

European Commission (2021a), European Green Deal: Commission proposes transformation of EU economy and society to meet climate ambitions, Press release, https://ec.europa.eu/commission/presscorner/detail/en/ip_21_3541

European Commission (2021b), For a resilient, innovative, sustainable and digital energy-intensive industries ecosystem: Scenarios for a transition pathway, SWD(2021) 277 final, https://ec.europa.eu/docsroom/documents/47059/attachments/1/translations/en/renditions/native

European Commission (2021c): Plastics own resource. https://ec.europa.eu/info/strategy/eu-budget/long-term-eu-budget/2021-2027/revenue/own-resources/plastics-own-resource_en

European Commission (2021d), Updating the 2020 New Industrial Strategy: Building a stronger Single Market for Europe's recovery, https://ec.europa.eu/commission/presscorner/detail/en/ip_21_1884

Eurostat (2022a), Annual detailed enterprise statistics for industry (NACE Rev. 2, B-E), https://ec.europa.eu/eurostat/databrowser/view/sbs_na_ind_r2/default/table?lang=en

Eurostat (2022b), Greenhouse gas emissions by source sector (source: EEA), https://ec.europa.eu/eurostat/databrowser/view/ENV_AIR_GGE__custom_5357533/default/table?lang=en

FCH (2019), Hydrogen Roadmap Europe. A sustainable pathway for the European energy transition, https://op.europa.eu/en/publication-detail/-/publication/0817d60d-332f-11e9-8d04-01aa75ed71a1/language-en

Fraunhofer (2013), Energieverbrauch und CO2-Emissionen industrieller Prozesstechnologien Einsparpotenziale, Hemmnisse und Instrumente. Karlsruhe, https://www.isi.fraunhofer.de/content/dam/isi/dokumente/ccx/2013/Umweltforschungsplan_FKZ-370946130.pdf

Fraunhofer Institute for Systems and Innovation (2019), GHG-neutral EU2050 – a scenario of an EU with net-zero greenhouse gas emissions and its implications. Full report, On behalf of the German Environment Agency, https://www.umweltbundesamt.de/sites/default/files/medien/1410/publikationen/2019-11-26_cc_40-2019_ghg_neutral_eu2050_0.pdf

Freudenberg Group (2021), 2020 Annual Report, https://www.freudenberg.com/fileadmin/downloads/english/FreudenbergGroup_AnnualReport2020.pdf

Friedrich-Ebert-Stiftung Nordic Countries (FES) / Fink, P. (2021), The Road Towards a Carbon-Free Society. A Nordic-German Trade Union Cooperation on Just Transition. http://library.fes.de/pdf-files/bueros/stockholm/17520.pdf

Gesamtverband Kunststoffverarbeitende Industrie e.V. (GKV) (2011): IG BCE und GKV: Gemeinsam für eine nachhaltige Kunststoffindustrie. Pressemitteilung, 15. August 2011. https://www.gkv.de/de/service/presse/ig-bce-und-gkv-gemeinsam-fuer-eine-nachhaltige-kunststoffindustrie.html

Global CCS Institute (2020), Global status of CCS 2020, https://www.globalccsinstitute.com/wp-content/uploads/2021/03/Global-Status-of-CCS-Report-English.pdf

Green Chemistry and Commerce Council (2021), The gc3 Blueprint of Green Chemistry Opportunities for a Circular Economy, https://greenchemistryandcommerce.org/documents/gc3-circular-economy-report.pdf

Großmann, Dr. A.; Wolter, Dr. M. I.; Hinterberger, Dr. F.; Püls, L. (2020), Die Auswirkungen von klimapolitischen

With the financial support of the European Union

Maßnahmen auf den österreichischen Arbeitsmarkt, ExpertInnenbericht, https://downloads.gws-os.com/Gro%c3%9fmannEtAl2020_ExpertInnenbericht.pdf

High-Level Group on Energy-intensive Industries (2019), Masterplan for a CompetitiveTransformation of

