12.2 Vertical coherence of legislation

• Continue to update PACT (the Public Activities Coordination Tool) to provide an up-to-date overview of all planned and ongoing initiatives on chemicals by authorities across different pieces of legislation	EU/MS	S
• Suggest technical guidance to promote harmonised implementation and better enforcement of legislation on occupational safety and health	Industry	M

Finally, stakeholders reflected on means to improve the enforceability of existing legislation; focusing in particular on imported products allowing authorities to detect when these products do not comply with EU standards; especially for online sales of consumer products. Under the Market Surveillance Regulation, the Commission proposes to lay down uniform conditions and frequencies of checks for certain products where specific risks or serious breaches of applicable EU harmonisation legislation have been continuously identified. It also wishes to explore the use of digital tools to support market-surveillance and customs authorities and to improve the compliance of products containing chemicals that are sold online to European consumers. Implementation of legislation can also be improved by fully deploying existing synergies and further developing existing public-private partnerships or by creating specific support to help SMEs implement legislation. Technical guidance may also help to explain regulatory requirements and harmonise interpretation and implementation.

The table below summarises proposals made by stakeholders on enforcement.

Topic 13: Effective and efficient enforcement		
Actions	Actors	Timeframe
• Consider developing analytical methods to support enforcement. Increase available resources for enforcement	Industry and EU/MS	S
• Share for Member States consideration, successful non-regulatory enforcement measures (e.g. voluntary actions, schemes and stewardship initiatives) that make the enforcement of legislation more efficient and more effective	Industry	S
• Lay down – under the Market Surveillance Regulation – uniform conditions and frequencies of checks for certain products where specific risks or serious breaches of applicable EU harmonisation legislation have been continuously identified	EU	S
• Explore the use of digital tools to support market-surveillance and customs authorities and to improve the compliance of products containing chemicals that are sold online to European consumers	EU	S/M
• Encourage MS to use the Recovery and Resilience Facility to invest in strengthening market-surveillance infrastructures and digitalisation	EU/MS	S/M
• Extend the scope of action of the European Anti-Fraud Office in coordination and investigation, so it can help to tackle the circulation of illicit chemical products in the EU	EU	S/M

During the co-development process, stakeholders expressed their willingness for the Commission to develop a comprehensive and integrated overview of the legislation applied to the chemical industry at EU level. This could provide industry with a better understanding of the upcoming regulatory framework, as well as the opportunities available at European level.

The resulting regulatory roadmap became a third component of the transition pathway for the chemical industry. This overview of existing legislation and major R&I initiatives relevant to the chemical industry has been developed using the best available knowledge at the time of writing. It includes the latest publicly available information and best-scenario assumptions about the ongoing legislative and non-legislative procedures. However, the timeline of this roadmap remains purely indicative; especially for those proposals whose content is still under development.

The overview does not include all financial opportunities supporting the implementation of the legislation (where it exists) and/or the transition of the industry. It also does not include all supportive EU documents, such as the guidance on boosting circular business models referred to in the ESPR. However, it aims to be a tool to help decision-makers in the chemical industry and other stakeholders.

5) ACCESS TO ENERGY AND FEEDSTOCK

Around half of the chemical subsector's energy input is consumed as feedstock with fuel used as a raw material input rather than as a source of energy. Upstream processes are the most emissions intensive but in a 'linear' economy (i.e. an economy that uses new raw materials which are then discarded as waste and not recycled), the carbon embedded in products also creates substantial emissions at the products' end of life. To reach the EU's climate goals, the chemical industry should move progressively away from primary fossil-based feedstocks. The European gas-demand-reduction plan, published in response to sanctions against Russia, greatly affects the chemical sector, as it is heavily reliant on gas consumption both as a fuel and as a feedstock. This reliance on Russian gas makes the transition to greener alternatives even more important. Furthermore, the EU objective to be climate-neutral by 2050 will need to address the challenge of both direct and indirect emissions (e.g. 'scope 3' emissions[54]).

Products from the chemical industry that are used in a variety of applications can help consumers and end-users to support EU actions. For example, products from the chemical industry are used for wind energy, solar energy, electromobility, energy efficiency in buildings, etc. However, the production of these chemicals necessary for the twin transition relies on: (i) cheap and readily available energy (which should be renewable and/or clean); and (ii) alternative feedstocks. Alternative fuels such as renewable hydrogen or e-ammonia and e-methanol have much lower energy density than fossil fuels. Producing these alternative fuels will require massive amounts of electricity sourced from clean energy. However, converting renewable electricity to renewable fuels may also result in a loss of energy. There could be a risk that the industry's transition to climate neutrality results in higher levels of final energy consumption. Moreover, because of the trend towards electrification of boilers and furnaces (as argued below), the sector's electricity demand is expected to grow significantly.

According to the industry's initial estimations as part of the iC2050 modelling project[55], annual electricity demand from the chemical industry will be well above 200TWh in 2030 and could reach up to 700TWh in 2050, which is a level four times higher than today. Some stakeholders stress the need to reconsider our energy needs and move towards a 'sufficiency' approach. According to the same iC2050 modelling estimations, total demand for biomass is also set to increase significantly over the coming years and decades, reaching 22Mt in 2030 and 88Mt in 2050. Several other sectors (e.g. transport and heating) will depend on the same limited resource, and if sustainably available biomass is scarce, prices risk becoming uncompetitive.

The 2022 progress report on the EU's bioeconomy strategy[56] reflects on the increased importance of the bioeconomy in the new policy context and in the context of the EU Green Deal. It outlines the need for policy coordination and action areas to address the demand for – and availability of – biomass for different applications, ensuring biomass is used in a way that contributes to addressing the biodiversity and climate crises.

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[54] 'Scope 1' indicates direct greenhouse gas (GHG) emissions that are from sources owned or controlled by the reporting entity. 'Scope 2' indicates indirect GHG emissions associated with the production of electricity, heat, or steam purchased by the reporting entity. 'Scope 3' indicates all other indirect emissions, i.e., emissions associated with the extraction and production of purchased materials, fuels, and services, including transport in vehicles not owned or controlled by the reporting entity, outsourced activities, waste disposal, etc. (source: IPCC, 2014. Glossary. In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change).

[55] CEFIC, 2021. Towards implementing the Climate Law.

[56] European Commission, 2022. EU Bioeconomy Strategy Progress Report.

To ensure the supply of energy and feedstocks, long-term needs have to be anticipated as suggested by stakeholders and presented in the table below.

Topic 14: Anticipate long-term needs for the supply of energy and feedstock resources		
Actions	Actors	Timeframe
• Estimate the future needs for energy and alternative feedstock to ensure continued production of chemicals	Industry and EU/MS	S
• Evaluate the impact of increases in energy prices	Industry and EU/MS	S
• Consider developing a strategy for the competitive supply of clean energy and strategic raw materials to the EU that takes geopolitical factors into consideration. (REPowerEU). Consider evaluating the potential role of eliminating tariffs for supplies of key resources *(Linked to Topic 2.3 and 15.2)*	EU/MS	S

The sixth strategic energy and technology (SET) action plan[57] intends to record the agreements between stakeholders on actions to '*increasing efforts to make EU industry less energy, resource and emissions intensive and more competitive*'. It prioritises R&I activities with the highest potential for reducing both carbon emissions and the consumption of energy/resources. The bullet points below outline in more detail two out of the six policy areas in which the action plan identifies a pressing need for R&I activities.

- **Electrification**

Chemical industry requires the possibility to purchase cost competitive climate-neutral electricity. In chemical processes, electricity can be introduced either directly or indirectly. This indirect use of electricity can be considered for generating heat and steam or low- and high-temperature processes (e.g. e-crackers). Direct use of electricity can be done via electrochemistry[58] or alternative forms of energy (e.g. ultrasound and plasma).

- **Integrated production of hydrogen with a low-carbon footprint**

Large supplies of electricity will also be essential for hydrogen production. The chemical industry is both a major producer and a major consumer of hydrogen. The hydrogen-production method most commonly used in the EU is the reforming of natural gas or the bottom fraction of crude oil. This method emits significant quantities of CO_2. Meanwhile, technologies such as methane pyrolysis or photo-electrocatalysis are under development for cost competitive production of hydrogen, in addition to water electrolysis.

Renewable hydrogen[59] must be affordable and should be prioritised when replacing unabated fossil-based hydrogen[60]. It should be seen as part of a broader set of options leading the chemical industry towards climate neutrality. Stakeholders stress that regulatory barriers to the procurement of green electricity for hydrogen self-production should be avoided, and that

[57] SET-Plan ACTION n°6 - Declaration of Intent '[Continue efforts to make EU industry less energy intensive and more competitive]'.

[58] Electrochemistry refers to the relationship between electrical and chemical energy and the conversion of one to the other.

[59] JRC, 2021. [Cleaning up hydrogen production with local renewables].

[60] According to the EU hydrogen strategy, unabated hydrogen is hydrogen produced through a variety of processes using fossil fuels as a feedstock, mainly the reforming of natural gas or the gasification of coal.

regulation should prioritise renewable hydrogen for the chemical industry. On energy supply, direct electrification (when possible) should be prioritised over hydrogen, which is by nature less energy efficient for the moment.

These sources of hydrogen must be economically viable and priced at a level that the chemical industry can afford. Thus, chemicals produced with low-carbon methods or renewable hydrogen should be supported and priced so that they reflect robust GHG-accounting rules. The difference in cost between zero-emissions chemicals-production technologies and other more polluting alternatives in global market prices are still significant. This difference could be bridged through several options, such as carbon contracts for difference (where the EU would subsidise producers so that it would pay for any covering the difference in cost between zero-carbon technologies and more polluting ones) and entering into long-term contracts for clean energy. REPowerEU sets up an action plan for a massive scaling-up and speeding-up of this clean energy in power generation.

To support the economically viable purchase of clean energy, the actions set out in the following table could be taken.

Topic 15: Economically viable purchases of clean energy		
Actions	Actors	Timeframe
15.1 Channel investments for clean energy		
• Adopt a social climate fund to support small business in the transition (REPowerEU)	EU/MS	S
• Channel investments to players committed to the green transition and to becoming 'frontrunners' in the use of novel sustainable technologies *(Linked to Topic 6.1)*	Industry and EU/MS	S/M
• Strengthen the funding and de-risking measures (e.g. contracts for difference, robust investment-protection policies) to support the deployment of green and smart technologies and the sourcing of clean energy up to demonstration plants and first-of-their-kind plants – e.g. via the Innovation Fund	EU/MS	M
15.2 Ensure the competitive supply of clean energy		
• Reassess electricity-market rules with the aim of making electrification cost-competitive for energy-intensive industries	EU/MS	S
• Implement the EU solar strategy to double solar photovoltaic capacity	EU/MS	S/M
• Consider setting up 'go-to' areas for renewables with shortened and simplified permitting processes *(Linked to Topic 4.3, 6.3, 10.2, 11.2 and 14.2)*	MS	S/M
15.3 Improve power-purchase agreements (PPAs)		
• Publish guidance to Member States on PPAs	EU/MS	S
• Set up EU certifications and standards for feedstock (addressing energy and chemicals, including hydrogen)	Industry and EU/MS	S

• Set up risk-sharing facilities to support micro-firms & SMEs *(Linked to Topic 4.3)*	EU/MS	S
• Introduce an electricity-price system for industry that ensures internationally competitive energy prices and supports the transition towards climate neutrality. Consider increasing the number of renewable-energy PPAs	EU/MS	M/L
• Ensure diversification of sources and the strategic autonomy of the EU for essential power supply while safeguarding competitive supply	EU	M/L

The production of chemicals and materials still relies heavily on fossil-based feedstocks, and therefore solutions for substitution need to be implemented alongside the management of demand for these alternatives.

- **Biomass as an alternative feedstock**

Various types of biomass can be considered for producing chemicals (e.g. from sugars, sustainably sourced vegetable oils, residues, and agricultural or forest-based lignocellulosic biomass and residues). The value chains being created to make bio-based chemicals and materials include a large portfolio of technologies roughly categorised into pre-treatment, conversion, and downstream processing. These technologies make possible the processing of a broad range of biomass feedstocks into an array of high-value products. Actors in the bioeconomy seek to extract value from all fractions of the biomass raw material, including those that might formerly have been considered as waste or residues (secondary biomass). Innovative process technologies are promising in that they raise the possibility of using residual biomass to produce commodity chemicals.

The challenge is firstly to ensure that this biomass is sustainably sourced, in line with the approach of the EU Bioeconomy Strategy and the Green Deal. The next challenge is to link all bio-based processing steps into integrated value-chain networks while ensuring that production is resource efficient, energy efficient, cost efficient, and contributes to the zero-pollution ambition. In this context, R&I is key to contribute to the sustainability of bio-based processes.

The design and production of bio-based chemicals, along with dedicated infrastructure for supply and production (e.g. bio-refineries, bio-based supply chains) should support the production of chemicals and materials, creating quality jobs and added value. This added value should come by turning responsibly and sustainably sourced biomass into high-value products (cascading use of biomass). Nonetheless, future scenarios of biodiversity loss and climate change mean that the forecasts for biomass availability (for both energy and chemical uses) remain a key challenge in transitioning away from fossil-based feedstocks. According to some stakeholders, facilitating imports of biomass may help overcome any potential biomass shortages. However, the impact of biomass sourcing in non-EU countries would need to be fully sustainable and should not aggravate environmental degradation nor promote unsustainable practice or increase strategic dependencies.

The prospect of the chemical sector becoming largely bio-based remains challenging. It will be difficult to achieve given: (i) the limited availability of sustainable primary biomass in the EU; (ii) the fierce competition for biomass resources from other sectors (in particular, the energy and transport sectors); and (iii) the sheer scale of demand. Increased pressure on

biomass demand therefore requires careful assessment of trade-offs[61] by adopting the biomass-use prioritisation principle on the national or EU level[62]. The 'cascading' principle for biomass as proposed in RED III (the revised version of the Renewable Energy Directive, which has yet to become law) ensures that biomass is used first where it has the highest economic added value and the lowest environmental impact.

- **Waste as an alternative feedstock**

Organic and inorganic waste[63] can be used as an alternative feedstock for chemicals. For instance, some petrochemical companies collect used cooking oil as organic waste to generate biofuel. The re-use of inorganic waste (e.g. plastics, iron, steel, and aluminium[64]) is of strategic importance to environmental protection and to achieving the circular economy. Chemical-recycling[65] technologies break down the chemical structure of polymeric waste and other input materials such as plastic or textile waste into monomers and chemical building blocks. These technologies then transform the monomers and chemical building blocks into valuable secondary raw materials, and dedicated and drop-in intermediates for manufacturing new products. Outputs include chemicals and other products, some of which are fuels. Stakeholders state that fuel use is excluded from the definition of 'recycling' in the Waste Framework Directive. These new products include chemicals and plastics (but do not include the use of these products for energy recovery and incineration)[66]. Chemical-recycling processes each have their own requirements regarding the inputs used and result in different outputs. These processes are typically depolymerisation, pyrolysis and gasification. These three techniques offer a solution for best dealing with the deteriorating quality of the polymer chains after each cycle of mechanical recycling. A fourth technique is solvolysis, which makes it possible to separate polymers from other materials.

Certain breakthrough upcycling' technologies are now commercially scalable. These technologies involve recycling with a high yield a broad range of plastic waste, including hard-to-recycle plastics, into high-purity products (such as waxes, oils and solvents) that can be used across a variety of different industries. These innovative and sustainable business cases only require plastic waste as a feedstock, thereby enabling the circular production of fossil-free chemicals.

Despite these promising niche applications of chemical-recycling processes, some stakeholders report significant hurdles to scaling up these technologies. They stress the need for more transparency and evidence around mass flows, chemical use, and the viability of processes in real-life waste-management circumstances. Moreover, clear standards for

[61] See action on 'Integrated Bioeconomy Land Use Assessments' in COM(2021) final https://europa.eu/!9xCx8D.

[62] COM(2022) 283 final. EU Bioeconomy Strategy Progress Report: stocktaking and future developments europa.eu/!dGJMKR.

[63] EEA Glossary: Waste composed of material other than plant or animal matter, such as sand, dust, glass and many synthetics https://www.eea.europa.eu/help/glossary/eea-glossary/inorganic-waste.

[64] The Commission is preparing a set of end-of-waste criteria for priority waste streams under the Waste Framework Directive.

[65] ISO, 2008 Definition: Chemical recycling: 'conversion to monomers or production of new raw materials by changing the chemical structure of plastics waste through cracking, gasification or depolymerization, excluding energy recovery and incineration'.

[66] Article 3(17) of the Waste Framework Directive: 'recycling' means any recovery operation by which waste materials are reprocessed into products, materials or substances whether for the original or other purposes. It includes the reprocessing of organic material but does not include energy recovery and the reprocessing into materials that are to be used as fuels or for backfilling operations.

environmental sustainability and safety should be set for the energy required for these transformation processes.

To meet the ambitious European objectives for sustainability and circularity, increased volumes of plastic waste must be recycled and a broader range of markets need to be served with plastic products containing higher recycled content. However, stakeholders say that the chemical industry faces increasing barriers to intra-EU cross-border shipments of waste and that there is a need for harmonised application of 'end-of-waste' criteria. Some stakeholders point out that the EU framework is not yet applicable to local and regional waste laws and directives in individual Member States. They also argue that waste-as-feedstock technology is not being implemented on a large scale and still partly involves the use of large amounts of energy.

- **CO_2 as an alternative feedstock[67]**

Carbon from CO_2 captured from concentrated sources (e.g. industrial sources, biogenic gaseous carbon) is a potential alternative to virgin fossil feedstock. In the longer-term, CCU technologies may mitigate climate change by removing CO_2 from the atmosphere or using carbon-containing (not only from CO_2, but also from CO for example) flue gases (industrial off-gases, including from fermentation processes from food, beverages, etc.). These flue gases are captured directly at point sources so that they do not enter the atmosphere and can instead be converted into chemicals. In December 2021, the Commission adopted the Sustainable Carbon Cycles[68] communication, which sets out an action plan on: (i) how to develop sustainable industrial solutions to increase carbon removals (using direct air capture and bio-based products with long lifetimes); and (ii) key actions to support the industrial capture, use and storage of CO_2 (CCU and CCS). Carbon capture (CCS/CCU) technologies are key technological pathways for the decarbonisation of energy-intensive industries, including the chemical industry. Their application potential has been identified as particularly high for the chemical sector (both CO_2 and CO)[69]. However, these technologies still face some challenges. The two main challenges are listed in the bullet points below.

  - It is complex and costly to collect and purify CO_2 directly from the air.
  - There is not a lot of carbon-free renewable energy (e.g. to produce green hydrogen required to produce chemical feedstocks from CO_2).Transforming CO_2 via electrolysis for CCU requires a lot of energy, preferably from renewable sources.

The CO_2 captured can also be stored either permanently in geological sites or in long-lasting products.

Today the industry is already working on four fronts to play its role in the circular economy. These four fronts are set out in the four bullet points below.

  - Firstly, the industry is seeking to improve processes (e.g. optimisation of mechanical recycling) including by using fewer resources and less energy (e.g. through energy recovery, waste recovery, and innovative recycling technologies).
  - Secondly, the industry is seeking to design and re-design chemical products and materials to reduce waste from the outset, improve circularity, and improve recycling

[67] Including CO capture from 'industrial waste gases'.

