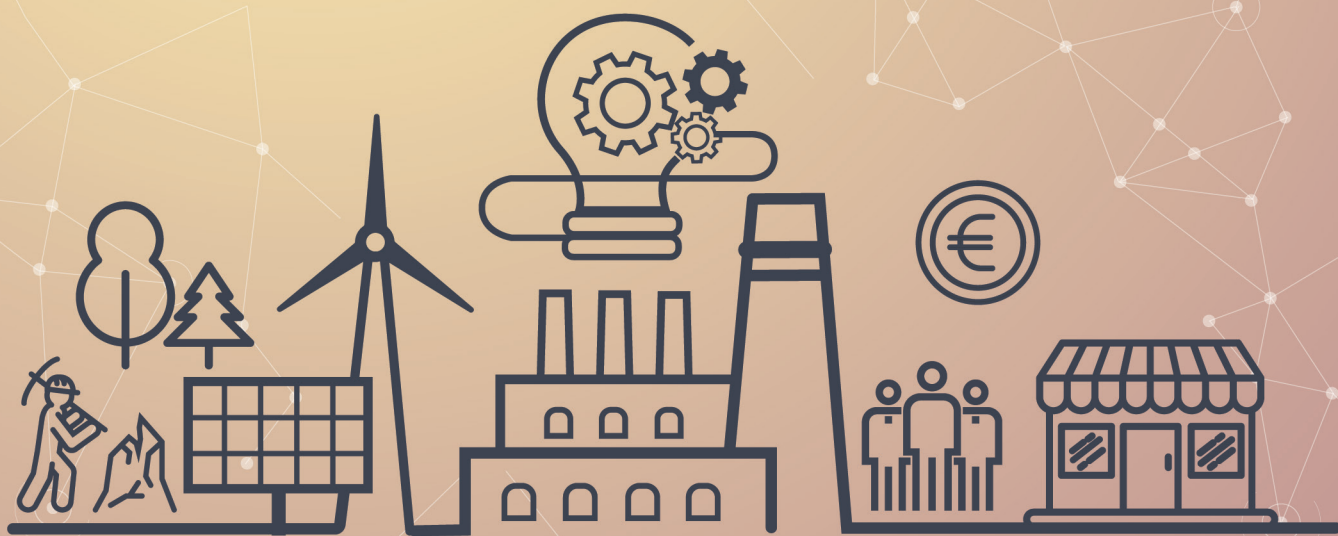


Masterplan for a Competitive
Transformation of
EU Energy-intensive Industries
Enabling a Climate-neutral,
Circular Economy by 2050



Report by the High-Level Group on Energy-intensive Industries

Disclaimer

This report reflects the work of the High Level Group on Energy Intensive Industries; the recommendations, however, do not necessarily represent the position of individual members nor the position of individual Member States or the European Commission.

About the High-level Group on Energy-intensive Industries

The Commission set up the High-level Group on Energy-Intensive Industries in October 2015, composed of Member States, industry and civil society. The group's objective is to advise and assist the Commission in the preparation of policy initiatives of relevance to energy-intensive industries.

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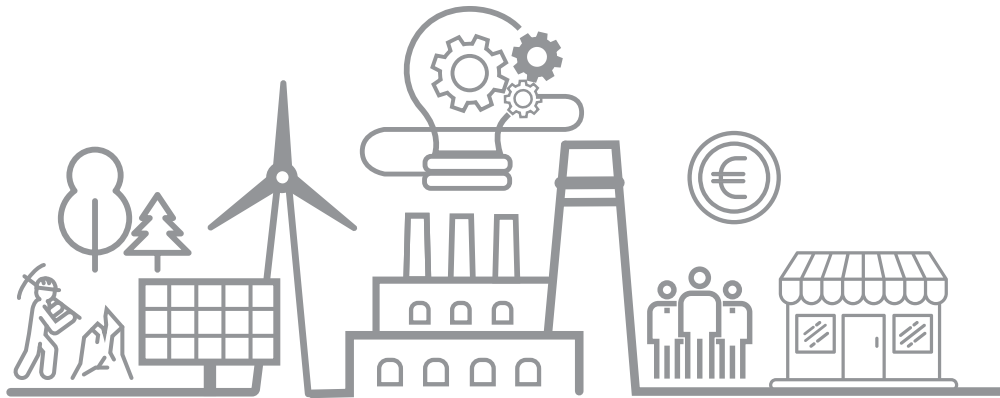
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Contents