EU Energy-intensive Industries Enabling a Climate-neutral, Circular Economy by 2050, https://ec.europa.eu/docsroom/documents/38403/attachments/1/translations/en/renditions/native

H2 cluster Finland (2021), A systemic view on the Finnish hydrogen economy today and in 2030 – Our common playbook for the way forward, Whitepaper 9/21, https://h2cluster.fi/wp-content/uploads/2021/09/H2Cluster-Whitepaper-09-2021.pdf

Hoch, Markus; Lambert, Jannis; Kirchner, Almut; Simpson, Richard; Sandhövel, Myrna Mündlein; Tabea (2020), Jobwende - Effects of the Energiewende on Work and Employment, Friedrich-Ebert-Stiftung, http://library.fes.de/pdf-files/fes/16769-20210201.pdf

Hock, Jana Maria (2021), Slow Reactions. Chemical companies must transform in a low-carbon world, ShareAction, https://api.shareaction.org/resources/reports/Slow-Reactions-Chemicals-and-Climate.pdf

Hydrogen Council (2017), A sustainable pathway for the global energy transition. https://hydrogencouncil.com/wp-content/uploads/2017/11/Hydrogen-Scaling-up_Hydrogen-Council_2017.compressed.pdf

ICCA (2021), Life Cycle Assessment of circular systems: Guide & case studies, https://icca-chem.org/wp-content/uploads/2021/05/ICCA_Avoiding-GHG-Emissions_Life-Cycle-Assessment-of-Circular-Systems_Guide-and-Case-Studies.pdf

ICCA/IEA/Dechema (2013), Technology Roadmap Energy and GHG Reductions in the Chemical Industry via Catalytic Processes, https://dechema.de/dechema_media/Downloads/Positionspapiere/IndustrialCatalysis/Chemical_Roadmap_2013_Final_WEB-called_by-dechema-original_page-136220-original_site-dechema_eV-view_image-1.pdf

IEA (2021a): Electricity Market Report - July 2021, https://www.iea.org/reports/electricity-market-report-july-2021

IEA (2021b): Net Zero by 2050. A Roadmap for the Global Energy Sector, https://iea.blob.core.windows.net/asseIFAts/beceb956-0dcf-4d73-89fe-1310e3046d68/NetZeroby2050-ARoadmapfortheGlobalEnergySector_CORR.pdf

IEA (2021c), World Energy Investment 2021, https://www.iea.org/reports/world-energy-investment-2021

IFA (2020), Kunststoff, Gummiwaren. Ausführliches Branchenbild aus dem Risikoobservatorium der DGUV, https://www.dguv.de/medien/ifa/de/fac/arbeiten_4_0/branchenbild_kunststoff_gummiwaren.pdf

IG BCE (2021), Szenarien zum Zukunftskongress, https://igbce.de/igbce/themen/berichterstattung-zukunftskongress

IG BCE Innovationsforum Energiewende e. V. (2018), Potentialatlas für Wasserstoff. Analyse des Marktpotentials für Wasserstoff, der mit erneuerbarem Strom hergestellt wird, im Raffineriesektor und im zukünftigen Mobilitätssektor, https://www.dwv-info.de/wp-content/uploads/2018/04/Potentialstudie-f%C3%BCr-gr%C3%BCnen-Wasserstoff-in-Raffinerien.pdf

IGBCE/BAVC (2021), The Future Skills Report Chemistry. An AI-based trend analysis on the future skills of the chemical and pharmaceutical industry, https://future-skills-chemie.de/en/

ILO/OECD (2020), Social Dialogue and the future of work, Thematic brief, https://www.theglobaldeal.com/resources/Thematic-Brief-Social-Dialogue-and-the-FoW.pdf

IndustriAll Europe (2019), IndustriAll Europe welcomes idea of going climate neutral by 2050. 'A Clean Planet for All' creates opportunities to re-industrialise Europe', https://news.industriall-europe.eu/content/documents/upload/2019/2/636863422964119410_Postiionpaperclimateplan0319-EN.pdf