[68] COM(2021) 800 final. Commission communication on Sustainable Carbon Cycles, p.19 https://europa.eu/!9xCx8D.

[69] See chapter 2 (p. 28) in ERA Industrial technology roadmap for low-carbon technologies in EIIs.

end-products (e.g. using new recyclable composites for windmill blades). It is possible to develop a circular model for chemicals that pose certain risks to health and ecosystems.

- Thirdly, the industry is making progress towards turning second-generation, primary, secondary and waste biomass into valuable inputs for bio-based chemistry.
- Fourthly, the industry is making progress towards using CO_2 from industrial off-gases and fermentation as a valuable input for chemical feedstocks. The industry is also working on the direct air capture of gaseous effluent chemicals to turn them into a valuable feedstock input.

Based on these elements, stakeholders presented a series of actions aimed at identifying and developing new and sustainable sources of feedstock; as well as at further developing alternative feedstocks such as biomass, waste and CO_2. The table below summarises these actions as suggested by the stakeholders.

Topic 16: Feedstock Substitution		
Actions	Actors	Timeframe
16.1 Identify and develop new and sustainable sources of feedstock		
• Consider setting targets for renewable/non-fossil content to stimulate demand	EU/MS	S
• Consider harmonising EU and international certification systems for the sustainable sourcing of biomass feedstock (including secondary biomass) and standards irrespective of the feedstock's end-use	EU/MS	S
• Assess further the economic and technical potential of aquatic biomass (third-generation biomass)	Industry	S
• Provide a detailed definition of 'non-fossil sources' and a methodology to calculate the share of total feedstock in carbon sources. Make statistical data more detailed to support the calculation of this share[70].	Industry and EU/MS	S
• Increase reporting of scope-3 GHG emissions and explore opportunities to use feedstock from waste and recycled materials	Industry	M
• Consider promoting projects on turning alternative sources into valuable feedstock inputs, partly through joint agreements & interdisciplinary cooperation; ensuring SMEs participation	EU/MS	S/M
• Harmonise criteria and methodologies – and make sure they also apply to SMEs – to assess the environmental and socioeconomic performance of bio-based systems (integrating biodiversity for example). Ensure that these criteria and methodologies are aligned with the future SSbD framework.	Industry and EU/MS	S/M

[70] See 'Industrial Sustainable Carbon challenge' in COM(2021) 800 final. Sustainable Carbon Cycles https://europa.eu/!9xCx8D.

• Accelerate the market deployment of existing circular and bio-based solutions (whether they are mature or innovative) – e.g. via the Innovation Fund	Industry and EU/MS	S/M

16.2 Biomass as an alternative feedstock

• Create a balance and prioritisation between the different uses of biomass by providing a set of sustainability criteria (e.g. considering deforestation risk) and develop concrete incentives for the use of these criteria	Industry and EU/MS	S/M
• Further improve methodologies to monitor the environmental performance of biomass as a feedstock	Industry and EU/MS	S/M
• Increase the efficiency and transparency of biomass supply chains	Industry and EU/MS	M/L

16.3 Waste as an alternative feedstock

• Promote setting targets for recycled and bio-based content in order to stimulate demand	Industry	S
• Suggest improvements on transparency – and ending restrictions on transparency – in the use of 'substances of concern' to clean up material cycles (ESPR) at national level	Industry	S
• Advocate for promotion of early international cooperation on standards to prevent potential barriers to market access barriers from arising	Industry	S
• Advocate for chemical recycling as a complementary option for waste that cannot be recycled mechanically, if it causes less environmental burden than incineration and virgin plastic production	Industry	S
• Increase the recyclability of products to boost the use of upcycled resources instead of virgin materials	Industry	S/M
• Phase out the most harmful substances from consumer products, unless they are essential for society, as per the CSS	Industry	S/M

16.4 CO_2 as an alternative feedstock

• Consider using circular carbon sourced from CO_2 as a feedstock	EU/MS	S/M
• Support the economic and technological development of CO2 as a feedstock	EU/MS	S/M
• Consider developing an impact assessment on the CO_2 footprint of the increased demand for strategic metals *(Linked to Topic 2.1)*	Industry and EU/MS	S/M
• Consider harmonising the EU regulatory framework for cross-border CO_2 transport	EU/MS	M

New business models and more efficiently produced materials could help reduce emissions by about 65Mt CO_2 per year across the value chain[71]. The opportunities in this area include: (i) improving design; (ii) reducing waste during the production of chemicals; (iii) having higher-performance materials; (iv) reducing over-specification; and (v) encouraging higher intensity use of chemicals. The chemical industry must also consider new business models. Chemical leasing[72] for instance, could address the over-consumption of chemicals by charging customers based on functions performed by the chemicals rather than by the volume of chemicals purchased.

Process intensification (e.g. by changing reactor designs, or by developing new catalysts) can also provide major opportunities for resource and energy efficiency. With these new processes, chemical reactions can be achieved at optimal conditions with significantly fewer side reactions, creating fewer by-products, and using fewer auxiliary materials. As catalysts are key enablers for higher selectivity and reduced energy consumption, novel catalysts must be designed to accommodate more complex feedstocks and/or more variable feedstock quality (e.g. biomass, waste, CO_2). Intensified separation technologies and their control technologies must complement higher selectivity of the reactions. Further innovation in this area is required to significantly reduce energy consumption and costs. However, the development of a new generation of catalysts relies on the availability of certain raw materials[73]. The increased demand for energy infrastructure (electricity, hydrogen), transport, and deployment of digital technologies will require large volumes of several strategic metals. These raw materials needed for the transformation of EU industries will mostly come from mining and refining.

Process efficiency can be complemented at plant and site level with the implementation of other optimisation measures such as energy recovery, including energy recovery from low-temperature energy streams. Industrial symbiosis will make it easier to implement some of the above-mentioned options, for example through exchange of material or energy flows for heat integration. Digital technologies could also play a role in efficient production processes, starting as early as the virtual planning and simulation phase of new production-line processes. The table below summarises actions stakeholders suggest on process and resource efficiency.

Topic 17: Process and resource efficiency		
Actions	Actors	Timeframe
• Re-think business models and identify potential enablers for these new business models	Industry and EU/MS	S
• Support the development of advanced and alternative separation technologies	Industry and EU/MS	S/M
• Promote industrial symbiosis as a commonplace approach for advancing the circular economy *(Linked to Topic 18.1)*	Industry and EU/MS	S/M
• Invest in the development of novel catalysts	Industry	M/L

[71] Materials Economics, 2019. Industrial transformation 2050: Pathways to Net-Zero Emissions from EU Heavy Industry, p. 26.

[72] Chemical leasing is a business model that intends to shift the focus from increasing sales volume of chemicals towards a value-added approach.

[73] See SRIA: Innovation Priorities for EU Global Challenges. Priorities include the design and scalable production of catalysts with reduced consumption of critical raw materials and preferably starting from abundant and accessible raw materials.

6) INFRASTRUCTURE

Access to energy and feedstock and the corresponding infrastructure is of essential importance. The necessary infrastructure will need to be built or scaled up to secure the chemical industry's access to energy and feedstock, and in particular to electricity, hydrogen, waste, CO_2, and biomass. Infrastructure will also support both industrial symbiosis[74] and better integration of processes within industrial clusters (e.g. capturing, storing and transporting CO_2 from an emitting plant to the chemical industry). The development of such structures is being slowed down by: (i) the lack of infrastructure around certain industrial sites, especially on inland locations and in central and eastern Europe; and (ii) the slow approval procedures at Member State level for energy and industrial processes. The necessary permits and infrastructure for energy transition and feedstock diversification must still be put in place.

Expanding the gas and electricity grid is necessary to access low-carbon energy from all sites, not only those sites close to electricity-generation plants. Bottlenecks in the gas grid must be abolished, and cross-border interconnectors must be put in place to enable the free flow of energy between countries. Existing sources of gas must be adapted so that they respond to demand and provide flexible generation units and storage. Progress must be made in new sources of flexibility such as power to-X[75] and new types of storage (e.g. for renewable or low-carbon hydrogen and ammonia).

Finally, the availability and deployment of ample CCS and CCU capacity are essential enablers for climate neutrality. For this reason, bilateral agreements could be concluded between countries that ship captured CO_2 and those that receive it to facilitate the access of landlocked production sites to CO_2 storage sites.

Industry stakeholders speak of both the stringent safety standards requirements for hydrogen infrastructure and the public protests against these large-scale developments. In October 2021, a report[76] was published on barriers to – and mitigation measures for – clean hydrogen projects.

To overcome these barriers, the European Clean Hydrogen Alliance supports the large-scale deployment of clean hydrogen technologies by 2030 by bringing together: (i) renewable and low-carbon hydrogen production; (ii) demand from industry, mobility and other sectors; and (iii) the transmission and distribution of hydrogen. Together with ammonia producers, the chemical sector is projected to be one of the EU's industrial champions in the use of clean hydrogen, as shown by an analysis[77] of around 1 052 specific investment projects which have been submitted as part of the European Clean Hydrogen Alliance. In addition, the industry already produces vast amounts of hydrogen that is completely used in internal manufacturing processes.

[74] Industrial symbiosis is the process by which waste or by-products from an industry or industrial process become the raw materials for another.

[75] Technology that converts renewable electricity from solar or wind farms into other forms of energy (e.g. renewable hydrogen, renewable methanol).

[76] European Hydrogen Alliance, 2021. Reports of the alliance roundtables on barriers and mitigation measures https://ec.europa.eu/growth/document/download/5b759bcc-db55-49ad-b0d4-bf0e16255aab_en.

[77] European Commission, 2021. 'European Clean Hydrogen Alliance: Overview of projects collected' presentation at the Hydrogen Forum, 17-18/06/2021 https://prod5.assets-cdn.io/event/6779/assets/8375992644-bc85860f7c.pdf.

If the RED III is adopted as proposed by the European Commission, it will mandate a 50% share of green hydrogen (RFNBO) in the total hydrogen consumption of the chemical industry. The EU and Member States should ensure the necessary infrastructure is in place to supply this hydrogen to each point of consumption (e.g. each plant) to make this target attainable. The hydrogen and decarbonised-gas market package[78], published in December 2021, puts forward policy measures required to support the creation of: (i) optimal and dedicated infrastructure; and (ii) efficient markets. This package aims to remove barriers and create the conditions for a more cost-effective transition. In her 2022 State of the Union speech, President of the Commission Ursula von der Leyen also announced the creation of a market for hydrogen through a new European Hydrogen Bank, dedicated to investing EUR 3 billion to power the economy of the future.

To improve the development of large-scale electricity and hydrogen infrastructure, the actions set out in the table below should be taken.

Topic 18: Large-scale electricity and hydrogen infrastructure		
Actions	Actors	Timeframe
18.1 Enable the free flow of energy between countries		
• Identify preliminary hydrogen-infrastructure needs by March 2023, based on the TEN-E Regulation (REPowerEU)	EU / MS	S
• Set up a dedicated workstream on joint, renewable hydrogen purchasing under the EU Energy Platform[79]	EU/MS	S
• Develop an infrastructure outreach programme to non-EU countries via the EU global gateway strategy[80]	EU/MS	S/M
• Abolish electricity-grid bottlenecks and increase the number of cross-border interconnectors	Industry and EU/MS	M
18.2 Develop separate hydrogen infrastructure at EU level		
• Re-dedicate current gas pipelines and refineries and construct new pipelines dedicated to hydrogen infrastructure	Industry and EU/MS	M
• Invest in new harbour-storage capacity in key EU ports or in relocating industrial harbours to more suitable locations	Industry and EU/MS	M
• Support and drive investments in appropriately sized dedicated hydrogen grids (including local grids, highly interlinked grids, high-capacity grids and digitalised grids) with an extended electricity grid to support hydrogen	EU/MS	M
• Develop a certification system for the import of low-carbon hydrogen	Industry and EU/MS	M

[78] Hydrogen and decarbonised gas market package https://europa.eu/!YPpd33 .

[79] https://energy.ec.europa.eu/topics/energy-security/eu-energy-platform_en.

[80] https://ec.europa.eu/info/strategy/priorities-2019-2024/stronger-europe-world/global-gateway_en#key-areas-of-partnership.

Designing and building a demonstration plant and deploying solutions on an industrial scale are major challenges for developing many abatement technologies and solutions. It also often requires collaboration between different industries and partners on a regional level and across borders. The investment returns from building a demonstration plant and deploying solutions on an industrial scale are uncertain and there is the risk of technological 'lock-in' and stranded investments. Security planning is also often hampered by long and complex permitting procedures, which create uncertainty around new infrastructure projects. This issue of uncertainty affects both questions about the viability of the chemical facility itself and questions about how to guarantee the supply of resources to it.

To support the development of new sustainable and decentralised production models to ensure resilience, the actions set out in the table below should be taken.

Topic 19: Development of new and sustainable production facilities		
Actions	Actors	Timeframe
19.1 Develop recycling facilities and bio-refineries (and exploit synergies with the chemical industry)		
• Launch pilot projects to develop sustainable infrastructures	Industry and EU/MS	S/M
19.2 Accelerate and improve permitting		
• Facilitate and accelerate approval procedures for production plants and products, notably via the ongoing revision of the IED	EU/MS	S/M
• Publish an annual comparative report to identify Member States' best practices in planning and permitting law; create an exchange of best practices	EU/MS	S

A pan-European rail infrastructure would enable a significant modal shift from roads to rail for the transport of feedstock and chemical products. The development of such infrastructure is currently being held back by: (i) the lack of an integrated system for managing international rail-freight traffic and capacity; and (ii) the poor quality of rail transport in general. Regulations have been put in place to support: (i) the development of energy interconnections and energy infrastructure (the Trans-European Networks for Energy TEN-E); and (ii) the Green Deal ambitions for modal shift and improvements in freight-transport efficiency (Trans-European Networks for Transport TEN-T).

To support the development of sustainable transport of raw materials and chemical products, the actions set out in the table below should be taken.

Topic 20: Sustainable transport of raw materials and chemical products		
Actions	Actors	Timeframe
20.1 Increase the availability and capacity of multi-modal terminals that are close to industrial clusters		
• Support investment in rail and inland waterway transport through public-private partnerships	Industry	S

• Develop a framework for trusted, secure and resilient B2B transport and logistics for data sharing (DTLF)	EU/MS	S
• Set up sustainable and resilient value-chain logistics for the sustainable supply of alternative feedstock (e.g. following the 'Hubs4Circularity' concept (Horizon Europe) and the EU global gateway strategy)	Industry	M
• Support the development of a multi-modal single European transport area through the Cohesion Fund (TEN-T)[81]	EU/MS	M
20.2 Improve use of rail transport		
• Adopt in 2023 a legislative package on greening freight transport (REPowerEU)	EU/MS	S
• Improve reliability, rail punctuality, and rail-infrastructure coordination between different national railway systems	MS	S

The digital transformation of the chemical industry and the deployment of available technologies for production and distribution will accelerate the industry's path towards the digital, green and resilience objectives.

The chemical industry must increase its deployment rate of digital technologies (e.g. the 'internet of things', big data, artificial intelligence, automation, smart sensors, digital twins and robotics) for product design, process design, production and logistics (e.g. paperless transport; real-time logistics planning and steering; and reducing idle transport capacity).

To take full advantage of the enabling power of digitalisation, the industry requires high-speed and reliable digital infrastructure. Industry associations say that there is a need for new standards for digital platforms to make possible the exchange of information on chemicals. These standards must be set in a way that promotes greater technical and semantic interoperability, while the governance systems for these digital platforms should also be designed in a way that ensures the protection of confidential business information. The Commission's new standardisation strategy[82] aims to support these goals by focusing on standardisation needs in strategy areas and improving the overall governance and integrity of the European standardisation system. This digital shift brings with it both cybersecurity risks and the problem of human resistance to change. The Commission fosters innovations – such as this one in standards – by creating investment programmes such as the InvestEU or the Digital Europe Programme.

To support the development and deployment of new and available technologies for the digitalisation of chemical manufacturing, the actions set out in the table below should be taken building upon in particular the policies, measure and actions set in the European Strategy for data[83].

[81] Trans-European Transport Network (TEN-T) https://transport.ec.europa.eu/transport-themes/infrastructure-and-investment/trans-european-transport-network-ten-t_en.

[82] https://ec.europa.eu/commission/presscorner/detail/en/ip_22_661.

[83] See COM(2020)66 final. A European strategy for data. https://europa.eu/!BB46Mq.

Topic 21: Deployment of digital technologies		
Actions	Actors	Timeframe
21.1 Deploy safe, high-speed and reliable digital infrastructure		
• Development of an open data platform data space for chemicals to ensure seamless access and combination of data and tools complying with GDPR, IP, confidential business information and access rights (CSS and SRIP)	Industry and EU/MS	S
• Consider drawing up standards for both data interoperability and governance to protect confidential business information based on the developments in the context of common European Data Spaces	Industry and EU/MS	S
• Provide data on product carbon footprints for chemicals, and feed-in data for wider sectoral KPIs being developed within the CSS in alignment with the Digital Product Passport	Industry and EU/MS	S/M
21.2 Deploy technologies to improve chemical manufacturing processes and data gathering		
• Extend partnerships with innovative actors offering digital solutions *(Linked to Topic 8.1)*	Industry	S/M

To develop infrastructure for the recycling and re-use of materials, it will be necessary to invest in organic and inorganic waste collection, sorting, and value chains. This will improve access to important alternative sources of feedstock. Local and regional legislation must also be updated to avoid the landfilling, incineration and export of waste. Nonetheless, there remain strong economic barriers to this circularity project, in particular: (i) the price competitiveness of virgin materials compared to material recycled via mechanical recycling processes (virgin materials are often cheaper); and (ii) the lack of support for creating post-consumer recycled end-markets. Outdated 'linear' support for waste incineration, landfilling and shipment will have to be changed, and this change should be incentivised by law – including at municipal level – to engage the full circular value chain. The new circular economy action plan shows the path to a climate-neutral competitive economy by changing the way we produce and consume along with initiatives to modernise and transform our economy while protecting the environment.

The deployment of CCU and CCS[84] technologies also require the scale-up of reliable infrastructure for transporting and storing CO_2. The main barrier preventing the chemical industry from deploying these technologies is insufficient access to CO_2 pipes and storage as well as the lengthy and complex implementation process, especially in this phase of the transition. The ETS Innovation Fund provides support to small- and large-scale projects focusing on scaling up the construction of CCU and CCS technologies and infrastructure. In addition, through local industrial symbiosis (the Hubs4Circularity concept), the CO_2 produced

[84] Carbon capture and storage (CCS) is a set of technologies aimed at capturing, transporting, and storing CO_2 emitted from power plants and industrial facilities.

See: https://energy.ec.europa.eu/topics/oil-gas-and-coal/carbon-capture-storage-and-utilisation_en#:~:text=Carbon%20capture%20and%20storage%20(CCS,Strategy%20(2020%2D2024).

by an energy-intensive industry (e.g. the steel industry), can be used by a chemical facility nearby, avoiding the need to scale up infrastructure for transporting and using CO_2.