Introduction	7
I. Creation of markets for climate-neutral, circular economy products	12
1. General principles for product and market-related measures	13
2. Long term carbon pricing issues	19
3. Social dimension	23
II. Developing climate-neutral solutions and financing their uptake	25
1. The Research and Innovation challenge: timely bringing new solutions to the market	25
2. The investment challenge: deployment of innovative solutions	34
3. The social dimension: managing the impact of industry transition on collectivities and local communities	37
III. Resources and deployment	39
1. Access to key energy and non-energy inputs	42
2. Circular Economy, resource- and energy-efficiency	49
3. Which infrastructure for 2050?	52
4. Social dimension	54

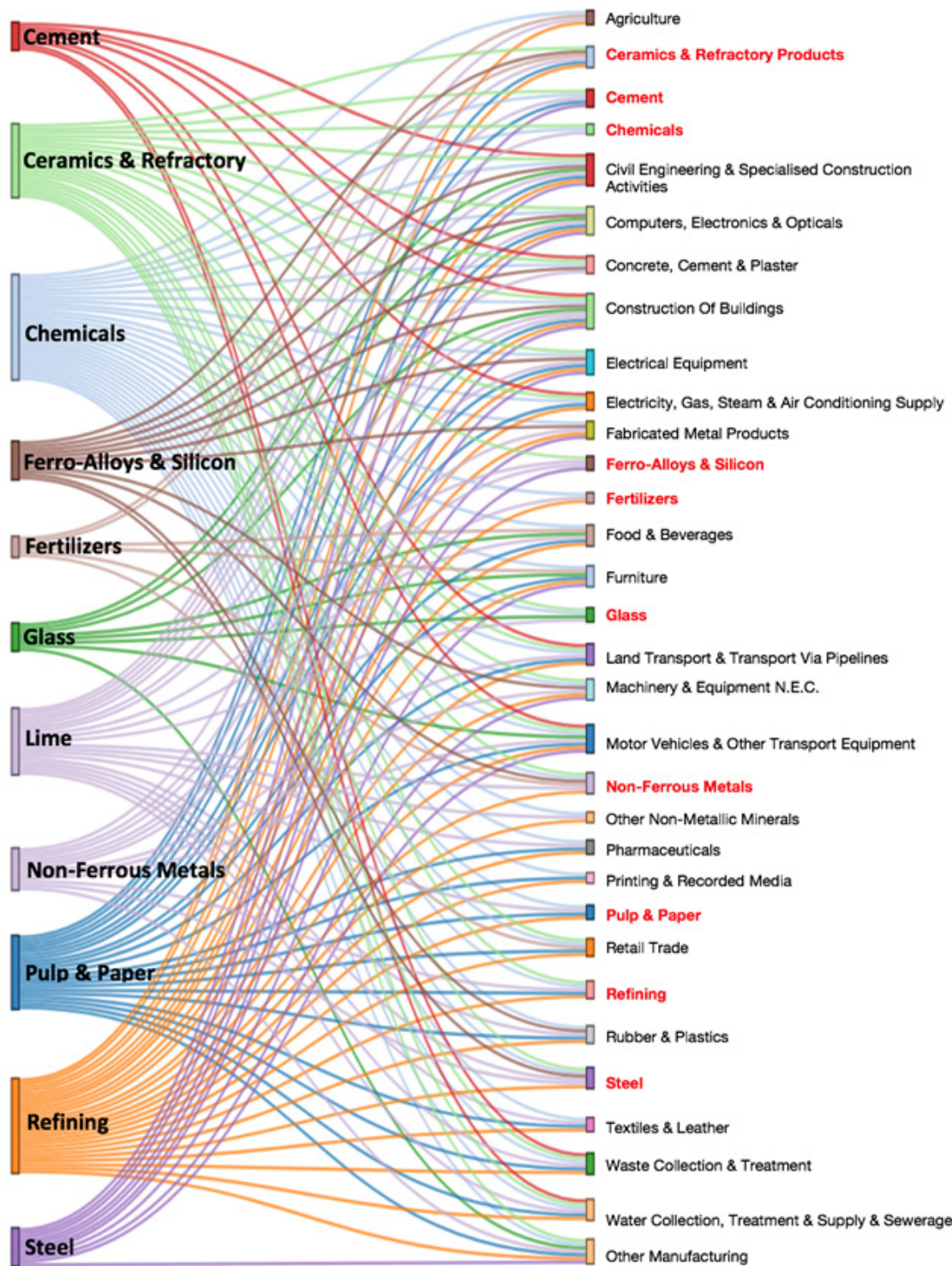


Figure: Value chain links of energy-intensive industries to other sectors in the economy and other energy-intensive industries (red). VUB-IES, Industrial Value Chain: A Bridge Towards a Carbon Neutral Europe - Europe's Energy Intensive Industries contribution to the EU Strategy for long-term EU greenhouse gas emissions reductions, 2018.

Introduction

Context

In December 2015, parties to the Paris Agreement committed jointly to keeping the global temperature increase to well below 2°C and to pursue efforts to limit temperature increase to 1.5°C above pre-industrial levels.

In November 2018, following the invitations by the European Parliament and the European Council, the European Commission presented its Strategic Vision “A Clean Planet for all”. This has contributed to an EU-wide informed debate with other institutions and stakeholders in view of adopting and submitting to the United Nations Framework Convention on Climate Change (UNFCCC) a long-term strategy by 2020, as requested under the Paris Agreement.