IndustriAll Europe (2020), Climate proofing our industrial jobs, News, https://news.industriall-europe.eu/Article/462

IRENA (2020), Reaching zero with renewables: Eliminating CO2 emissions from industry and transport in line with the 1.5 °C climate goal, International Renewable Energy Agency, Abu Dhabi, https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2020/Sep/IRENA_Reaching_zero_2020.pdf

IZA (2011), Cross-border collective bargaining and transnational social dialogue, https://ftp.iza.org/report_pdfs/iza_report_38.pdf

Izt/ Öko-Institut e.V. (2021): Deutschland auf dem Weg zur Klimaneutralität: Welche Chancen und Risiken ergeben sich durch die Digitalisierung?, https://www.kfw.de/PDF/Download-Center/Konzernthemen/Research/PDF-Dokumente-Studien-und-Materialien/KfW_Digitalisierung_Klimaschutz.pdf

Jepma, Catrinus J., Spijker, Eise, Hofman, Erwin (2019), The Dutch Hydrogen Economy in 2050. An exploratory study on the socio-economic impacts of introducing hydrogen into the Netherlands energy system, https://www.vno-ncw.nl/sites/default/files/the_dutch_hydrogen_economy_in_2050_march_2019.pdf

Kaiser, Oliver, Malanowski, Norbert (2020), Voraussetzungen für eine wettbewerbsfähige Wasserstoffwirtschaft. Fördernde und hemmende Faktoren im Verkehrssektor und der Chemischen Industrie, Working Paper Forschungsförderung Nummer 193, Hans Böckler Stiftung, https://www.boeckler.de/download-proxy-for-faust/download-pdf?url=http%3A%2F%2F217.89.182.78%3A451%2Fabfrage_digi.fau%2Fp_fofoe_WP_193_2020.pdf%3Fprj%3Dhbs-abfrage%26ab_dm%3D1%26ab_zeig%3D9102%26ab_diginr%3D8483

Kemianteollisuus (n.d.), Responsible Care, https://www.kemianteollisuus.fi/en/sustainability/responsible-care/

Kemianteollisuus (2021), Cap the Carbon! Aiming for a Climate Neutral Finland, https://kemianteollisuus.studio.crasman.cloud/file/dl/a/ii4Qug/yOW6Wo-Lo4uzbGqrHR1ZCA/Cap_the_Carbon_.pdf

Kemianteollisuus et.al. (2020), Sustainable and circular business models for the chemical industry. Circular economy playbook for chemical companies, https://media.sitra.fi/2020/05/28111719/sustainable-and-circular-business-models-for-the-chemical-industry.pdf

Kemianteollisuus et.al. (2021), STRATEGIC CAPABILITIES FOR CARBON NEUTRALITY IN THE CHEMICAL INDUSTRY, March 2021, https://kemianteollisuus.studio.crasman.cloud/file/dl/a/LhoP_g/Yd7J__SrHY9VabNqGdl4Ww/StrategicCapabilitiesforCarbonNeutrality_Report_EN.pdf

Kolev, Galina, Kube, Roland, Schaefer, Thilo, Stolle Leon (2021), Carbon Border Adjustment Mechanism (CBAM), Motivation, Ausgestaltung und wirtschaftliche Implikationen eines CO2-Grenzausgleichs in der EU, IW-Policy Paper

With the financial support of the European Union

6/21, https://www.iwkoeln.de/fileadmin/user_upload/Studien/policy_papers/PDF/2021/IW-Policy-Paper_2021_Carbon-Border-Adjustment.pdf

Krichewsky-Wegener, Léna, Abel, Sebastian, Bovenschulte, Marc (2020), Working paper of the Institute for Innovation and Technology Nr.55, https://www.iit-berlin.de/wp-content/uploads/2021/01/2020_11_iit-perspektive_Hydrogen-Economies.pdf