To increase the development of infrastructure that promotes recycling and re-use, stakeholders recommend that the actions set out in the table below should be taken.

Topic 22: Circularity: recycling and re-use of infrastructure		
Actions	Actors	Timeframe
22.1 Set a regulatory framework for the transport of waste		
• Ensure the harmonised EU implementation of the Basel Convention through the Waste Shipment Regulation	EU/MS	S
22.2 Improve the management of logistics for waste feedstock		
• Increase the coordination of waste-management infrastructure with Hubs4Circularity (Horizon Europe) (e.g. mechanical treatment of waste management) *(Linked to Topic 3.2.)*	EU/MS	S
• Use the Innovation Fund to support the deployment and upscaling of CCS technologies and infrastructure, aimed at capturing, transporting, and storing CO_2 emission	EU/MS	S
• Implement the Waste Framework Directive and Waste Shipment Regulation; encourage cooperation between municipalities	MS	S
• Enforce the regulation of illegal imports to avoid contamination of the recycling loop *(Linked to Topic 13)*	MS	S
• Consider participating in infrastructure projects[85]	EU/MS	S
• Invest in the management of waste feedstock	Industry	M

[85] e.g. Porthos, Antwerp at Sea, North Sea Port.

7) SKILLS

Some SMEs have only limited capacity to upskill and reskill their workforce in-house. At the same time, other SMEs are an integral part of the vocational educational system, where most of the EU's retraining, upskilling and re-skilling opportunities occur. Nevertheless, SMEs are especially vulnerable to the risk of employees leaving the workplace after completing the vocational education, which is often a significant investment for a company. Skills partnerships for stakeholders in the chemical industry (and skills partnerships under the Pact for Skills) will provide opportunities to investigate the existing and emerging skills needs across the chemical industry, including the skills needs for people working in or managing SMEs. The EU's Pact for Skills, for example, could provide common support, leadership and monitoring for the development of skills in the chemical industry among stakeholders in the EU chemical industry. This would help to reskill and upskill the workforce for the twin transition in line with the targets set in the Digital Decade Policy Programme. Moreover, the SRIP[86] for safe and sustainable chemicals and materials identifies the skills that will be critical for: (i) training a new generation of researchers; and (ii) improving sustainability management in industry, and specifically in R&I. Additional sources for skills support are set out in the two bullet points below.

- The digital education action plan aims to support the sustainable and effective adaptation of the education and training systems of Member States to the digital context. This action plan could be used to help identify the main gaps and necessary actions in the chemical industry.
- The European strategy for universities provides actions that also contribute to the transition pathway for the EU chemical industry since the strategy aims to help universities adapt to changing conditions, and to contribute to Europe's resilience and recovery.

To support the re-skilling and upskilling of the chemical workforce, stakeholders suggested the actions set out in the table below.

Topic 23: Education (re-skilling/upskilling the workforce)		
Actions	Actors	Timeframe
23.1 Develop skills with a sustainability focus		
• Develop a roadmap for skills, including the social dimension	Industry and EU/MS	S
• Set up sector-specific training, including training on green and sustainable chemistry, chemicals regulation, and safety	Industry	S
• Identify and address SSbD skills mismatches and skills gaps in the field of SSbD in the chemical industry. Ensure appropriate skills at all levels – including in vocational and tertiary education, in research, in industry, and among regulators	Industry and EU/MS	S
• Increasing awareness of the European Digital Innovation Hubs in the sector and digital technology training they offer	EU	S

[86] COM, 2022. Science, Research and Innovation Performance of the EU (SRIP) report.

• Participate in the EU blueprint for sectoral cooperation on skills, including the Blueprint Alliance on energy-intensive industries/industrial symbiosis	Industry	S
• Develop a more effective compensation scheme for SMEs that contribute to vocational education	Industry and EU/MS	S/M
23.2 Adapt secondary, post-secondary and university education		
• Contribute to the activities of the European Year of Youth in cooperation with national associations of chemical employers	Industry	S
• Adapt university curricula to industry needs, by adding courses on regulation, sustainable chemistry, green chemistry and the principles of SSbD to university programmes in chemistry. Adapt apprenticeships and vocational education and training programmes to teach future-proof knowledge	EU/MS	S/M
• Develop and ensure broad science, technology, engineering and mathematics (STEM) education across all education sectors	EU/MS and social partners	M
• Make use of tools and initiatives under the European Skills Agenda, such as the EU Pact for Skills	EU/MS	M

New, effective and inclusive training approaches are essential in swiftly integrating new workers into the job market. It is also important that workers benefit from training opportunities combined with actual work tasks. This will require the modernisation of teaching methods and training programmes. Considering their great importance in vocational education, SMEs should play a central role in achieving these objectives. Stakeholders report that the chemical industry will lack skilled workers, in particular in technical fields, digital/IT fields, R&I, production, logistics, chemical safety, chemical regulation, etc. This lack of skilled workers is especially acute in the area of digital skills. Re-skilling workers should be a priority to avoid overall job losses and to benefit the chemical sector. Specific attention should be given to training university students on the regulatory and safety aspects of the chemical industry.

To ensure sufficient high-quality jobs at technical level, the actions in the following table should be taken.

Topic 24: Sufficient supply of jobs at technical level		
Actions	Actors	Timeframe
24.1 Increase corporate training		
• Foster/organise regional training programmes and centres where in-company training is difficult (e.g. in small companies), in line with existing programmes	EU/MS and Industry	S
• Further promotion of lifelong learning	EU/MS	S
• Forecast and address the challenges connected to skills needed to introduce new technologies, with full contribution from workers' representatives (including digital skills)	Industry	S/M

• Provide company-based training, and reskill workers so they are prepared for the professions of the future. Link this training to job-to-job transition plans	Industry	S/M
• Provide in-company training opportunities, career paths, and apprenticeships	Industry	S/M
• Invest in the re-skilling of workers, especially by ensuring financial support for SMEs	Industry	M

24.2 Increase the attractiveness of the sector

• Ensure good communication by company managers with their workers, notably about the risks linked to the transition. This will reduce existing uncertainties and help workers to embrace the transformation of the industry in which they work	Industry	S
• Provide attractive employment conditions, such as flexible working hours, digital technologies, job sharing, etc.	Industry	S
• Increase the exposure of young scientists to R&D carried out in industry as well as in academia. 'Industry led' research is also science that should be given equal value/status in education	EU/MS	M

8) SOCIAL DIMENSION

The European Green Deal and the EU digital strategy pay particular attention to supporting those regions, industries, workers, households and consumers that will face the greatest challenges coming from the social impact of the twin transition. This impact varies according to sector, occupation, region and country, and will entail job changes within industrial sectors, and changes to investment patterns and staff numbers across these sectors.

This requires appropriate anticipation of change and socially responsible restructuring where necessary[87]. Through the responsible care initiative, the EU chemical industry has already demonstrated its focus on workers' health. For the industry, particular attention should also be paid to regional cohesion, the industry's impact on workforce and consumers, and improving gender equality and diversity in the sector. The twin transitions will likely shift jobs away from some places and towards others, creating job losses in some sectors, but increasing staff numbers in others.

The green transition must be fair and inclusive, putting people first, and paying particular attention to supporting those workers, households and consumers that will face the greatest challenges. Social dialogue should play an important role in this context.

Sustainable products will soon become the norm, and this will make it easier for consumers to take 'sustainable' decisions. Higher production costs will ultimately be borne by consumers but are expected to be minimal, as they will be spread very broadly. In any case, potential negative social consequences should be avoided. To avoid negative impacts on workers and consumers, stakeholders suggested that the following actions be taken.

Topic 25: Impact on workers and consumers		
Actions	Actors	Timeframe
25.1 Regional cohesion		
• Monitor and assess the environmental and economic impact of chemical production in the region	Industry	S
• Inform the public about the impacts and risks linked to the transition. This will reduce existing uncertainties and help encourage the public to embrace the transition	Industry	S
• Conduct a detailed investigation of employment in industries at NUTS 2 and 3 levels to identify where jobs are being created, transformed and lost in order to target support and cohesion policies	EU/MS	M
• Support active regional labour market policies, including policies to increase workers' skills	EU/MS	M/L
25.2 Safety and social security of workers		
• Continue to adapt safety protocols before introducing new technologies.	Industry	S

[87] Industrial Forum, 2022. Blueprint for the development of transition pathways.

• Develop 'job transition plans' (based on social lifecycle assessments (e.g. SEE balance[88]), and dialogue at company, local and sectoral levels)	Industry	S
• Take business decisions with workers' representatives involved to ensure that the decisions incorporate occupational safety and health, work organisation, training needs etc.	Industry	S
• Ensure social dialogue at company, sectoral and regional/national levels through an appropriate legal framework (EMPL Committee 2013 Cercas report) and make public funding for transition projects dependent on the involvement of workers and their representatives in these projects	EU/MS	M
• Share best practices and develop synergies among sectors on clean and smart production processes	Industry and EU/MS	S/M

Gender equality, inclusion and diversity are among the EU's founding values. In a sector that has historically been gender unbalanced such as the chemicals sector, actions and initiatives to address this shortcoming and lack of diversity are therefore necessary to increase the proportion of women in the sector. As reported by the EIB[89], more investment in women entrepreneurs is the right thing to do socially and ethically. When eliminating barriers for women to access the chemical industry and develop a career path within it, due attention must be paid to the principle of fairness: one size does not fit all.

Measures should also be taken to address the existing knowledge gap on certain aspects of the chemical industry. For example, there is a need to: (i) increase the collection of data on the differentiated risks affecting working women; and (ii) provide an exhaustive assessment of such data. It is also important to address the lack of extended data on exposure to chemicals that are detailed enough to show the risks that women in particular face when exposed to certain chemicals.

The following table summarises actions proposed by the stakeholders on improving gender equality and diversity in the sector.

Topic 26: Improve gender diversity and equality in the sector		
Actions	Actors	Timeframe
• Follow-up on the outcomes of the 2022 report on equal participation of women in the EU chemical industry and on the e-platform 'Children – Care – Career'	Industry	S
• Further implement the EU gender-equality strategy, with policy objectives and actions to make significant progress by 2025 towards a gender-equal Europe	EU/MS	S
• Encourage women into chemistry and chemical engineering programmes and raise awareness of careers for women in the chemicals industry at high schools	Industry and EU/MS	M

[88] A methodology designed by BASF to measure all the three pillars of sustainability – environment, society and economy.

[89] EIB, 2022. Women entrepreneurs are our best opportunity.

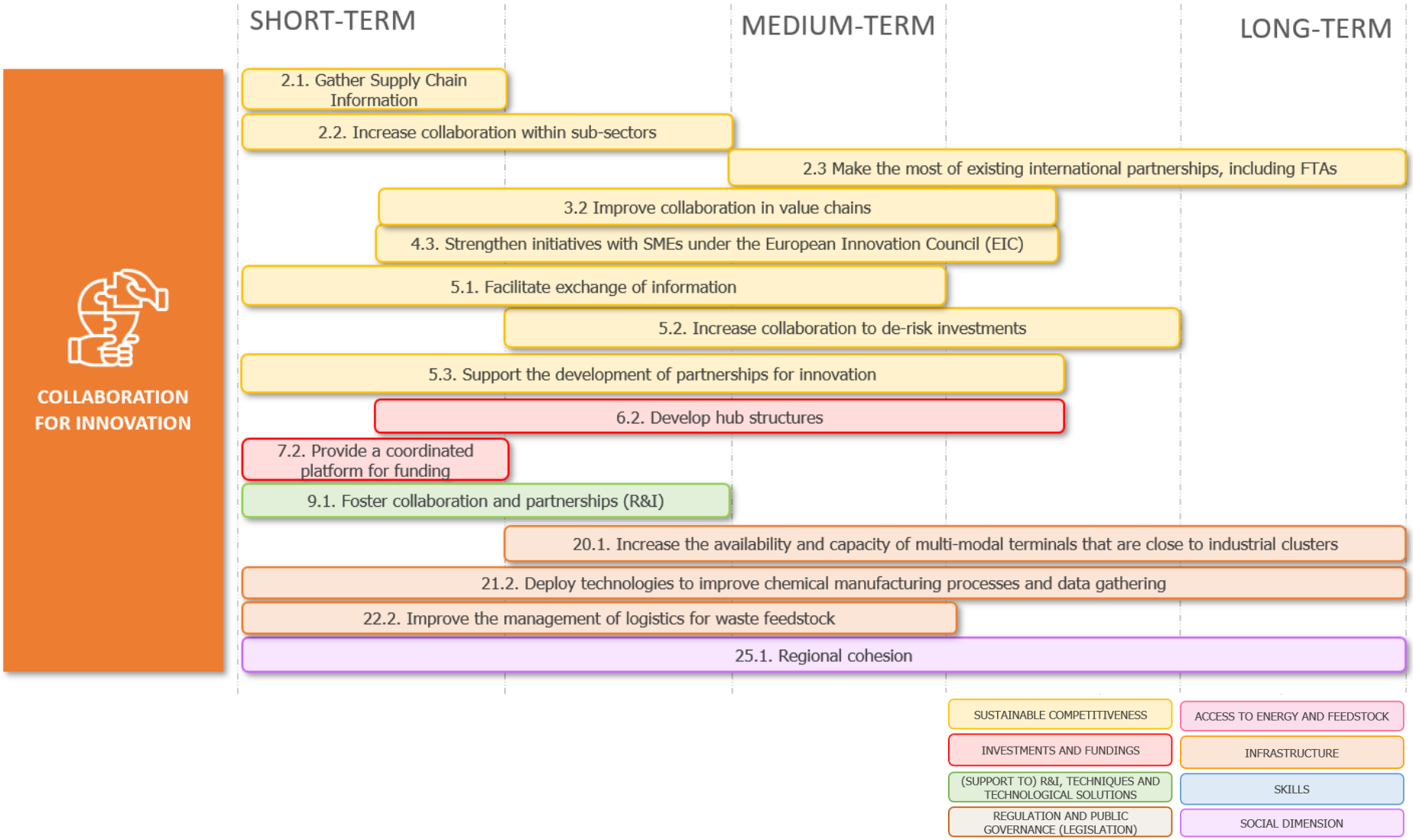
III/ ROADMAP

The Commission and stakeholders used the key topics of the eight building blocks to develop a roadmap for the EU chemical industry to achieve the twin transition and resilience of the industry. These key topics were sequenced against a timeline. The outcome is a roadmap composed of three components as set out below.

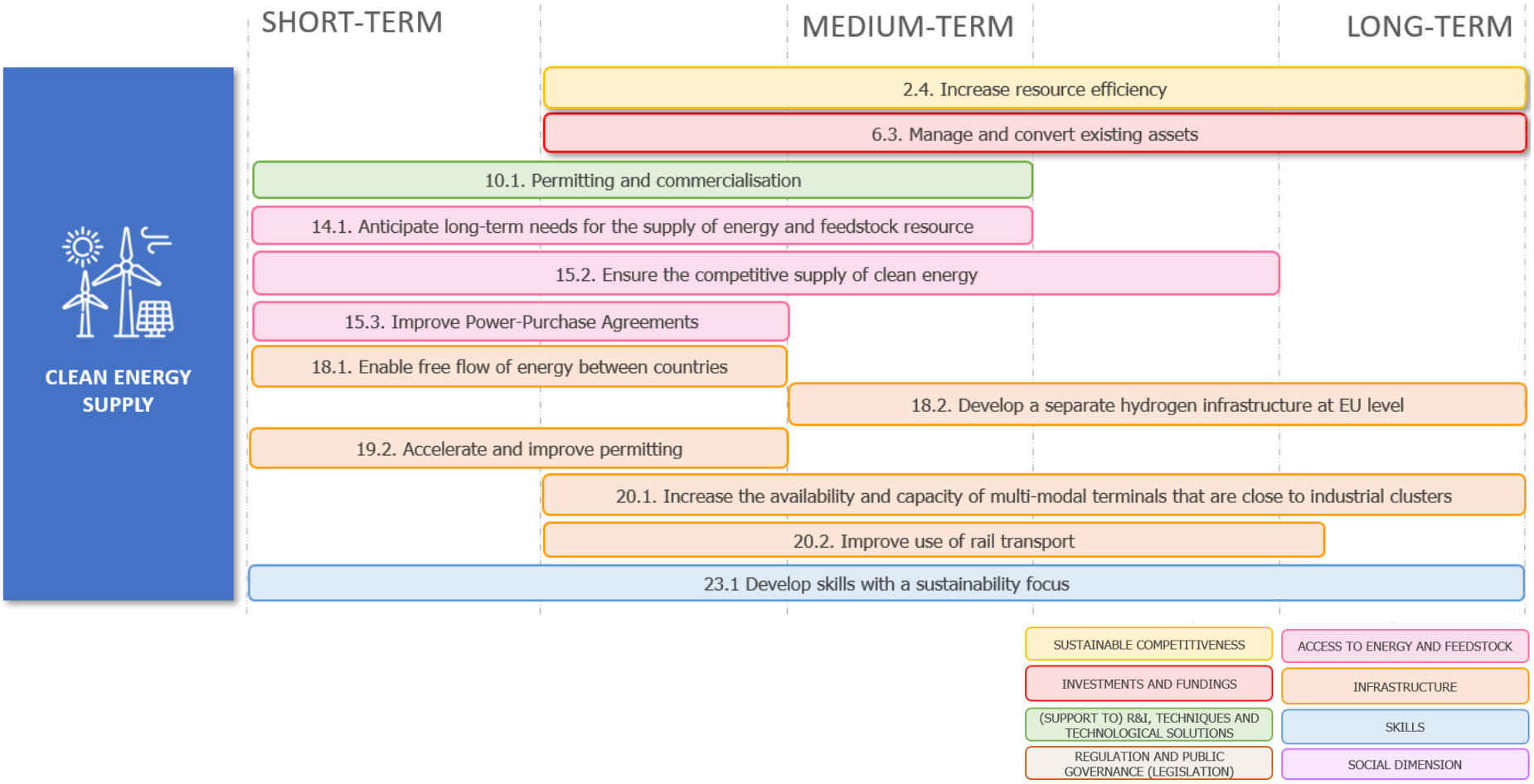
1. **An action-oriented component** grouping the topics under three cross-cutting themes: collaboration for innovation; clean-energy supply; and feedstock diversification. The choice of these themes was informed by analysis of the existing literature and discussion with stakeholders.
2. **A technology component** that provides an overview of the different topics that are related to technology as a contribution to the twin transition and resilience. The basis for this roadmap is the SET action plan, its supportive actions and EU initiatives.
3. **A regulatory component** that collects the existing legislation – including major R&I initiatives influencing developments in the chemical industry.

By implementing actions identified under each topic, the chemical industry will accelerate the twin transition and improve its resilience, sustainability and circularity in line with the European Green Deal.

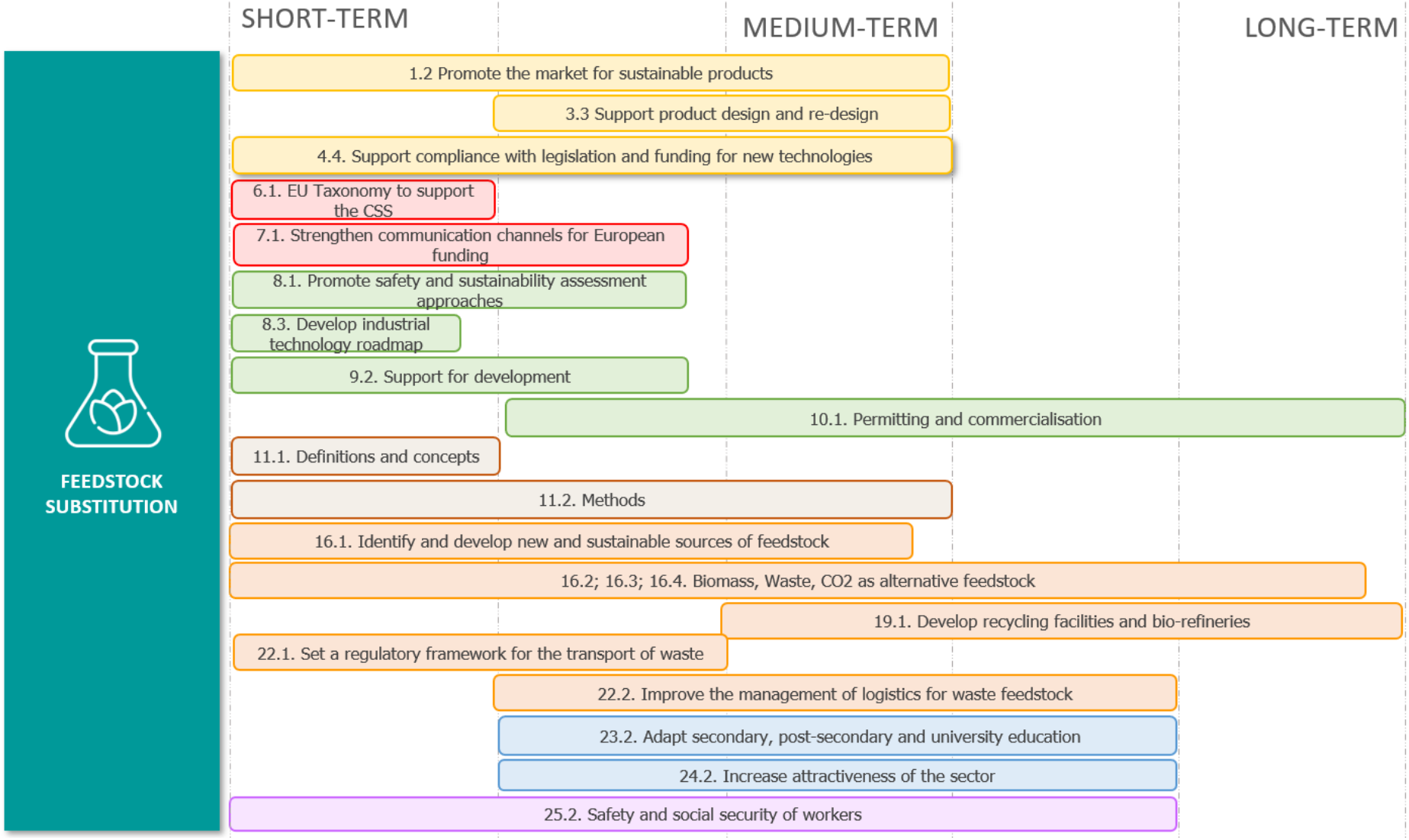
1) ACTION-ORIENTED ROADMAP



The REPowerEU plan sets out a series of measures to rapidly reduce the EU's dependence on Russian fossil fuels well before 2030 by accelerating the clean-energy transition. The REPowerEU plan is based on saving energy, producing clean energy, and diversifying the EU's energy supplies. As part of its plan to scale up the use and production of renewable energy, the Commission proposes to increase the target for the use of renewable energy to 45% of all energy used in the EU by 2030. The supply and availability of clean energy is therefore key to the chemical industry's transformation. The graph below lists actions aiming to facilitate the supply of clean energy in the EU.



Feedstock substitution is a key aspect that must be developed in order to achieve the objectives of the twin transition. The replacement of feedstock that uses a lot of fossil carbon is essential and will be driven by the deployment of current technologies and development of new ones.



2) TECHNOLOGY ROADMAP

EU Initiatives supporting Technological Transition *(SET Action Plan)*	**Actions** *(as presented in Building Blocks – Part II)*	**EU Initiatives**
A) ELECTRIFICATION	6.2. Develop hub structures 8.3. Development of an industrial technology roadmap 14. Anticipate l-t needs for the supply of energy and feedstock resource 15.1. Channel investments for clean energy 15.2. Ensure competitive supply of clean energy 15.3. Improve Power-Purchase Agreements 18.1 Enable the free flow of energy between countries 20.1. Increase availability and capacity of multi-modal terminals close to industrial clusters 20.2. Improve use of rail transport	• REPowerEU • EU Renewable Directive • TEN-E Regulation • Proposal for a directive on Energy Efficiency
B) HYDROGEN	6.2. Develop hub structures 6.3. Manage and convert existing assets 15.1. Channel investments for clean energy 15.2. Ensure the competitive supply of clean energy 18.2. Develop a separate hydrogen infrastructure at EU level	• European Clean Hydrogen Alliance • Hydrogen and decarbonised gas market package
C) BIOMASS	4.3. Strengthen initiatives with SMEs under the EIC 8.1. Promote safety and sustainability assessment approaches 9.1. Foster collaboration and partnerships 16.2. Biomass as an alternative feedstock 19.1. Develop recycling facilities and bio-refineries (and exploit synergies with the chemical industry)	• Revision of the Renewable Energy Directive • INCITE (Industrial Emissions Directive)
D) WASTE	3.2 Improve collaboration in value chains 3.3 Support product design and re-design 8.1. Promote safety and sustainability assessment approaches 11.1. Definitions and concepts 11.2. Methods 16.3. Waste as an alternative feedstock 22.1. Set a regulatory framework for the transport of waste 22.2. Improve the management of logistics for waste feedstock	• Hubs4Circularity • Waste Framework Directive • Landfill Directive
E) CCU & CCS	6.3. Manage and convert existing assets 9.2. Support for development 16.4. CO_2 as an alternative feedstock 22.2. Improve the management of logistics for waste feedstock	• Hubs4Circularity • Sustainable Carbon Cycle
F) PROCESS EFFICIENCY	3.2 Improve collaboration in value chains 3.3 Support product design and re-design 5.1. Facilitate exchange of information (new synergies) 5.3. Support the development of Partnerships for Innovation 6.3. Manage and convert existing assets 17. Process efficiency 19.1. Develop recycling facilities and bio-refineries (and exploit synergies with the chemical industry) 20.1. Increase the availability and capacity of multi-modal terminals that are close to industrial clusters 21.2. Deploy technologies to improve chemical manufacturing processes and data gathering 25.2. Safety and social security of workers	• REPowerEU • Industrial Symbiosis • Revision of the Industrial Emission Directive

The SET action plan prioritises technologies to be developed to reach the objectives of resilience and the twin transition. The table below summarises general EU initiatives and actions to support the SET action plan.

In addition, the ERA industrial technology roadmap for low-carbon technologies sketches out the key technologies and the means to transfer them to the industrial ecosystem for energy-intensive industries at EU and national level. See page 28, Table 3 - Overview of technological pathways, TRLs and application potential by sector.

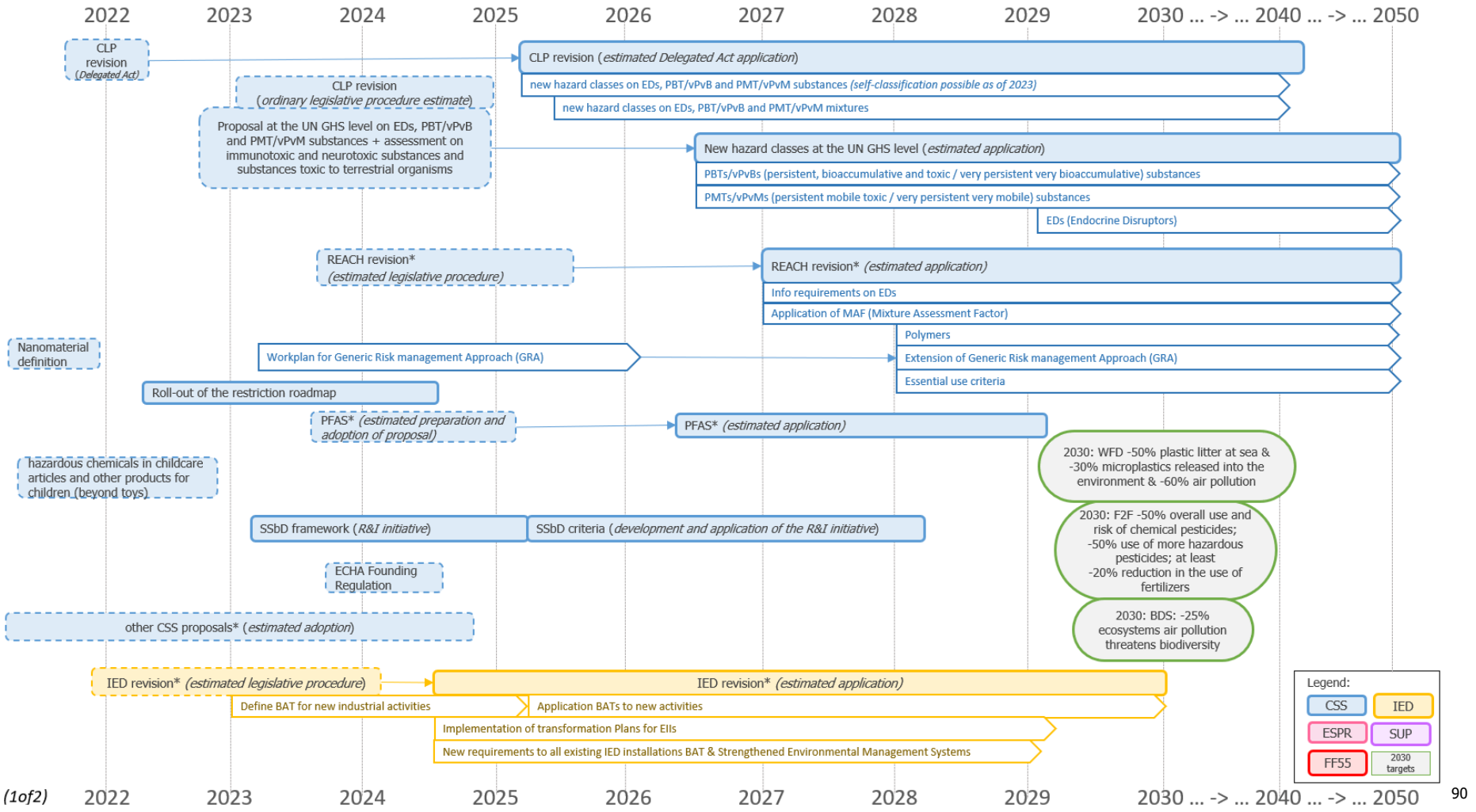
3) REGULATORY ROADMAP (INCLUDING R&I INITIATIVES)

This overview of existing legislation and major R&I initiatives relevant to the chemical industry has been developed using the best available knowledge at the time of writing. It includes the latest publicly available information and best-scenario assumptions about the ongoing legislative and non-legislative procedures, as proposed by the Commission. However, the timeline of this roadmap remains purely indicative – especially for those proposals whose content is still under development.

The overview does not include all financial opportunities supporting the implementation of the legislation (where it exists) and/or the transition of the industry. It also does not include all supportive EU documents, such as the guidance on boosting circular business models referred to in the ESPR. However, it aims to be a tool to help decision-makers and other stakeholders in the chemical industry.

In the figures below, boxes surrounded by a dashed outline indicate the timeframe for the estimated development and adoption of the proposal. Boxes with solid outlines indicate the estimated timeframe for application. However, the period in which the legislation will be valid is expected to go beyond the end of the box.

A full list of the acronyms used in the figure below is available in Annex 2, while additional information after the figure covers elements that are part of the proposals for which a detailed timeline is still not available.



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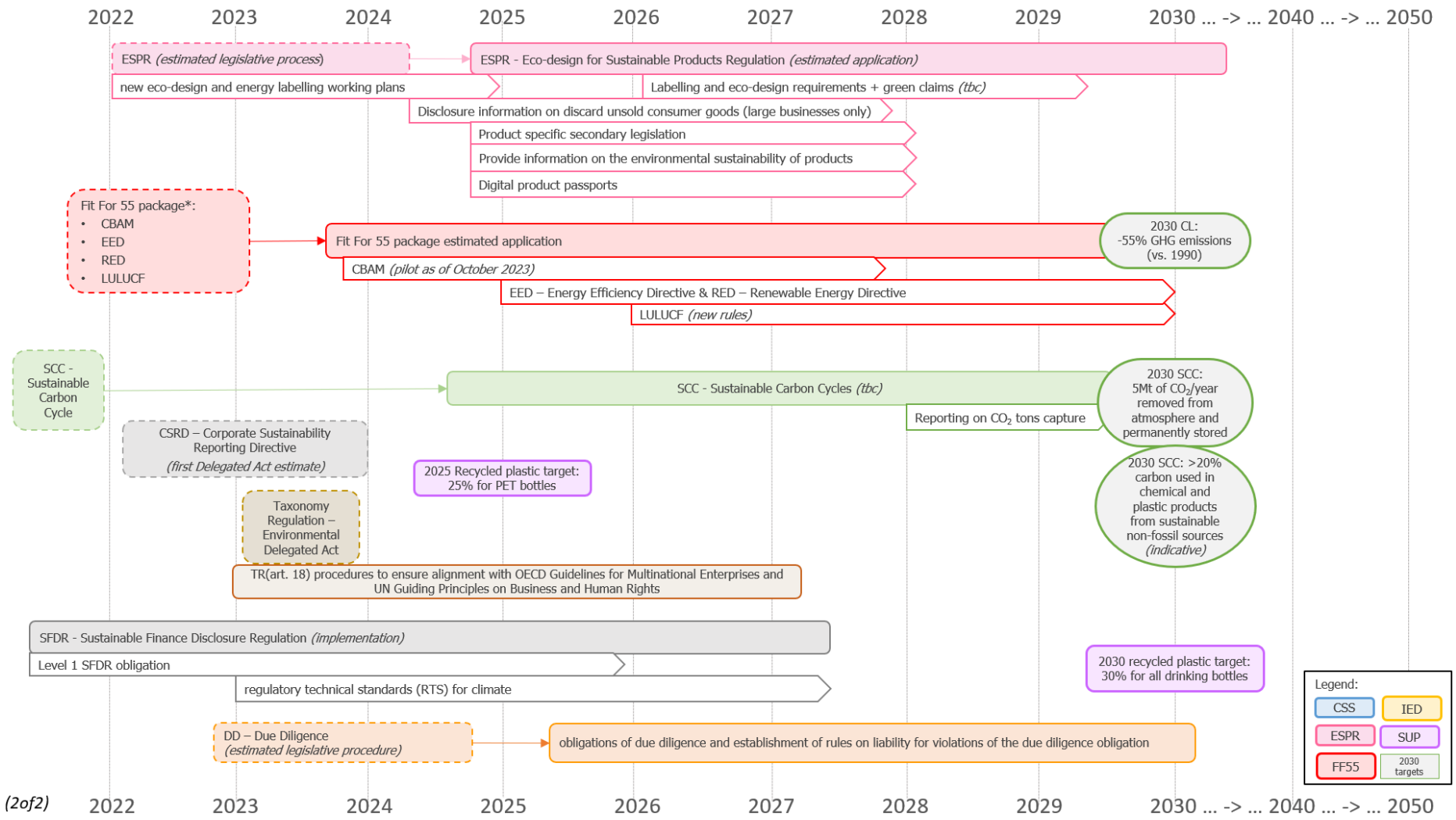
[90] Minimise the presence of substances of concern in products by introducing requirements, also as part of the SPRI, giving priority to those product categories that affect vulnerable populations as well as those product categories with the highest potential for circularity, such as textiles, packaging (including food packaging), furniture, electronics, ICT, equipment, construction and buildings.



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*PFAS – *additional elements* COM(2020) 667 final:

- Restriction under REACH for all non-essential uses including in consumer products.
- Add PFAS where possible as a group in the review of annexes of the Environmental-Quality Standards Directive and Groundwater Directive.
- Proposal to address the emissions of PFAS from the waste stage including through the revision of the Sewage Sludge Directive.
- Address the presence of PFAS in food by introducing limits in the Food Contaminants Commission Regulation.
- Address PFAS concerns at a global scale via proposals under the Stockholm Convention and the Basel Convention.

*REACH revision – *additional elements* COM(2020) 667 final:

- Authorisation and restriction processes + requirements for registration.
- Amend Article 68(2) to include professional users.
- Introduce MAFS in Annex I.
- 'One substance, one assessment' process.
- Draft a restrictions roadmap of CMRs, EDs, PBT/vPvBs, immunetoxicants, neurotoxicants, substances toxic to specific organs and respiratory sensitisers.
- Amend REACH Article 57 to add EDs, PMT and vPvM substances to the list of substances of very high concern.

*Other proposals (according to Annex CSS):

- 2021: EU Strategic Framework on Health and Safety at work - Occupational safety and health in a changing world of work.
- 2022: EU repository of human and environmental health-based limit values.
- 2023: Creation of an open platform on chemical-safety data and tools for accessing relevant academic data.
- 2023: General proposal to: (i) remove legislative obstacles to the re-use of data; (ii) streamline data flows across legislation; and (iii) extend the open-data and transparency principles from the EU food-safety sector to other pieces of chemical legislation.
- 2023: Proposals to allow EU and national authorities to commission testing and monitoring of substances as part of the regulatory framework.

*IED revision – *additional elements* COM(2022) 156 final:

- Permits – reviewing and updating permits, depending on the status of the receiving environment, and/or planning measures to comply with environmental-quality standards, objectives, plans and programmes under water legislation.
- More detailed reporting of pollutants at installation level.
- Indirect release of polluting substances – clarifying the rules that apply to the indirect release of polluting substances into water through urban wastewater treatment plants.
- Fostering innovation will help address persistent chemical substances and substances newly identified as being of concern, including PFAS, microplastics and pharmaceuticals.
- BREFs – 'exchange of information' process under the IED to draw up and review best-available-technique reference documents (BREFs). These BREFs should take account of the identification of substances of concern under EU water legislation. In particular, these include 'watch lists' of substances for groundwater and surface water, and substances identified as possibly posing a significant risk to or via the aquatic environment at EU level.
- Setting additional and updated criteria to support the EU Taxonomy on sustainable investments.
- List of pollutants replaced by Annex II on pollutants of E-PRTR Regulation (as amended).
- Strengthened provisions on sanctions + specified minimum content of penalties.
- Extension to large-scale battery production (manufacture of lithium-ion batteries with a production capacity of 3.5 GWh or more per year) and mining.