Löckener, Ralf; Ulrich, Philip; Lehr, Ulrike; Sundmacher, Torsten; Timmer; Birgit and Vorderwülbecke, Arne (2016), Energiewende in Baden-Württemberg. Auswirkung auf die Beschäftigung, Study Nr. 344, Hans-Böckler-Stiftung, November 2016, https://um.baden-wuerttemberg.de/fileadmin/redaktion/m-um/intern/Dateien/Dokumente/2_Presse_und_Service/Publikationen/Energie/161101_Study_Energiewende-in-BW_Auswirkungen-Beschaeftigung.pdf

Material Economics (2019), Industrial Transformation 2050 - Pathways to Net-Zero Emissions from EU Heavy Industry, https://materialeconomics.com/material-economics-industrial-transformation-2050.pdf?cms_fileid=303ee49891120acc9ea3d13bbd498d13

McKinsey (2018a), Decarbonisation of industrial sectors: the next frontier, June 2018. https://www.mckinsey.com/~/media/mckinsey/business%20functions/sustainability/our%20insights/how%20industry%20can%20move%20toward%20a%20low%20carbon%20future/decarbonization-of-industrial-sectors-the-next-frontier.pdf

McKinsey (2018b): How plastics waste recycling could transform the chemical industry. December 12,2018. Article. https://www.mckinsey.com/industries/chemicals/our-insights/how-plastics-waste-recycling-could-transform-the-chemical-industry

McKinsey (2020): What the future of mobility holds for chemical players. September 21, 2020. Article. https://www.mckinsey.com/industries/chemicals/our-insights/what-the-future-of-mobility-holds-for-chemical-players

Michelin (2020a), Michelin - Climate Change 2020, https://www.michelin.com/en/documents/response-to-cdp-climate-change-questionnaire-2020/

MiniMichelin (2020b), Motion for Life. 2020 Universal Registration Document, https://www.michelin.com/en/documents/2020-universal-registration-document/

Nelissen, Guido (2019), Framework conditions for a just and deep decarbonisation of the Energy Intensive Industries, industriAll Europe, presentation at the EU refining Forum, 25 April 2019.

Neuwirth, Marius, Fleiter, Tobias (2020), Hydrogen technologies for a CO2-neutral chemical industry – a plant-specific bottom-up assessment of pathways to decarbonise the German chemical industry, Fraunhofer Institute for Systems and Innovation Research ISI Competence Center Energy Technology and Energy Systems, https://www.isi.fraunhofer.de/content/dam/isi/dokumente/cce/2020/6-110-20_Neuwirth.pdf

Nokian tyres (2021), Corporate sustainability report 2020, https://dc602r66yb2n9.cloudfront.net/pub/web/attachments/publications/Nokian_Tyres_corporate_sustainability_report_2020.pdf

OECD (2012), The jobs potential of a shift towards a low-carbon economy, FINAL REPORT FOR THE EUROPEAN COMMISSION, DG EMPLOYMENT, https://www.oecd.org/els/emp/50503551.pdf

Pirelli (2020), To innovate is to keep learning, 14/02/2020, https://www.pirelli.com/global/en-ww/life/to-innovate-is-to-keep-learning

Pirelli (2021), Annual report 2020, https://psi-dotcom-prd.s3.eu-west-1.amazonaws.com/corporate/PIRELLI_ANNUAL_REPORT_2020_ENG_INTERATTIVO.pdf

Prognos (2011), Untersuchung einer Nachfolgeregelung zur Energie- und Stromsteuerentlastung, Sachverständigenauftrag 86/1, 28.10.2011, Berlin, https://www.bmwi.de/Redaktion/DE/Publikationen/Studien/untersuchung-einer-nachfolgeregelung-zur-energie-und-stromsteuerentlastung.pdf?__blob=publicationFile&v=4