*Fit For 55 package – *additional elements* COM(2021) 550 final:

- **CBAM** broadening of the scope to include organic chemicals, plastics, hydrogen, ammonia and indirect emissions.
- **EED** – Energy Efficiency Directive: Annual energy-savings obligations for MSs of more than 0.8% (2021-2023) & annual energy savings obligations for MSs of more than 1.5% (2024-2030).
- **RED** – Revision of the Renewable Energy Directive to increase the binding EU minimum share of renewable energy sources in final energy consumption to 40% by 2030, in effect doubling the share of renewable energy sources in the energy mix over the course of a single decade (2021-2030). The proposal would also set a comprehensive framework for the deployment of renewable energy sources across all sectors of the economy, with a particular focus on sectors where progress has been slow (transport, buildings and industry). The

binding EU headline target of 40% would be supported by a series of higher EU and national targets for these different sectors, and the promotion of hydrogen consumption in transport and industry.

- **Energy taxation**: main changes include the following points:
  - fuels will start being taxed according to their energy content and environmental performance rather than their volume, helping businesses and consumers alike to make cleaner, more climate-friendly choices;
  - according to this ranking, conventional fossil fuels, such as gas oil and petrol will be taxed at the highest rate and electricity at the lowest rate;
  - products are categorised for taxation purposes in a simplified way to ensure that fuels most harmful to the environment are taxed the most;
  - exemptions for certain products and home heating will be phased out (thus, fossil fuels can no longer be taxed below minimum rates);
  - fossil fuels used as fuel for intra-EU air transport, maritime transport and fishing should no longer be fully exempt from energy taxation in EU.
- **ESR** – Effort Sharing Regulation.
- **LULUCF** proposal for: (1) moving away from the 'no-debit' rule (where GHG emissions cannot exceed GHG removals within the sector) from 2026; (2) increasing the carbon-sink potential to deliver GHG removals in the current decade; (3) strengthening Member States' obligation to submit integrated mitigation plans for the land sector; (4) improving monitoring requirements using digital technologies supported by the European Environment Agency and the Copernicus programme; (5) alignment with other key biodiversity and bioenergy policy initiatives; (6) expanding the scope of the regulation to cover the whole land sector from 2031 by including non-CO_2 emissions from the agriculture sector; and (7) setting a value on mitigation actions by introducing a carbon-removal certification scheme and the possibility to trade in certificates.
- **SCF** – Social Climate Fund.

IV/ NEXT STEPS

The co-creation process with stakeholders has shown how relevant it is to work together to support the twin transition. However, the cooperation must not stop when the transition pathway is published. It should continue with a co-implementation process involving all interested stakeholders, accompanied by structures and participatory processes to bring forward the agreed actions and monitor progress on the industry's transition.

The co-implementation process will start by the publication of the transition pathway and by disseminating this pathway to all relevant stakeholders. Then, the Commission services could organise a first co-implementation meeting. The aim of this meeting would be the discussion of – and agreement on – the approach to follow for such co-implementation.

The co-implementation process will consider policy coordination necessary across EU Member States. Indeed, the support of the EU Member States for the transition is crucial, to guide and provide support at regional and local levels and to implement regulatory changes in a coordinated and harmonised manner.

The specific approach will be discussed and agreed with stakeholders participating in the co-implementation once the final version of the transition pathway for the chemical industry is published. Stakeholders should consider the following points:

- Organising an annual plenary meeting for a stocktaking exercise on the co-implementation of the transition pathway. During this meeting, participants will also identify topics and actions to tackle in the coming months. They may wish also to agree on a prioritisation for carrying out specific actions before others and announce pledges. This meeting would be also an opportunity to prepare yearly conclusions on the implementation progress of the transition pathway for the chemical industry.
- Adopting an annual progress report to be shared and discussed with the Competitiveness Council and all relevant EU and national institutional stakeholders.
- If necessary, creating specific task forces dedicated to topics of high priority that require additional discussion. Actions set out for these topics in the transition pathway will then be allocated to these task forces to follow and guide. These task forces would self-organise their work, and with the support of Commission services, they would prepare each year a summary of the progress made on the actions which would be presented at the annual meeting.
- Distributing an annual survey for stakeholders who have made specific commitments to help implement transition-pathway actions and objectives. Such commitments will be as quantifiable as possible, with an appropriate engagement level by different actors. These commitments will also mention an indicative timeframe for implementation. The updated status of commitments would be published online to inform and encourage other stakeholders.
- This Pathway may be updated to take account of new developments and the evolution of EU legislation.

ANNEXES

Annex 1 - Overview of Green Deal objectives impacting the chemical industry

This Annex collects the objectives for the green and digital transition, as well as for resilience of the chemicals sector, based on existing EU documents; including strategies, actions plan, etc.

Green objectives	Source[91]
Climate neutrality by 2050	
No net emission of greenhouse gas emissions in EU by 2050	GD
Net reduction of GHG emissions by at least 55% (By 2030 vs. 1990 level)	CL1
5Mt of CO_2 to be annually removed from the atmosphere and permanently stored through frontrunner projects by 2030	SCC1
Energy	
EU gross final consumption of energy to be at least 45% from renewable energy sources (2030) {*binding target*}	RED II
At least 32.5% improvement in energy efficiency by 2030 (2007 projects for 2030)	EED1
Reducing primary (39%) and final (36%) energy consumption by 2030	EED2
Annual energy savings obligations by MSs: 2021-2023: >0.8% and 2024-2030: >1.5%	EED3
Environment and Health	
Improving water quality by reducing waste, plastic litter at sea (by 50%) and microplastics released into the environment (by 30%) (2030)	ZPAP1
Reduction in air pollution (60%, 2030)	ZPAP2
Reducing the EU ecosystems where air pollution threatens biodiversity (25%)	ZPAP3/BD
Reducing the overall use and risk of chemical pesticides (50%) and the use of more hazardous pesticides (50%) by 2030 and at least 20% reduction in the use of fertilizers (2030)	F2F
Circularity	
Increasing municipal waste recycling: >55% by weight by 2025 >60% by weight by 2035	WFD
Restrict landfilling of waste recyclable or suitable for energy recovery (2030)	LD
Content recycling target (2025): 25% for PET bottles 30% for all drinking bottles	SUPD
75% target for recycling of packaging waste (2030)	PPWD

[91] See Annex 2 for the full list of abbreviations.

Reduce transport-related greenhouse gas emissions by 90% by 2050	GD

Green objectives: Industry Level	Rf
Climate[92]	
At least 20% of carbon used in the chemical and plastic products to be from sustainable non-fossil sources by 2030 (indicative)	SCC2
Reporting every ton of CO_2 captured, transported, used and stored and accounting it by fossil, biogenic or atmospheric origin (2028)	SCC3
Environment and Health	
Stepping up innovation for the green transition of the chemical industry and its value chains.	CSS(G1)
Making the EU chemicals policy evolve and establish safe and sustainable chemicals as an EU global benchmark, securing international competitiveness.	CSS(G2)
Most harmful substances banned for consumer products unless they are essential for society.	CSS(G3)

Digital objectives	Rf
Development of digital tools and instruments towards safer and sustainable chemicals	CSS(D)
Digitalisation of chemical production (e.g. through internet of things, big data, artificial intelligence, smart sensors and robotics exploitation, digital product passports, data sharing across supply chains, etc.) bulding upon the actions, initiatives and mearures for the digitalization of bussiness set in Digital Decade Policy Programme.	SCC(D1)
Paperless chemicals transport based on data sharing across the supply chain, and multimodal optimisation of transportation capacity.	SCC(D2)
Exploitation of digital tools for faster action on enforcements and optimal use of resources, including of market surveillance authorities, and foster digital innovations for advanced tools, methods and models, and data analysis capacities to also move away from animal testing.	SCC(D3)

Resilience objectives	Rf
Strengthening EU's open strategic autonomy by notably promoting the EU's resilience of supply and sustainability of critical chemicals	CSS(R)
Substitution of alternative feedstock, integration of renewable energies and increase in energy efficiency (reduce EU energy consumption) in order to avoid dependencies from Russian gas to be fastened as announced in REPowerEU	REP(R)

[92] This list does not include indications from impact assessments and are Commission's working documents. For example, the IA SWD(2020) 176 final mentions "Industry to reduce GHG emissions between 20.3% & 25.15 by 2030 (vs 2015 level)".

Annex 2 - Overview of initiatives impacting the chemical industry

Non-exhaustive list of initiatives that include green and digital objectives for the chemical industry, as identified by stakeholders:

Annex 1 source	Full reference	URL
BDS	EU Biodiversity Strategy for 2030	https://europa.eu/!vw76Rn
CL1	European Climate Law	https://europa.eu/!b9jcXm
CL2	SWD(2020) 176 final - Impact Assessment accompanying document for COM/2020/562 final.	https://europa.eu/!gC43Cr
CSS	Chemicals Strategy for Sustainability Towards a Toxic-Free Environment	https://europa.eu/!Vt94Yr
EED II	Proposal for a Directive on energy efficiency (recast) – COM(2021) 558 final	https://europa.eu/!w4jVHV
F2F	Farm to Fork Strategy	https://europa.eu/!rt73kQ
GD	The European Green Deal	https://europa.eu/!DG37Qm
GT[93]	EU taxonomy for sustainable activities	https://ec.europa.eu/info/business-economy-euro/banking-and-finance/sustainable-finance/eu-taxonomy-sustainable-activities_en
IS II	A New Industrial Strategy for Europe	https://europa.eu/!ghHBCV
LD	Landfill Directive	https://europa.eu/!F88pXB
PPWD	Packaging and Packaging Waste Directive	https://europa.eu/!qYCFN7
RED III	Renewable Energy Directive (recast) – COM(2021) 557 final	https://europa.eu/!TBQJtY
REP	REPowerEU	https://europa.eu/!WDnDg6
SCC	Sustainable Carbon Cycle	https://europa.eu/!9xCx8D
SUPD	Single-Use Plastics directive	https://europa.eu/!RD46Uw
WFD	Waste Framework Directive	https://europa.eu/!TW93TN
ZPAP	Pathway to a Healthy Planet for All EU Action Plan: 'Towards Zero Pollution for Air, Water and Soil'	https://europa.eu/!wRCWv9

Additional policy initiatives impacting chemical industry's twin transition:

- The Eco-design for Sustainable Products Regulation
- Revision of REACH

[93] In the case of the EU Green Taxonomy, it is not an objective but rather a system to classify which parts of the economy may be marketed as sustainable investments.

- Revision of CLP - Classification, Labelling and Packaging
- Implementation of EU ETS - Phase 4
- Definition of sectorial targets for GHG emissions reduction by 2030 and by 2050 (vs. 1990 levels)
- Bioeconomy Strategy and Bioeconomy Action Plan
- Circular Economy and Action Plan
- EU Methane Strategy
- Corporate Sustainability reporting Directive
- Initiative on substantiating green claims

Additional policy initiatives that will have an impact on the industry resilience:

- European Critical Raw Materials Act
- Corporate Sustainability Due Diligence
- EU Advanced Materials manifesto and the critical raw material strategy
- Review of EU strategic dependencies and capacities
- EU's Trade strategy
- IED – Industrial Emissions Directive's revision
- Revision of the Environmental Crime Directive.

Annex 3 – Summary of the topics under each building block

Building Blocks	Topics
Sustainable Competitiveness	**Topic 1:** International Competitiveness **Topic 2:** Reduction of unsustainable dependencies and supply chains vulnerabilities **Topic 3:** Safety and Sustainability **Topic 4:** Innovation and growth of SMEs **Topic 5:** New synergies
Investments and Funding	**Topic 6:** Fund for Green Investments **Topic 7**: Access to Funding
R&I, Techniques and Technological Solutions	**Topic 8:** Better conceptualisation of new techniques and technical solutions (TRL 1 to 5) **Topic 9:** Developing new techniques and technological solutions (TRL 6 to 7) **Topic 10:** Deployment of new techniques and technological solutions (TRL 8 to 9)
Regulation and Public Governance (legislation)	**Topic 11:** More effective and predictable legislation **Topic 12:** Vertically and horizontally coherent legislation **Topic 13**: Effective and efficient enforcement
Access to energy and feedstock	**Topic 14**: Anticipate long-term needs for Energy and Resource Supply **Topic 15**: Economically viable purchase of clean energy **Topic 16**: Feedstock Substitution **Topic 17**: Process and resource efficiency
Infrastructure	**Topic 18**: Large-scale electricity and hydrogen infrastructure **Topic 19**: Development of new sustainable production facilities **Topic 20**: Sustainable transport of raw materials and chemical products **Topic 21**: Deployment of digital technologies **Topic 22**: Circularity: recycling and reuse infrastructure
Skills	**Topic 23**: Education (reskilling/upskilling the workforce) **Topic 24**: Sufficient supply of jobs at technical level
Social Dimension	**Topic 25**: Impact on workforce and consumers **Topic 26**: Improve gender diversity and equality in the sector

Annex 4 – Additional actions on legislation suggested by stakeholders

Stakeholders suggested additional actions to those included in the chapter "regulation and public governance (legislation)" as potential contributors to the transition of the chemical industry towards green and digital objectives, as well as its resilience. These proposals are not part of the final roadmap of the EU chemicals transition pathway because it only includes actions and measures deriving from existing legislation.

To make the EU legislation more effective and predictable, stakeholders propose:

- To deepen the climate component of the transition pathway by developing a sectoral roadmap to meet the climate neutrality objective of the chemicals sector; in line with the European Climate Law (art.10);
- To develop and to implement – with the support of Member States - a plan of work proposed by Commission services for staged implementation of the GRA (Generic Risk Assessment) under REACH revision, differentiating substances, consumer mixtures and articles, and distinguishing professional uses according to exposure patterns;
- To develop OECD testing schemes and testing methods for the safety assessment of polymers in cooperation with the authorities (linked to the REACH revision);
- To create new regulations to require an increasing proportion of materials to be reused, recycled or from renewable materials and to be designed for circularity (binding goals, not just for packaging; adoption of a "mass-balance" methodology in support of recycling[94];
- Consider the use of predictive toxicology, such as QSAR by the OECD, to fill the gaps in (eco)toxicity data needed for the assessment of chemicals hazard;
- Inclusion in the Better Regulation of a balance between requests for data and costs for the industry in collecting and reporting the requested data;
- Do not hamper the use of digital technologies by the chemical industry under the ongoing legislative initiatives on digital. For example, in the definition of "high risk AI – Artificial Intelligence" consider the potential negative impact on including some of the chemical industry appliances.

To improve the coherence of legislation vertically and/or horizontally, stakeholders proposed:

- Establishing a coordination mechanism within the Commission services to agree and synchronise – to the extent possible – legislation on chemicals. For example, revision of the Waste Framework Directive to happen before Packaging and Packaging Waste Directive review[95]. This would avoid an "all in once" implementation of the legislation. A link between PACT and such mechanism should also be explored;

[94] This may include verification and certification protocols for mass balance systems, clear definitions of recycled content and chemical-recycling technologies and a harmonized EU implementation of the Basel Convention.

[95] A stakeholder suggests also improving the interplay between OSH legislation and other chemicals legislation and strengthen their enforcement to promote the safer use of chemicals as well as the use of safer and more sustainable chemicals to support a harmonised enforcement in Member States.

- To align chemicals, waste and product legislation[96] on key definitions such as "recycling";
- Harmonisation of rules on the end-of-waste criteria in the revision of the EU Waste Framework Directive;
- Revision of Block Exemption Regulations and of antitrust rules to facilitate value chain cooperation for the development and implementation of techniques and technical solutions largely contributing to the twin transition. This could include using "regulatory sandboxes"[97].

Finally, to ameliorate the enforcement and implementation of existing legislation, stakeholders proposed:

- Explore the use of digital tools to support market surveillance and customs authorities, as well as to improve the compliance of products containing chemicals sold online to European consumers;
- Include in bilateral and multilateral trade agreements a cooperation on enforcement of chemicals legislation and on capacity building necessary for enforcement;
- Proposal for carbon leakage protection for export and across the entire value chain;
- Support the deployment of synergies to exploit between industry and health authorities, occupation and epidemiological databases as a basis for future regulatory action;
- Consider reattribution of technical and scientific work on chemicals performed under the relevant pieces of legislation to European agencies, including work of SCHEER and SCCS[98] as also proposed in the Commission's Chemicals Strategy for Sustainability;
- Foresee a "warning" mechanism providing an advice service to SMEs before sanctioning the company in case of non-compliance with EU legislation due to regulatory overburden;
- Propose a new partnership mechanism to support development of high-quality REACH registration dossiers and support SMEs for safety assessment;
- Provide incentives to the downstream users and customers, help the uptake of new technological solutions via Green Public Procurement[99] or eco-modulated EPR fees[100], among others.

[96] This includes, among others, Eco-design for Sustainable Products Regulation, Waste Framework Directive, Waste Shipment Regulation and Packaging and Packaging Waste Directive.

[97] European Commission, TOOL #21. Research & Innovation, Better Regulation Toolbox; European Commission 6783/20 (COM (2020)103); Council conclusions 13026/20 Annex.

[98] A stakeholder suggests allowing EU and national authorities to commission testing and monitoring of substances. Another strengthening and formalize the role of the ECHA Enforcement Forum.

[99] GPP is a voluntary instrument, it has a key role to play in the EU's efforts to become a more resource-efficient economy. It can help stimulate a critical mass of demand for more sustainable goods and services which otherwise would be difficult to get onto the market. GPP is therefore a strong stimulus for eco-innovation.

[100] OECD, 2021. Modulated fees for extended producer responsibility schemes (EPR) https://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=ENV/WKP(2021)16&docLanguage=En

Annex 5 – Additional actions on R&I suggested by stakeholders

In addition to product (re-)design, main R&I priorities to decrease GHG emissions, increase resource efficiency and circularity as well as safety in the chemical industry include:

- The integration of climate-neutral energy through direct and indirect electrification (e.g. electrification of heat); steam generation or upgrade; electrification of chemical processes in particular through electrochemical processes; or alternative energy forms like plasma and photons
- The use of alternative carbon feedstock (see the energy and feedstock building block)
- The production of hydrogen with a reduced carbon footprint for existing and expected higher future use, either as chemical feedstock, or in the future, as an energy carrier
- Process efficiency, including process intensification and advanced separation technologies
- Carbon capture and storage.

Such priorities require new process technologies and their combination will be essential to reach the 2050 EU climate-neutrality objective. Advanced tools supporting decision-making from the design phase to production, supported by digital technologies as well as advanced materials, will also be key enabling priorities for the chemical sector.

Stakeholders suggested a series of initiatives to further strengthen the role of R&I in the twin transition and economic resilience of the EU chemical industry. These actions include:

- A dedicated Horizon Europe Innovation Programme on the CSS (focus on SSbD for most impacted value chains), a joint public-private programme supporting projects with higher TRL to avoid "valley of death";
- Development of different project assessment's criteria for higher TRLs (from TRL7 upwards) in European funding;
- Involve industry closely to ensure transfer of knowledge into innovation;
- Support faster co-creation of new digital technologies and related collaborations as well as early adopters of digital technologies through appropriate risk sharing and funding measures for the chemical industry;
- Propose a framework on how to exchange data at EU level (incl. IPRs implications across EU technology platforms and activities) via innovation platforms;
- Simplified and coordinated access to EU and national research programmes (especially for SMEs);
- Further strengthen the agility and effectiveness of the EU project funding process;
- Develop methodologies for chemical risk assessment that consider the whole life cycle of substances, materials and products;
- Develop effective Risk-Sharing Instruments with appropriate evaluation at all TRLs including for demonstration plant and first-of-its-kind (FOAK) plant;

Annex 6 – Glossary

Carbon Border Adjustment Mechanism (CBAM)

Carbon Border Adjustment Mechanism (CBAM) is a system designed in compliance with World Trade Organization (WTO) rules and other international obligations of the EU. EU importers will buy carbon certificates corresponding to the carbon price that would have been paid, had the goods been produced under the EU's carbon pricing rules. Conversely, once a non-EU producer can show that they have already paid a price for the carbon used in the production of the imported goods in a third country, the corresponding cost can be fully deducted for the EU importer. The CBAM will help reduce the risk of carbon leakage by encouraging producers in non-EU countries to green their production processes.

Carbon Capture and Storage

Carbon Capture and Storage (CCS) technologies aim to capture as much as 85% - 90% of CO_2 emissions from power plants and heavy industry before transporting it by pipeline or ship and storing it permanently and safely at least 800 metres below the earth's surface.

Carbon Capture and Utilisation

Carbon capture and utilisation technologies may mitigate climate change by removing CO_2 from the atmosphere and converting it into other materials such as fuels, chemicals and plastics.

Circular economy

A circular economy aims to maintain the value of products, materials and resources for as long as possible by returning them into the product cycle at the end of their use, while minimising the generation of waste.

Circular Economy Action Plan

It's one of the main building blocks of the European Green Deal, Europe's new agenda for sustainable growth. The EU's transition to a circular economy will reduce pressure on natural resources and will create sustainable growth and jobs. It is also a prerequisite to achieve the EU's 2050 climate neutrality target and to halt biodiversity loss.

Cohesion Fund

The Cohesion Fund provides support to Member States with a gross national income (GNI) per capita below 90% EU-27 average to strengthen the economic, social and territorial cohesion of the EU. It supports investments in the field of environment and trans-European networks in the area if transport infrastructure.

Digital Innovation Hubs

European Digital Innovation Hubs (EDIHs) are one-stop shops supporting companies to respond to digital challenges and become more competitive. More information is available at the webpage https://digital-strategy.ec.europa.eu/en/activities/edihs

Energy and Industry Geography Lab (EIGL)

The Energy and Industry Geography Lab is a tool for geographical data related to energy, industry and infrastructure. The tool makes it possible to find and filter energy-related data, and create and share maps displaying this data. It enables analyses and assessments that support Europe's transition to climate neutrality.

Energy-intensive industries

Energy-intensive industries (EIIs), embedded in many strategic value chains, make up more than half of the energy consumption of the EU industry. EIIs produce goods and materials that enable reduction of emissions in other sectors of the economy, including transport, construction and power generation.

ERA industrial technology roadmap

Industrial technology roadmap under the new European research area (ERA) provides an evidence base on the state of play of low-carbon technologies in energy-intensive industries in the EU and available support instruments, and points to possible research and innovation action in view of accelerating development and uptake of these technologies. These possible ways forward build on contributions from industry, other research and innovation stakeholders, Member States, and relevant European partnerships. This roadmap will feed into the transition pathway for the energy-intensive industries ecosystem under the EU industrial strategy and supports the work to accelerate the green and digital transitions under the ERA policy agenda.

EU Chemicals Strategy for Sustainability

The EU's chemicals strategy aims to better protect citizens and the environment and boost innovation for safe and sustainable chemicals. Its main actions are banning the most harmful chemicals in consumer products - allowing their use only where essential, boosting the investment and innovative capacity for production and use of chemicals that are safe and sustainable by design.

Euroclusters

Clusters are groups of firms, related economic actors, and institutions located near each other and with sufficient scale to develop specialised expertise, services, resources, suppliers and skills. Together, SMEs can be more innovative, create more jobs, and

register more international trademarks and patents than alone. There are over 1500 clusters located in more than 200 EU-27 regions. Clusters account for almost 25% of total EU employment.

European Digital Innovation Hubs (EDIHs)

They help companies dynamically respond to the digital challenges and become more competitive. By providing access to technical expertise and experimentation as well as the possibility to 'test before invest', EDIHs help companies improve business/production processes, products, or services using digital technologies. They also provide innovation services, such as financing advice, training, and skills development that are needed for a successful digital transformation. Environmental issues are also considered, regarding energy consumption and low carbon emissions.

European Green Deal

The European Green Deal will transform the EU into a modern, resource-efficient and competitive economy in order to overcome challenges as climate change and environmental degradation that are an existential threat to Europe and the world.

Green Public Procurement (GPP)

Green Public Procurement (GPP) is defined in the Communication "Public procurement for a better environment" (COM (2008) 400 final) as "a process whereby public authorities seek to procure goods, services and works with a reduced environmental impact throughout their life cycle when compared to goods, services and works with the same primary function that would otherwise be procured." GPP is a voluntary instrument, which means that Member States and public authorities can determine the extent to which they implement it.

Horizon Europe Research & Innovation Programme

Horizon Europe is the EU's key funding programme for research and innovation with a budget of €95.5 billion from 2021 to 2027. It tackles climate change, helps to achieve the UN's Sustainable Development Goals and boosts the EU's competitiveness and growth. The programme facilitates collaboration and strengthens the impact of research and innovation in developing, supporting and implementing EU policies while tackling global challenges. It supports creating and better dispersing of excellent knowledge and technologies. It creates jobs, fully engages the EU's talent pool, boosts economic growth, promotes industrial competitiveness and optimises investment impact within a strengthened European Research Area. Legal entities from the EU and associated countries can participate.

Hubs4Circularity

The Hubs 4 Circularity (H4C) are key instruments to advance the research and innovation agenda of European industries towards the Green Deal's objectives. H4Cs have a strong technological focus and industrial dimension, but their implementation leverages elements well beyond research and innovation. Specific implementation (including funding) strategies will have to be co -designed, ensuring the participation of all stakeholders; industry, Small and medium-sized enterprises (SMEs), research and technology organizations (RTOs), local authorities, educational institutions and civil society.

Industrial symbiosis

Industrial symbiosis is the process by which wastes or by-products of an industry or industrial process become the raw materials for another. Application of this concept allows materials to be used in a more sustainable way and contributes to the creation of a circular economy.

Intergovernmental Panel on Climate Change

The Intergovernmental Panel on Climate Change is the United Nations body for assessing climate change science. It produces regular assessments of the scientific basis of climate change, its impacts and future risks, and options for adaptation and mitigation. These reports inform governments in the development of climate policy as well as guiding the UN's international climate change negotiation.

Just Transition Fund (JTF)

The Just Transition Fund is a new instrument with an overall budget of €17.5 billion, of which €7.5 billion are coming from the Multiannual Financial Framework (MFF) and €10 billion from the NextGenerationEU. The JTF is a key element of the European Green Deal and the first pillar of the Just Transition Mechanism (JTM). It aims to alleviate the social and economic costs resulting from the transition towards a climate-neutral economy, through a wide range of activities directed mainly at diversifying the economic activity and helping people adapt in a changing labour market.

Just Transition Mechanism (JTM)

The Just Transition Mechanism (JTM) is a key tool to ensure that the transition towards a climate-neutral economy happens in a fair way, leaving no one behind. It provides targeted support to help mobilise around €55 billion over the period 2021-2027 in the most affected regions, to alleviate the socio-economic impact of the transition.

Open Innovation Test Beds

It is a set of entities, established in at least three Member States or Associated Countries, providing common access to physical facilities, capabilities and services required for the development, testing and upscaling of nanotechnology and advanced materials in industrial environments. Its objective is to bring nanotechnologies and advanced materials within the reach of companies and users advancing from validation in a laboratory to prototypes in industrial environments.

Private-Public Partnerships

Long term contractual arrangements between the government and a private partner whereby the latter delivers and funds public services using a capital asset, sharing the associated risks. This broad definition shows that PPPs can be designed to achieve a wide array of objectives in various sectors, such as transport, social housing and healthcare, and can be structured under different approaches.

QSAR

The JRC QSAR Model Database is a historical archive providing information on the validity of Quantitative Structure-Activity Relationship (QSAR) models that were submitted to JRC's EU Reference Laboratory for Alternatives to Animal Testing (EURL ECVAM).

Safe and sustainable-by-design

A process to accelerate widespread market uptake of new and alternative chemical products and technologies that deliver greater consumer confidence in their safety, environmental and societal benefits and advance the transition towards a circular economy and climate-neutral society.

Social Life Cycle Assessment

Social Life Cycle Assessment (S-LCA) is is a method that can be used to assess the social and sociological aspects of products, their actual and potential positive as well as negative impacts along the life cycle. This looks at the extraction and processing of raw materials, manufacturing, distribution, use, reuse, maintenance, recycling and final disposal.

Sustainable Products Initiative (SPI)

It aims to make products placed on the EU market more sustainable. Consumers, the environment and the climate will benefit from products that are more durable, reusable, repairable, recyclable, and energy efficient.

Trans-European Networks for Energy

The Trans-European Networks for Energy (TEN-E) is a policy that is focused on linking the energy infrastructure of EU countries. As part of the policy, nine priority corridors and three priority thematic areas have been identified.

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A Green Deal Industrial Plan for the Net-Zero Age

1. INTRODUCTION: A GREEN DEAL INDUSTRIAL PLAN FOR THE NET-ZERO AGE

This decade will be decisive for the world to limit the rise in global temperatures and to take the necessary steps towards net-zero. The stakes are high and the challenges complex – but there is a once in a generation opportunity to use this imperative to act as a catalyst to invest in the clean energy economy and industry of the net-zero age.

The European Green Deal sets in stone our green transition ambitions, including our climate targets towards net-zero by 2050. The Fit for 55 package provides a concrete plan to put the European economy firmly on track, with the REPowerEU Plan accelerating the move away from fossil fuels. Alongside the Circular Economy Action Plan, this sets the framework for the transformation of the EU's industry for the net-zero age.

In the next few years, the economic shape of the net-zero age will be firmly set. New markets will have been created, breakthrough clean technologies will have been innovated, developed, and brought to market, and our energy systems transformed. Therefore, those who invest first and faster today will secure their place in this new economy and create jobs for a newly skilled workforce, rejuvenate industrial manufacturing bases, lower costs for people and businesses and be in a prime position to support other parts of the world to decarbonise their own economies.

The scale of the opportunity for European industry puts this need in sharp focus. The International Energy Agency estimates that the global market for key mass-manufactured clean energy technologies will be worth around USD 650 billion a year by 2030 (approximately EUR 600 billion) – more than three times today's level. The related energy manufacturing jobs could more than double in the same time period[1]. The net-zero industry globally is growing strongly, to the extent of demand sometimes outpacing supply.

The EU is well equipped to step up and seize the net-zero opportunity. Europe's economic model, built on its Single Market, has brought rising prosperity over the past decades. Europe is a leading player on innovation, venture capital and deployment of net-zero technologies and sustainable products. It has a strong starting point – an industry with a track record as a proven trend-setter and standard-setter, with growing levels of digitalisation. Manufacturing high quality and innovative products that are used across the world. It has world-leading scientists and researchers, consistently developing breakthrough solutions or refining existing technologies.

The EU has also shown how the **green transition can strengthen competitiveness**. The phase-out of Russian fossil fuels has accelerated a new industrial revolution aimed at ending the age of fossil fuels. A wide range of new net-zero technologies is being developed and deployed across our economy: in transport, buildings, manufacturing, energy, and even creating entirely new markets. Our net-zero ecosystem was worth over EUR 100 billion in 2021, doubling in value since 2020[2].

The EU has also proven its inbuilt resilience to continued change and challenge. Industry is being challenged on everything from high inflation, labour shortages, demographic change, post-COVID supply chains disruptions, rising interest rates, spikes in energy costs and input prices. This is paired with strong, but not always fair, competition on the fragmented global market. Despite these headwinds, so far, the EU economy has held up remarkably and political unity is paying off. Gas and oil prices have now fallen below pre-war levels. Inflation across

[1] Energy Technology Perspectives (2023), International Energy Agency.
[2] The rise of European Clean Tech – Report, https://dealroom.co/uploaded/2022/04/Dealroom-Talis-Climate-Tech-Europe-2022.pdf

Europe dropped for the second consecutive month, and markedly, in December 2022. Unemployment is lower than before the 2008 financial crisis and labour markets continue to perform well.

The EU is committed and convinced that it can speed up net-zero industrial transformation at home. On top of needs and opportunities such as the roll-out of renewables, the transformation of energy and transport infrastructures such as grids, the massive switch to fossil-free hydrogen as a storage medium, fuel and feedstock, the EU can also be a leading player in the net-zero industries of the future. We can also create new forms of clean tech cooperation with our partners abroad. By working together with partners on developing net-zero technologies, diversifying and strengthening supply chains, and supporting others on their green transition, the race to net-zero can be good for the planet and for business.

And the encouraging signs are that Europe's partners are also beginning to seize the net-zero industrial opportunities. The United States' Inflation Reduction Act will mobilise over USD 360 billion by 2032 (approximately EUR 330 billion). Japan's green transformation plans aim to raise up to JPY 20 trillion (approximately EUR 140 billion) – through 'green transition' bonds. India has put forward the Production Linked Incentive Scheme to enhance competitiveness in sectors like solar photovoltaics and batteries. The UK, Canada and many others have also put forward their investment plans in clean tech technologies. Europe is committed to working with all of those partners for the greater good.

However, trade and competition on net-zero industry must be fair. Some of our partners' initiatives can have undesired collateral effects on our own net-zero industries. More fundamentally, China's subsidies have long been twice as high as those in the EU, relative to GDP[3]. This has distorted the market and ensured that the manufacturing of a number of net-zero technologies is currently dominated by China, which has made subsidising clean tech innovation and manufacturing a priority of its Five-Year Plan. China's pipeline of announced investments in clean technologies exceeds USD 280 billion (approximately EUR 260 billion). Europe and its partners must do more to combat the effect of such unfair subsidies and prolonged market distortion. Where the public footprint in private markets is outsized, distortions create an unlevelled playing field and unfair competition emerges. The Commission will continue to make full use of trade defence instruments (TDI) to defend the Single Market, and rules-based international trade, from unfair trade practices like dumping and distortive subsidies.

Going forward, competitiveness challenges remain. The era of cheap fossil fuels is now over, calling for an acceleration of the green transition to ensure industry has access to abundant and affordable clean energy. The EU needs to build on its greatest strength, the Single Market, and avoid fragmentation. Therefore the Commission is committed to come forward with a comprehensive European approach, based on common strategic priorities and an investment needs assessment. This will require to explore various options to secure a common EU response, including EU funding. More also needs to be done to facilitate businesses' access to private funding, notably by completing the Capitals Market Union. Greater competitiveness must go hand in hand with well-paid quality jobs and investment in human capital.

The net-zero industrial age will be framed by the decisions taken today. The EU must be ready to lead the way, with speed, ambition and a shared sense of direction. A common response, anchored in EU policies and instruments, will be far more effective than the addition of 27 national approaches.

[3] Chinesische Subventionspolitik: Effekte auf deutsche Unternehmen (vbw-bayern.de)

2. A GREEN DEAL INDUSTRIAL PLAN – STAYING AHEAD OF THE GAME

Against this backdrop of seismic opportunity and challenge, Europe needs a new Green Deal Industrial Plan. The Plan will form part of the European Green Deal, which set us on the path to climate neutrality, and will enable Europe to lead the way globally in the net-zero industrial age.

The starting point for the Plan is the need to massively increase the technological development, manufacturing production and installation of net-zero products and energy supply in the next decade, and the value added of an EU-wide approach to meet this challenge together. This is made more difficult by the global competition for raw materials and skilled personnel. The Plan aims to address this dichotomy by focusing on the areas where Europe can make the biggest difference. It also seeks to avert the risk of replacing our reliance on Russian fossil fuels with other strategic dependencies that could impede our access to key technologies and inputs for the green transition, through a mix of diversification and own development and production. The Plan will complement ongoing efforts to transform industry under the European Green Deal and the EU Industrial strategy, in particular the Circular Economy Action Plan. Modernising and decarbonising energy-intensive industries also remains a top priority, as does ensuring job transitions and quality job creation through training and education.

This is why a strong joint European response to boost the net-zero industry is needed. The Green Deal Industrial Plan will play to our strengths: openness, innovation, inclusiveness and sustainability. With the right conditions, the net-zero industry in Europe will play a vital role in transforming the continent into a green economy - delivering prosperity in the EU and leading globally both on technology and on combatting climate change and environmental pollution.

This outline for a new **Green Deal Industrial Plan is based on four pillars:**

- **a predictable and simplified regulatory environment;**
- **faster access to sufficient funding;**
- **skills; and**
- **open trade for resilient supply chains.**

2.1. A predictable, coherent and simplified regulatory environment

The EU has traditionally relied on a strong regulatory environment for setting conducive conditions for business, for providing quality employment for our workforce and a high level of protection for our environment. These three dimensions can be mutually reinforcing, if regulation is balanced and smartly designed, which requires continuous attention. This is why this year the Commission has introduced an additional 'competitiveness check' on all new regulation to ensure that all potential competitiveness impacts are addressed and unnecessary burdens avoided. A simple, predictable and clear regulatory environment is key to promoting investment. Action at EU level prevents fragmentation between 27 regulatory approaches.

This spring, the Commission will table three key proposals for industrial competitiveness, rooted in the need for reform:

First, **as part of the Green Deal Industrial Plan, the Commission proposes to put forward a Net-Zero Industry Act to underpin industrial manufacturing of key technologies** in the EU. The act would provide **a simplified regulatory framework for production capacity** of products that are key to meet our climate neutrality goals, such as batteries, windmills, heat

pumps, solar, electrolysers, carbon capture and storage technologies[4]. The Net-Zero Industry Act would in particular:

- Following sector-specific analysis, identify **goals for industrial capacity by 2030** where necessary to ensure that strategic dependencies do not put the green transition at risk. It will consider the whole supply and value chain across borders, so that supplies do not become a bottleneck;
- Reduce the length and enhance the predictability of **permitting** processes by defining specific time limits for different stages of permitting, and significantly reinforce Member States' administrative capacity, e.g. by introducing a '**one-stop-shop**' - a sole point of contact for investors and industrial stakeholders during the entire administrative process.

As European value chains are highly integrated and interconnected in the Single Market (see Figure 1), the Net-Zero Act would define simple and operational criteria for identifying net-zero supply chain projects of strategic interest. This should ensure that all Member States continue benefiting from innovative industrial deployment by promoting **strategic projects, including multi-country projects, accessible to both developed and less developed regions**. These projects could benefit from accelerated permitting procedures and attract private as well as EU and national public funding[5].

European standards can help to promote the roll-out of clean and digital technologies. In particular for new industrial value chains, anticipating and developing high-quality European standards could provide EU industries an important competitive advantage – including at global level. They could demonstrate 'marketability' and attract investment in firms that adhere to them. European standards would allow EU industries to scale up their technologies across the Single Market – this is very important for start-ups and SMEs.