Pöyry (2020), Roadmap to reach carbon neutral chemistry in Finland 2045. Final report, https://kemianteollisuus.studio.crasman.cloud/file/dl/i/0GtI_g/bilh3mQXLQvp85TOziHyZA/Kemianteollisuusroadmap.pdf

Pwc (2020), Chemicals trends 2020: Winning strategies for an era of sustainable value chains, 23rd Annual Global CEO Survey, Trend report, https://www.pwc.com/gx/en/ceo-survey/2020/trends/chemicals-trends-2020.pdf

Renssen, Sonja van (2021), Hydrogen tests climate policymakers with its job potential, Energy Monitor, https://energymonitor.ai/tech/hydrogen/hydrogen-tests-climate-policymakers-with-its-job-potential

Remes, Matti (n.d.), Hiilineutraali kemia, https://www.kemianteollisuus.fi/fi/uutishuone/juttusarjat/hiilineutraali-kemia/

Roland Berger (2021), Skills roadmap voor de Vlaamse klimaattransitie. Focus op de energie-intensieve sectoren [2020-2035], Een onderzoek in opdracht van de Vlaamse minister bevoegd voor Werk, in het kader van het VIONA-onderzoeksprogramma, https://publicaties.vlaanderen.be/view-file/44786

Roland Berger Strategy Consultants (2015), CHEMICALS 2035 –GEARING UP FOR GROWTH. How Europe's chemical industry can gain traction in a tougher world, Think Act, https://www.rolandberger.com/publications/publication_pdf/roland_berger_tab_chemicals_2035_20150521.pdf

Rothermel, Dr. Jörg (2020), The Chemical industry – Seeking and offering solutions for a CO2-neutral future, presentation at the Carbon2Chem 3rd Conference, October 29, 2020.

Shell (2021), DOW AND SHELL DEMONSTRATE PROGRESS IN JOINT TECHNOLOGY DEVELOPMENT FOR LOWER CO_2 EMISSION CRACKERS, 17th June 2021, https://www.shell.com/business-customers/chemicals/media-releases/2021-media-releases/dow-and-shell-demonstrate-progress-in-joint-technology.html

SNCP (2021), Impacts du développement du véhicule électrique sur la filière caoutchouc : des menaces, mais aussi des opportunités. Communiqué de presse, Vitry-sur-Seine, le 18 mai 2021, http://www.cfcp-caoutchouc.com/images/actualites/Communiqu%C3%A9_Impacts_sur_le_v%C3%A9hicule_%C3%A9lectrique.pdf

SPIRE (2012), SPIRE Roadmap, https://www.aspire2050.eu/sites/default/files/pressoffice/spire-roadmap.pdf

Stelpstra, Tjisse (2020), Why clean hydrogen can be part of the just transition, Foresight Climate & Energy, https://foresightdk.com/why-clean-hydrogen-is-a-key-part-of-the-just-transition/

Stiftung Arbeit und Umwelt (2019a), Beschäftigungseffekte der BDI-Klimapfade. Studie, https://www.arbeit-umwelt.de/wp-content/uploads/190404_Studie_BeschaftigungEffekteKlimapfadeBDI_StiftungIGBCE.pdf

Stiftung Arbeit und Umwelt der IGBCE (2019b), Gerechte Energiewende: Sieben Thesen zu Herausforderungen

With the financial support of the European Union

und Chancen aus industriegewerkschaftlicher Sicht, January 2019, https://www.arbeit-umwelt.de/wp-content/uploads/190115_StudieGerechteEnergiewende_StiftungIGBCE.pdf

Stiftung Arbeit und Umwelt der IG BCE (2020): Diskussionspapier – Klimaneutrale Industrie: Mögliche Varianten für zukunftsfesten Carbon-Leakage- Schutz im Vergleich. Berlin, https://www.arbeit-umwelt.de/wp-content/uploads/Diskussionspapier_Carbon-Leakage_Schutz_StAU.pdf

Stiftung Arbeit und Umwelt der IG BCE (2021): Branchenausblick 2030+: Die kunststoffverarbeitende Industrie. Berlin, https://www.arbeit-umwelt.de/wp-content/uploads/Branchenausblick2030_kunststoffverarbeitende_Industrie_StiftungIGBCE.pdf

Suschem (2018), Plastics Strategic Research and Innovation Agenda in a Circular Economy.