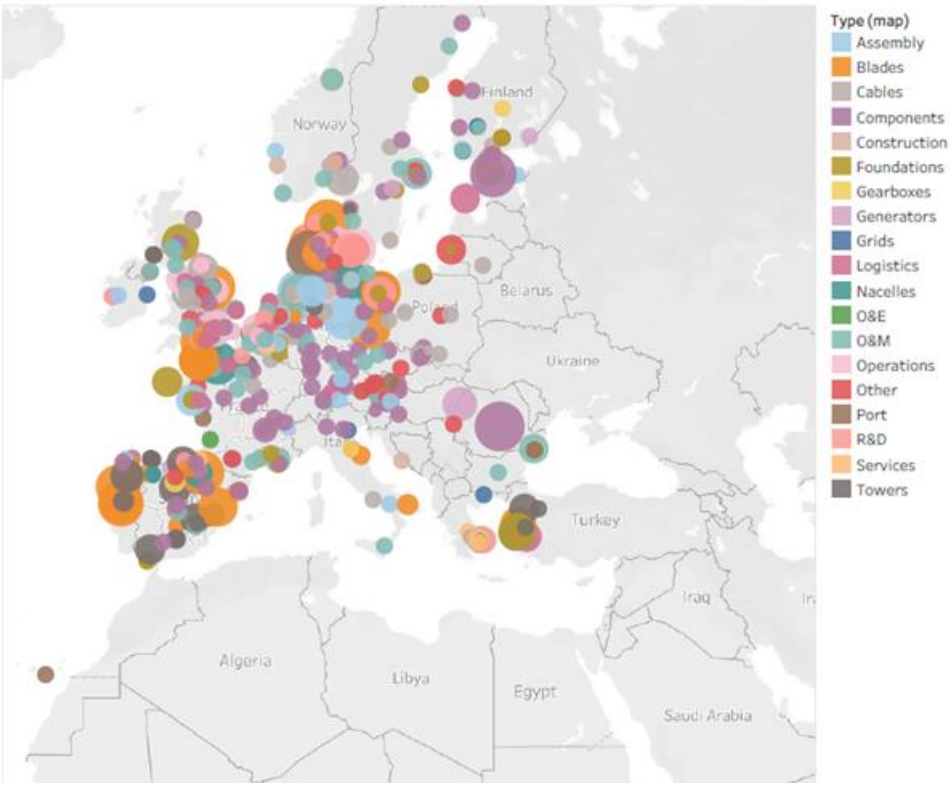
- The Act could enable the Commission to request **European standards** promoting the fast roll-out of key technologies[6].

[4] The precise product scope remains to be defined. Taking technology neutrality as a starting point, the Act would build on an assessment of strategic importance and identified needs of manufacturing investment in different types of net-zero products. Those technologies may go beyond the strategic net-zero technologies that will be eligible for the specific type of support available under the State aid Temporary Crisis and Transition Framework.

[5] National public funding constituting state aid shall be in line with the TCTF.

[6] For example, the recycling of raw materials for solar panels or the installation of wind turbines could be facilitated by complying with European standards developed in these fields. It is already possible to develop a standard for the collection, transport and treatment of batteries to enable fast-tracking and simplified procedure for recycling installations complying with that standard.

Figure 1 Wind supply chains and jobs are highly integrated in the EU and Europe



Source: Wind Europe. The map presents EU wind manufacturing facilities across its segments. The circles size is proportional to the number of jobs per facility (small circles: 10-50 employees; big circles: over 1000 employees).

To foster innovation, the Commission will assess the possibility to establish **regulatory sandboxes** to allow for rapid experimentation and disruptive innovation to test new technologies.[7] Such regulatory sandboxes may also pave the way for simplification of the process of authorisation/certification for placing products in the market. These procedures can now be lengthy, slowing the introduction of innovative products and representing a significant burden especially for SMEs and start-ups. The Commission will continue funding testing facilities as one important step to bring technology to market.

To further stimulate the demand for net-zero products at large scale, various forms of **public action such as public procurement, concessions and incentives to business and end users to use net-zero technologies based on sustainability and circularity can play a big role.** Public authorities in the EU spend around 14% of GDP (around EUR 2 trillion per year) on the purchase of services, works and products. Procurement policy and other public support can play a role in maximising public-interest returns on public money while fostering security of supply through diversification of sources. To this end, the Commission would define sustainability characteristics and possible requirements for net-zero products, using available legal tools and existing EU standards. It would promote a more predictable and uniform demand for net-zero solutions and allow public authorities to set out ambitious sustainability requirements.

[7] The Commission intends to publish a guidance showcasing the relevant use cases of regulatory sandboxes, test beds and living labs in order to support policymakers and innovators in their approach to experimentation in the EU by summer 2023.

Second, the Commission will propose a **Critical Raw Materials Act.** The manufacturing of EU net-zero technologies is only possible if access to relevant critical raw materials is ensured, including by diversifying sourcing and by recycling raw materials to lower the EU's dependence on highly concentrated supplies from third countries and boost quality jobs and growth in the circular economy. This act will aim to provide the EU security of supply, including by strengthening international engagement, facilitating extraction (where relevant), processing and recycling, while ensuring high environmental standards and continuing research and innovation, e.g. to reduce material use and to develop bio-based substitutes. There have already been tangible successes: today, some EU companies are using lignin stemming from wood in batteries, instead of graphite.

Third, **energy**. Russia's weaponisation of energy was a major wake-up call for security of supply and tackling dependencies. The competitiveness of many companies has been severely weakened by high energy prices and the disruptions in several supply chains. This has particularly been the case of the energy-intensive industries[8]. To address the high costs of energy and replace costly fossil fuels with cheaper renewables, important steps have been taken in line with the REPowerEU plan. For example, in 2022 wind and solar renewable energy production capacity in the EU exceeded 400 GW, an increase of over 25% compared to 2020.[9] We have set up the EU energy platform to pool gas demand, coordinate infrastructure use and negotiate with international partners, made savings, filled storages and put in place a cap on short-term markets. Several infrastructure projects and interconnections have been completed in both electricity and gas. **In March, the Commission will present a reform of the electricity market design,** for which a public consultation is currently ongoing. Long-term price contracts could play an important role to enable all electricity users to benefit from more predictable and lower costs of renewable power. As set out in the REPowerEU Plan, boosting industrial competitiveness will require both transforming industrial processes, massive speed-up and scale-up of renewable energy and stronger efforts for energy efficiency and reduction of energy demand as well as reskilling and upskilling of the workforce.

The new **EU regulatory framework for batteries** is a crucial element in the EU's transition to a climate neutral economy, by securing competitive and resilient value chains for battery production, reuse and recycling in the EU. Going forward, **the Ecodesign for Sustainable Products Regulation**[10] will apply to a broader range of products and further expand the range of sustainability requirements, in which EU industry excels. The Commission will give a high priority to work on net-zero technologies under the existing and future Ecodesign working plans.

Furthermore, it is key that consumers can make their choices based on transparent and reliable information on the sustainability, durability and carbon footprint of the products. Market transparency is a tool facilitating uptake of technologically and environmentally superior net-zero products. For example, the Commission will propose a **unified energy label** for heat pumps to allow users to compare different technologies[11] by the end of this year. The Commission proposal on empowering consumers for the green transition also works in this direction.

[8] Such as producers of polysilicon used in solar PV or of battery cells manufacturers.

[9] Commission estimates based on data from International Renewable Energy Agency (Irena) and industrial stakeholders.

[10] The EU's ecodesign policy sets harmonized rules for energy-related products on aspects such as energy consumption, water consumption, emission levels and material efficiency, stimulating both demand and supply for more sustainable products.

[11] For heat pumps thanks to the energy labelling database EPREL https://eprel.ec.europa.eu/screen/home

Finally, **infrastructure** is key to the conducive net-zero business environment that the Green Deal Industrial Plan seeks to establish. Full coverage of the TEN-T networks with charging and refueling infrastructure and development and strengthening of a European hydrogen backbone and the extension and strengthening of smart electricity grids to accommodate large quantities of renewables on the TEN-E network require large investment[12]. but also a strengthening of our regulatory framework. Now is the time to map the infrastructure needed with a European mindset. The Commission urges co-legislators to adopt the Alternative Fuels Infrastructure Regulation (AFIR) as soon as possible, to help create a future-proof charging and refueling network. To develop and strengthen hydrogen and electricity infrastructure the Commission will further examine the resource needs of the Connecting Europe Facility and will use the full scope of the revised TEN-E Regulation to accelerate the planning, financing and deployment of crucial (cross-border) infrastructure. Notably the development and implementation of the cross-border infrastructure needs to be accelerated in the coming years. The Commission will also consider further ways, including possible legislative action, to make sure that Member States deliver cross-border energy infrastructure, so that there are no undue delays to the roll-out of the strategic infrastructure.

The Green Deal Industrial Plan will succeed in boosting competitiveness if all actors (authorities, social partners, investors, consumers) join forces towards the same objectives. The recently established Clean Tech Europe Platform, the Clean Energy Industrial Forum, together with other relevant stakeholders, would support the plan, coordinate action to meet the investment and manufacturing targets and further promote matchmaking opportunities. The Commission will continue to engage closely with the European Parliament to make the Green Deal Industrial Plan a success.

2.2. Speeding up access to finance

Global net-zero industry has experienced strong growth, with clean energy investments up by 10% in 2022 year on year. The EU's net-zero industry is competitive in some sectors, such as wind energy or heat pumps, even in our relatively high-energy-price environment, while it has limited footholds in other segments, such as solar PV panels. Moreover, ensuring a timely transition to a net-zero economy requires faster development of those sectors. **The EU industry's market shares are under strong pressure, to a great extent because subsidies abroad are unleveling the playing field. This calls for access to funding for net-zero industry to be extended and accelerated.** This is the second pillar of the Green Deal Industrial Plan.

Targeted public funding must also play its role. Already today, the EU and national funding play an important role in fostering net-zero innovation, manufacturing, roll-out and related strengthening of grids and infratructure. Private funding will be key to unlock investments for the net-zero industry.

Under NextGenerationEU, the 27 national recovery and resilience plans funded by the Recovery and Resilience Facility (RRF) already make available EUR 250 billion for green measures, including investments supporting the decarbonisation of industry. Horizon Europe dedicates EUR 40 billion to Green Deal research and innovation, also in partnership with industry.

Cohesion policies make around EUR 100 billion available for green transition, including the Just Transition Fund. The Commission will further facilitate the swift mobilisation of Cohesion

[12] Regarding the investment needs, see Staff Working Document REPowerEU https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52022SC0230&from=EN

investments in support of the Net-Zero Industrial Plan, including by speeding up the design and reimbursements of energy efficiency and renewable projects through standard reimbursement schemes.

To date, these EU funding sources have largely benefitted research and innovation and deployment of renewable energy and related infrastructures, rather than targeting manufacturing capacity in the sector.

Funding for net-zero industrial value chains can be stepped up in scale and speed through targeted state aid. But to avoid fragmenting the Single Market due to varying levels of national support – and varying capacities to grant such support – there also needs to be adequate EU-level funding to facilitate the flourishing of such industrial value chains across the Union as a whole.

2.2.1 National funding

Starting with state aid: EU competition policy provides tools to support the development and deployment of key cutting edge technologies strategic for the green and digital transitions, while preserving the integrity of the Single Market and respecting EU's international obligations. In 2022 alone, the Commission approved aid schemes with an overall budget of EUR 51 billion to deploy new renewable energy production capacity and decarbonise industrial production across the Union. As early as March 2022, following Russia's aggression against Ukraine, the Commission adopted a Temporary Crisis Framework providing a tool for Member States to remedy the negative economic effects created by the war and facilitate structural adjustments to better respond to the resulting economic situation. The Framework has been amended twice and already includes specific provisions on simplified support for renewable energy, decarbonisation technologies and energy efficiency measures.

The Commission now intends to allow further flexibility for the Member States to grant aid limited to carefully defined areas and on a temporary basis. The Commission will consult Member States on a proposal to adapt State aid rules on a temporary basis, until end 2025, to further speed up and simplify, with easier calculations, simpler procedures, and accelerated approvals. These changes will also assist Member States in delivering on specific projects under National Recovery Plans which fall within their scope.

The Commission intends to **adapt state aid rules along five axes,** subject to conditions necessary to limit distortions to the Single Market, to avoid greater regional disparities and to ensure compliance with international obligations. Four of these will be implemented through the proposed amendment of the Temporary Crisis Framework (TCF), which will be transformed into the **Temporary Crisis and Transition Framework (TCTF)** for State aid:

1. *Simplification of aid for renewable energy deployments;*

The TCF has already simplified aid for renewable deployments. The draft TCTF would go further, by:

- extending the provisions to **all renewable technologies** (under RED II) and to renewable hydrogen and biofuel **storage**;
- eliminating the need for open tenders for **less mature technologies** (for which tenders may work less well); and
- **extending deadlines to complete projects**.

2. *Simplification of aid for decarbonising industrial processes ;*

Decarbonisation aid to industry had already been simplified by the TCF. The TCTF would go further with a number of provisions, such as:

- allowing aid by reference to **standard percentages of investment costs**, based on case experience – for hydrogen use, energy efficiency and electrification.
- More **flexible aid ceilings** per beneficiary in schemes fulfilling specific conditions.

3. *Enhanced investment support schemes for production of strategic net-zero technologies, including the possibility of granting higher aid to match the aid received for similar projects by competitors located outside of the EU while ensuring the proportionality of such aid;*
4. *More targeted aid for major new production projects in strategic net-zero value chains, taking into account global funding gaps.*

The draft TCTF would aim to ensure a level playing field with other jurisdictions and within the internal market, targeted to those sectors where a third-country delocalisation risk has been identified, and proportionate in terms of aid amounts. The TCTF would enable Member States to put in place schemes **to support new investments in production facilities in defined, strategic net-zero sectors, including via tax benefits**. The permitted aid amount would be modulated with higher aid intensities and aid amount ceilings if the investment is located in assisted areas, in order to contribute to the goal of convergence between Member States and regions. Appropriate conditions would be required to verify the concrete risks of diversion of the investment outside the EEA and that there is no risk of relocation within the EEA. Member States can **align their national fiscal incentives** along a common scheme that the Commission stands ready to prepare, and thereby create **a common scheme** offering greater transparency and predictability to businesses across the EU.

In addition, Member States would also be able to match the aid offered by a third country, for individual initial investments in the same targeted sectors relevant to net-zero technology leadership, subject to conditions, such as being part of a multi-country cooperation, with material positive spillovers across Member States and with particular consideration for assisted areas. Such aid should address substantiated risks of certain investments being diverted in favour of third countries outside the EEA, and it should not facilitate relocation of production activities between Member States. The aid would be limited to what is necessary for the project to take place in the EEA.

The Commission will remain committed to fast procedures under the TCTF, as is already the case for aid approved under the Temporary Crisis Framework, where median approval time has been 19 days.

5. *Significantly increasing notification thresholds for state aid in these fields*

The Commission will adapt the State Aid rules on this fifth axis by further revising the **Green Deal General Block Exemption Regulation.** In addition to provisions linked to IPCEI projects (see below), this would give Member States more flexibility:

- to support measures in key sectors, such as hydrogen, carbon capture and storage, zero-emission vehicles and energy performance of buildings, by further increasing thresholds triggering notification to the Commission.
- enlarge the scope of investment aid for recharging and refuelling infrastructures,
- further facilitating training aid for skills.

Today, the EU has five **Important Projects of Common European Interest (IPCEI)**, large development projects undertaken by several Member States to fund new technologies in strategic areas, with strong positive spillovers across borders and for innovation, workers and customers: one in microelectronics, two in batteries and two in hydrogen, with more projects in

preparation[13]. Public support of EUR 18 billion for approved IPCEIs is expected to unlock an additional EUR 36 billion in private investments, a leveraging factor of 2.

To accelerate the roll-out of new projects, the approval of IPCEI related projects will be further streamlined and simplified;

- A code of good practices for a transparent, inclusive and faster design of IPCEIs will allow for a streamlined assessment and is to be endorsed by the Member States and the Commission this spring.
- The Commission is also preparing to **speed up the implementation of smaller, IPCEI-related, innovative projects,** in particular by small and medium-sized enterprises, through higher notification thresholds and greater aid intensities under the General Block Exemption Regulation.

2.2.2 EU funding

To support the transition reaching the EU's net-zero objectives and REPowerEU targets with diversified sources and secure supplies, the EU will have to continue to rely on a competitive net-zero industry. Greater investments are needed by 2030 in the manufacturing of net-zero technologies given the European ambitious EU targets and international competition..

Important disparities exist within the EU in terms of support by Member States. For example, while in 2020, 0.57% of EU GDP was allocated to support renewable energy sources, one country allocated almost 1% of its GDP and ten others spent less than half the EU average.[14]

To avoid fragmenting the Single Market due to varying levels of national support, facilitate the green transition across the Union as a whole, avoid exacerbating regional disparities and address the gap between funding currently available and the financing needs for scaling up the net zero industry, we must also step up EU funding. Accompanying the Green Deal Industry Plan, the EU budget will continue to contribute to targeted and swift funding of the EU's net-zero industry. REPowerEU is our dedicated vehicle, and is boosted by other EU funds.

The Commission will continue to provide support to Member States to design, develop and implement reforms as well as help strengthen the administrative capacity of Member States to ensure effective implementation of the funding.

REPowerEU

Thanks to the agreement reached end of 2022, the EU support to the transition will now be increased with the additional funding brought to the RRF by the REPowerEU initiative: additional RRF grants (EUR 20 billion) will be available to Member States to promote the greening of industry, to support EU net-zero industry projects, and to assist energy-intensive industries in the face of high energy prices. Member States will also be able to dedicate grants of the Brexit Adjustment Reserve (EUR 5.4 billion) to these objectives. Furthermore, they will be able to use the remaining RRF loans (EUR 225 billion) with substantial pre-financing for these investments and reforms[15].

In order to assist the Member States in implementing the RRF and its REPowerEU component,

[13] Such as additional batteries and hydrogen, or possibly solar or heat pumps.

[14] Study on energy subsidies and other government interventions in the European Union - Publications Office of the EU (europa.eu). Public support measures include direct transfers to business and consumers; tax expenditures (e.g. tax credits, VAT reduction); income or price support; Research & Development (R&D) support.

[15] This comes on top of the existing transfer possibilities of 5% from the cohesion policy funds (up to EUR 17.9 billion).

the Commission published today the **Guidance on Recovery and Resilience Plans**. The Guidance provides flexibility to adjust the plans to the current context, and to prepare REPowerEU chapters. It acknowledges issues arising from the disruption of supply chains, energy prices and inflation and offers to Member States effective solutions to maintain the ambition of the initial plans. The Commission strongly encourages Member States to include in their modified RRPs simple and effective measures to provide immediate support to companies and boost their competitiveness:

- (i) **one-stop-shops** for the permitting of renewables and net-zero projects to accelerate, digitalize and streamline the processes for obtaining the necessary approvals and permits for building and operating net-zero-tech projects; coupled with dedicated strengthening of administrative capacity to eliminate administrative bottlenecks in permitting;(ii) **tax breaks** or other forms of support for green net-zero technologies investments undertaken by businesses, taking the form of either a tax credit, an accelerated depreciation or a subsidy linked to the acquisition or improvement of green investment assets;
- (iii) and investing in equipping the workforce with **skills** necessary for this industrial transition.

The European Investment Bank (EIB) Group will support the achievement of all the objectives of the RePowerEU Plan with additional loans and equity[16]. The Commission and the EIB Group will continue working together to explore how the EIB Group could step up its clean tech and other activities contributing to the Green Deal.

InvestEU Programme

The InvestEU Programme is well placed to boost net-zero investments in the EU. InvestEU is the Union's instrument for catalysing private investments in EU priority areas. Through the EIB, the EIF, the EBRD and 14 other implementing partners, the EU supports public and private investments in net-zero tech and industrial innovation. Examples of projects that can be supported are RDI of battery technologies, critical raw materials recycling, demonstration plants for manufacturing materials in the supply chain of electric vehicle batteries, hydrogen propulsion technologies, innovative advanced biofuels plants, advanced manufacturing technology equipment in steel processing. InvestEU can mobilise over EUR 372 billion of financing – public, but mainly private - through the backing of the EU budget guarantee of EUR 26.2 billion.

To date the Commission has signed InvestEU guarantee agreements for a total value of EUR 21 billion. On the back of these guarantee agreements, the EIF has already signed InvestEU guarantee agreements with 48 financial intermediaries from 19 Member States for EUR 2.3 billion lending to European SMEs and small mid-caps, and 54 agreements with funds from 14 Member States for equity investments worth EUR 1.9 billion[17].

Examples of InvestEU-supported investments by the EIB and the EIF in the area of clean technology:

- *A EUR 37 million investment by the EIB in a p-CAM (precursor cathode active material)*

16 EIB boosts clean energy financing in support of REPowerEU Plan. Press release available at: https://www.eib.org/en/press/all/2022-450-eib-boosts-clean-energy-financing-in-support-of-repowereu-plan

17 In addition, by December 2022 the EIB had signed agreements for 29 operations in 9 Member States for EUR 2.3 billion under InvestEU for financing projects in research and innovation, as well as in sustainable infrastructure and also for social investment and skills.

commercial demonstration production plant. P-Cam is used in the supply chain of electric vehicle batteries (high tech lithium-ion battery cells).

- *A EUR 315 million loan by the EIB to a joint venture for technology and product developments of hydrogen automotive propulsion technologies, and active safety systems.*
- *A EUR 32 million investment by the EIB in support of R&D projects of a manufacturing company in electrification technologies for agricultural machinery and power transmission systems for tractors and off-road vehicles.*
- *A EUR 101 million guarantee by the EIF to a fund in support of early-stage technology companies (venture capital), high growth potential industrial companies; and decarbonisation sector companies (renewable energy projects and sustainability companies).*
- *A EUR 125 million loan to a greenfield production facility for cathode materials. The cathode materials will be supplied to battery manufacturers of high-tech lithium-ion batteries that are primarily used in electric vehicles.*

To ensure a timely delivery on the objectives of the Green Deal Industrial Plan, InvestEU procedures, should be simplified, and its products aligned to current needs. Guarantee agreements and financial products need to be aligned with the revised state aid framework, while specific provisions of the GBER will significantly simplify state aid aspects for national compartments in InvestEU. The Commission will continue to work with the EIB, the EU's bank, and other partners to address in an efficient and timely way the financing needs of priority projects, such as IPCEIs.

Funding through InvestEU is heavily frontloaded, as the biggest part of the funding comes from NextGenerationEU. By end 2023 EUR 14.83 billion of the EU guarantee needs to be committed, leaving only EU 11.37 billion for the period 2024-2027. At the same time, one can expect a significant increase in the demand for InvestEU support, given the revised eligibility conditions foreseen under the forthcoming Temporary Crisis and Transition Framework (TCTF). In particular, lifting current financing limitations on manufacturing projects in the areas covered by the TCTF would give rise to an increased demand and use of the EU guarantee by implementing partners. Therefore, the Commission is assessing how the overall funding for InvestEU could be increased, in particular for the period covering 2024 until 2027.

Innovation Fund

The Innovation Fund supports the development and first-of-a-kind deployment of technologies and solutions that decarbonise energy intensive industry, boost renewable energy and energy storage (including batteries and hydrogen) and strengthen net-zero supply chains by supporting the manufacturing of critical components for batteries, wind and solar energy, electrolysers, fuel cells and heat pumps. Over the decade, an estimated EUR 40 billion will be available under the Innovation Fund.

The revised and upgraded Emission Trading System directive, as agreed at the end of 2022 as part of the Fit for 55 package, allows the Innovation Fund to subsidise, through competitive bidding, 100% of the funding gap for scaling up clean tech deployment and manufacturing. The Innovation Fund can thus act as a European one-stop-shop for such support, thereby reducing the difficulties for investors in stacking different revenue streams and funding sources.

The Commission will launch in autumn 2023 a first auction – or competitive bid - for supporting the production of renewable hydrogen. Winners of this auction will receive a fixed premium for each kg of renewable hydrogen produced over a period of 10 years. This will

have a similar impact as the production tax credit in the US IRA, the difference being that the premium, based on the received bids, will make EU support cost-effective, fast and administratively light. Terms and conditions for this first pilot auction, with an indicative budget of EUR 800 million, will be announced in June 2023. This pilot auction will be followed by further auctions or other forms of support for hydrogen production and use that contribute towards the REPowerEU hydrogen targets, thereby covering the EU domestic part of the Hydrogen Bank.

Further building on this experience, the Commission considers extending the new competitive bidding mechanism for scaling up manufacturing of components for solar and wind energy, batteries and electrolysers, based on an analysis of EU net-zero sector needs, market sizing, and potential project pipeline. Also here, the Innovation Fund support would take the form of a production subsidy, instead of the 60% share of relevant cost that is the current practice of the Fund.

The EU emission trading system revenues will increase in the coming years. The greater part of this amount will constitute national revenues that Member States must use for climate action. The Commission encourages Member States to devote a share of those revenues to scaling up manufacturing of net-zero technologies. A share of the increased ETS revenues could also underpin the reinforcement of an efficient EU net-zero investment vehicle, such as the Innovation Fund.[18]

Numerous funds are thus available, mostly geared to innovation and deployment. The Commission is exploring avenues to achieve greater common financing at EU level to support investments in manufacturing of net-zero technologies, based on an ongoing investment needs assessment Delivering on a comprehensive European approach will be essential in order to preserve the Single Market from fragmentation and realise maximum synergies and scale. The Commission will work with Member States in the short term, with a focus on the afore-mentioned instruments – REPowerEU, InvestEU and the Innovation Fund - on a bridging solution to provide fast and targeted support where it is most needed, in complement to the temporary and targeted state aid changes outlined above. While the operationalisation of these different elements may not come at the same time, we are committed to deliver on this comprehensive European approach.

For **the mid-term,** the Commission intends to give a structural answer to the investment needs, by proposing **a European Sovereignty Fund** in the context of the review of the Multi-annual financial framework before summer 2023. The aim is preserving a European edge on critical and emerging technologies relevant to the green and digital transitions, from computing-related technologies, including microelectronics, quantum computing, and artificial intelligence, to biotechnology and biomanufacturing and net-zero technologies. This structural instrument will build on experience of coordinated multi-country projects under the IPCEIs and seek to enhance all Member States' access to such projects, thereby safeguarding cohesion and the Single Market against risks caused by unequal availability of state aids. The Commission will work with Member States in the design of the Sovereignty Fund to ensure that it addresses their respective needs.

[18] This is without compromising the overall ETS revenues available for the repayment of the NGEU debt

2.2.3 Private funding

By far the greater part of the investments needed for the net-zero transition will have to come from private funding. Public funding can crowd-in private investments, but it will not be sufficient to close the investment-gap needs. For successful net-zero transformation, we need vast amounts of private-sector financing in particular, financing raised through capital markets from a broad range of investors, including small retail investors as well as big institutional ones. **Well-functioning capital markets and the sustainable finance framework** are thus essential. The EU must ensure that its capital markets can support the necessary volume and variety of funding for EU companies, in particular in strategic industrial segments.

The EU must intensify its efforts to create a fully developed Capital Markets Union (CMU). The CMU aims at increasing the size of individual capital markets and their cross-border integration to improve financing and investment opportunities for individuals and companies, including those operating in the clean tech sector.

A deeper and truly integrated single market for capital would provide EU companies the means to finance themselves, to scale up and become less dependent on bank financing and to obtain financing to manage the green transition. Advancing the Capital Markets Union is thus an essential contribution to the Commission's political objectives of green and digital global competitiveness of European firms and the EU's open strategic autonomy.

Achieving a fully integrated EU capital market requires greater ambition and commitment from all key stakeholders in reaching **swift agreement on the Commission's legislative proposals implementing the 2020 CMU Action Plan**.

The EU sustainable finance framework supports investors and businesses efforts to scale up their investments that would be aligned with the European Green Deal targets. EU sustainable-finance policies will support the green transition by making private funding of green projects and companies easier to obtain and more attractive, as recalled in the Renewed Sustainable Finance Strategy[19].

2.3. Enhancing Skills

The green transition must be people-centred and inclusive to ensure equitable and just outcomes, generating quality jobs and leaving no-one behind. The European economy counted 4.5 million green jobs in 2019[20] up from 3.2 million in 2000. The green transition will amplify demands for new skills at all levels, requiring a large-scale up-skilling and re-skilling of the workforce. The battery industry alone estimates it will need an extra 800 000 workers by 2025. In the next decade, there will be fierce competition for talents. The productivity of our industry, the prosperity of our society and our ability to meet the net-zero objectives will depend on our ability to retain and attract workers. **This is why the third pillar of the Green Deal Industrial Plan must focus on skills - green and digital, at all levels and for all people, with**

[19] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52021DC0390

[20] Based on Eurostat definition of green jobs ('Employment in the environmental goods and services sector')., Eurostat 'Environmental economy - statistics on employment and growth", data, https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Environmental_economy_%E2%80%93_statistics_on_employment_and_growth&oldid=583805#Development_of_key_indicators_for_the_environmental_economy.

inclusiveness of women[21] **and youth**[22] **at the heart** of the Plan.

Demand for talent is acute. Labour shortages, as proxied by the vacancy rate,[23] have doubled in sectors considered key for the green transition[24] between 2015 and 2021 and green transition technical skills are in growing demand[25]. As it is estimated that between 35% and 40% of all jobs would contribute to the twin transition, technical - including digital - skills requirements and education levels in the green economy outpace the economy overall[26]. Overall labour productivity is higher in the green sectors, with for example **productivity in the clean energy sector about 20% higher than on average across the economy**, rendering green skills even more important for future prosperity.[27]

The EU is taking action to address skills related challenges posed by the twin green and digital transition through its overarching framework - the **European Skills Agenda** , which runs in synergy with the **European Education Area**[28]. The **European Pact for Skills,** which recently celebrated its second anniversary, supports 14 large-scale partnerships in European industrial ecosystems helping them to equip the workforce with the skills necessary for the transition towards a carbon-neutral and digital economy. The partnerships promote coordinated action by companies, workers, public authorities, social partners, education and training providers and employment services. Over 1,000 members have so far signed up, including large multinational companies, SMEs, local training providers, and chambers of commerce. Collectively, **they have pledged to help upskill and reskill 6 million people**. In addition, the Clean Energy Industrial Forum commits to stepping up efforts and investments in the development of skills.

The Digital Education Action Plan, the Digital Decade and the Structured Dialogue for Digital Education and Skills that took place in 2022 have prepared the ground for speeding up actions in reforming education systems and the provision of basic and advanced digital skills across the economy and at all ages. This provides a strong starting point to ensure that the society and businesses alike, can use digital skills for more precision and efficient use of natural resources, for a more positive impact on the environment.

The recent Communication on **harnessing talents in Europe's regions** supports policies to help acquire and develop the skills required for the green transition in all EU regions[29].

The **European Year of Skills 2023 is a unique opportunity to develop the skills needed to** thrive in a rapidly changing economy and to step up efforts. It is time for the EU and its Member States to be bolder and more ambitious in bringing about step changes in the education and

[21] Female employment rate was 69.5% in Q2 2022 compared to 80.2% for men and 74.9% on average. Employment rate of people aged between 60 to 64 was 48.2% compared to 74.9% on average for the age group 20-64.
[22] Whilst the unemployment rate decreased to a record-low 6,0% in November 2022, youth unemployment (under 25 years) stands at 2,5 times of general unemployment.
[23] Vacancy rate is the proportion of empty vacancies in the total number of vacancies and is considered as one of the best possible measures to indicate labour shortage in a sector.
[24] These sectors include the electricity, steam, gas and air conditionings, transportation, construction and Manufacturing sectors. Data for the Water supply, sewerage, waste management and remediation activities sector that is also regarded as key for the transition are unfortunately not available at the EU level.
[25] Based on the narrow Eurostat definition of green jobs ('Employment in the environmental goods and services sector'). Labour shortages, as proxied by the vacancy rate, have doubled in sectors considered key for the green transition between 2015 and 2021.
[26] ILO report 2019: Skills for a greener future: a global overview, available at: https://www.ilo.org/wcmsp5/groups/public/---ed_emp/documents/publication/wcms_732214.pdf
[27] JRC Clean Energy Technology Observatory (CETO): Overall Strategic Analysis of Clean Energy Technology–2022 Status Report: https://publications.jrc.ec.europa.eu/repository/bitstream/JRC131001/2022.5375.pdf
[28] COM (2022) 625
[29] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of Regions, Harnessing talent in Europe's regions, COM(2023)32 final.

skills agenda, and to implement opportunities presented by the EU framework[30]:

- The Commission is working with Member States to set targets and indicators **to monitor supply and demand** in skills and jobs **in the sectors relevant for the green transition.** A gender gap continues to prevail in the net- zero technologies sector. For example, women are under-represented in vocational and higher education in Science, Technology, Engineering, and Mathematics (STEM) sub-fields that are highly relevant for the energy sector.[31] In the renewables sector, women account only for one third of the workforce[32], so there is a clear opportunity for harnessing female talent there.
- The Commission is working with Member States and the higher education sector to implement the **European strategy for universities**[33], which plays a key role in ensuring future-proof skills. The EU provides substantial financial support for this purpose, including through the Erasmus+ European Universities initiative (EUR 1.1 billion).
- Furthermore, we need to attract, and retain top talent to Europe, especially in Science, technology, engineering, and mathematics (STEM). We need to open new pathways for international STEM students and researchers to come to Europe.
- A **large-scale skills partnership for onshore renewable energy** under the Pact for Skills will be established by February 2023. The partnership will identify commitments and targets and develop a vision of concrete upskilling and reskilling needs for the renewable energy sector in Europe.
- A **Heat Pumps skills partnership** will be established by the end of this year and efforts are under way to create a skills partnership on energy efficiency.
- Modelled on the European Battery Alliance Academy34, the Commission will propose to establish **Net-Zero Industry Academies** to roll out up-skilling and re-skilling programmes in strategic industries for the green transition, such as raw materials, hydrogen and solar technologies, The Commission will initiate an Academy to offer on- and offline trainings for sustainable construction with a focus on the use of biobased materials, circularity and digital technologies.

Validation of skills, alongside efforts to support the recognition of qualifications across Member States and from third countries, as well as labour mobility policies, can facilitate matching people's skills to employers' needs. People learn in multiple ways and in different contexts outside of formal education and training structures. In order to support this:

- As part of the EU's Skills Agenda, the Commission will **facilitate recognition of qualifications**. This could allow for a "fast track" to recognition and reduce administrative by supporting quick authentication of qualifications by employers and training providers.
- The Commission will further consider how to combine a '**Skills-first' approach recognizing actual skills with existing approaches based on qualifications, in the interests** of EU mobile citizens and third-country nationals.
- In particular, to attract talent from outside the EU, the Commission is examining a skills-

[30] For example: micro-credentials, individual learning accounts, digital skills and education recommendations.
[31] This translates to lower share of patent applications with women inventors (only 20% in all patent classes in 2021 and just over 15% for climate change mitigation technologies), lower share of start-ups founded or co-founded by women (less than 15% in the EU in 2021), and lower amounts of capital invested into women-led companies (only 2% in all-female start-ups and 9% in mixed teams in the EU in 2021). Source: CETO: Overall Strategic Analysis of Clean Energy Technology in the European Union – 2022 Status Report
[32] 32% in 2019, according to the Clean Industry Energy Forum, Joint declaration on skills in the clean tech sector, https://commission.europa.eu/system/files/2022-06/ceif_joint_statement_on_skills.pdf
[33] COM (2022) 16
[34] The European Battery Academy will train, reskill and upskill approximately 800 000 workers by 2025.

based approach to facilitate access of third country nationals to EU labour markets in priority sectors through the development of **an EU Talent Pool** and present a proposal on recognition of qualifications of third-country nationals.

More can be done to support people in acquiring new skills. The EU has robust policy frameworks to **financially support skills development,** with Council Recommendations supporting a number of skills reforms in the areas of individual learning accounts and micro-credentials, to quality and effective apprenticeships and vocational education and training. Making these policy reforms deliver concrete results in a coordinated fashion across Europe requires both **public and private funding to align, which could include**:

- The General Block Exemption Regulation ceiling for aid to SMEs for training will increase from EUR 2 million to EUR 3 million.
- Measures providing opportunities to skill workers as part of an IPCEI will be taken into account in assessing state aid compliance of such projects.[35]
- To stimulate increased investment in training in new net-zero technologies and production processes, the Commission will explore the treatment of training expenditure by companies as an investment rather than as an expense or operating cost.

EU funding is also available. The Multiannual Financial Framework 2021-2027 and NextGenerationEU support investments of around EUR 64.8 billion in skilling, re-skilling and up-skilling.[36] Out of those EUR 64.8 billion, cohesion policy, through the **European Social Fund +** (ESF+) is the main EU instrument to support investments in skills and is making EUR 5.8 billion available for green skills and green jobs. **European Regional Development Fund (ERDF)** complements ESF+ with investments in skills, education and training, including infrastructure. The **Just Transition Mechanism (JTM)** supports with EUR 3 billion training and skills development of workers to adapt to the green transition.

The **Recovery and Resilience Facility** is providing a significant financial support. 14 Member States are including measures for training on green skills and jobs in their national Recovery and Resilience Plans that, together, amount to around EUR 1.5 billion.

2.4. Trade and resilient supply chains

The EU welcomes initiatives conducted across the world on the road to climate neutrality and environmental sustainability. The goal of net zero can be best achieved if net-zero technologies incentives are underpinned by principles of fair competition and open trade. **The fourth pillar of the Green Deal Industrial Plan consists of global cooperation and making trade work for the clean transition.**

The EU draws competitive and political strength from being a trading powerhouse. The EU remains an attractive destination for global investment. We would have not achieved our resilience and overcome the challenges of the past years without the efficiencies that trade brings and the win-win partnerships we developed with third countries. At the same time, an increase in unfair and coercive practices have required us to develop new tools and enforce our

[35] Point 18 of the Guidelines on IPCEIs: Communication from the Commission - Criteria for the analysis of the compatibility with the internal market of State aid to promote the execution of important projects of common European interest - OJ C 528, 30.12.2021, p. 10–18.

[36] European Social Fund +, Erasmus, Horizon Europe, European Regional Development Fund, Digital Europe Programme, Recovery and Resilience Facility and the Just Transition Fund.