Suschem (2020), Sustainable Plastics Strategy, Edition 2, December 2020.

Swedish Energy Agency (2021), Investment in climate-neutral methanol production at Perstorp is supported by the Swedish Energy Agency, http://www.energimyndigheten.se/en/news/2021/investment-in-climate-neutral-methanol-production-at-perstorp-is-supported-by-the-swedish-energy-agency

The Royal Society (2020), Ammonia: zero-carbon fertiliser, fuel and energy store. POLICY BRIEFING, https://royalsociety.org/-/media/policy/projects/green-ammonia/green-ammonia-policy-briefing.pdf

Toner, Phillip (2011), Workforces skills and innovation: An overview of major themes in the literature, OECD Directorate for Science, Technology and Industry (STI), Centre for Educational Research and Innovation (CERI), https://www.oecd.org/sti/inno/46970941.pdf

Trelleborg (2021), 2020 Annual report with Sustainability report, https://mb.cision.com/Main/584/3308884/1388875.pdf

VCI/BAVC/IGBCE/BMWi (2021), Handlungskonzept Chemie- und Pharmastandort Deutschland, https://www.vci.de/ergaenzende-downloads/2021-02-16-handlungskonzept-chemiepharma-final.pdf

VCI/Deloitte (2017): Chemie 4.0. Wachstum durch Innovation in einer Welt im Umbruch, Endbericht, https://www2.deloitte.com/de/de/pages/consumer-industrial-products/articles/chemie4-0.html

VCI/Prognos (2019), Wege in die Zukunft – Weichenstellung für eine nachhaltige Entwicklung in der chemisch-pharmazeutischen Industrie. Kurzfassung der Studie von VCI und Prognos, https://www.vci.de/vci/downloads-vci/publikation/2019-10-studie-vci-prognos-wege-in-die-zukunft-fuer-die-chem-pharm-industrie.pdf

VoltaChem (2016), Empowering the chemical industry. Opportunities for electrification, https://www.tno.nl/media/7514/voltachem_electrification_whitepaper_2016.pdf

Voß, Werner (2013a), Die Grundstoffchemie in Deutschland im internationalen Umfeld, Hans Böckler Stiftung, https://www.boeckler.de/pdf_fof/96090.pdf

Voß, Werner (2013b), Ressourceneffizienz als Herausforderung für die Grundstoffchemie in Deutschland, Abschlussbericht, Hans-Böckler-Stiftung, https://www.boeckler.de/pdf_fof/91484.pdf

wdk (2019), Nachhaltig handeln in der deutschen Kautschukindustrie. Erfolgreiche Projekte der wdk-

Mitgliedsunternehmen, https://wdk.de/wp-content/uploads/nachhaltig-handeln-ausgabe-august-2019_0.pdf (p.60)

WSP and Parsons Brinckerhoff/ DNV GL (2015), Industrial Decarbonisation &Energy Efficiency Roadmaps to 2050, MARCH 2015, report prepared for the Department of Energy and Climate Change and the Department for Business, Innovation and Skills Chemicals, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/416669/Chemicals_Report.pdf

Wyns et al. (2019), Industrial Transformation 2050. Towards an Industrial strategy for a Climate Neutral Europe, IES, https://brussels-school.be/sites/default/files/Industrial_Transformation_2050_0_compressed%281%29.pdf

Yara International (2021), Technical expert - Ammonia Product carbon footprint and certification scheme, https://jobs.yara.com/job/Oslo-Technical-expert-Ammonia-Product-carbon-footprint-and-certification-schemes/691846601/: Technical expert - Ammonia Product carbon footprint and certification schemes

With the financial support of the European Union