The Political Guidelines for the next European Commission 2019-2024 of the new Commission President-elect confirm this political commitment, proposing a “European Green Deal” that should make Europe become the first climate-neutral continent and a European Climate Law to enshrine the 2050 climate-neutrality target into law¹. The guidelines recognise that this transition should be just, leaving nobody behind. The Political Guidelines also contain several other important commitments that are relevant to energy intensive industries such as the declaration of a zero-pollution ambition and the announcement of a new European industrial strategy and a new Circular Economy Action Plan².

In March 2019, the European Council invited the Commission to present a long-term vision for the EU’s industrial future with concrete measures to implement it, addressing the challenges European industry faces, touching upon all relevant policy areas. The European Council also called for a long-term action plan for better implementation and enforcement of Single Market rules³.

The European Commission is currently preparing the response to this invitation. Several initiatives contribute to this work, including the Strategic Forum for Important Projects of Common European Interest⁴, the Industry 2030 high level industrial roundtable⁵, the Technical Expert Group on sustainable finance, the Commission assessment of the Integrated National Energy and Climate Plans, the strategic plan for Horizon Europe and the High Level Group on Energy-intensive Industries (HLG EIs).

Energy Intensive Industries (EIs) were actively involved in some of these processes. Eleven industries share the ambition of the Paris Agreement and recognise the size of the transformation challenge as well as the opportunities it brings. EI industry associations will give strong support to the development of policies to enable the transition to a climate-neutral economy by 2050, whilst keeping industry competitive.

To play an active and solution-oriented role in the European debate on Europe’s contribution the EIs participating in the High Level Group joined their forces to present a report⁶ in September 2018 as their collective contribution to the Commission’s Strategic Vision “A Clean Planet for all”. In February 2019, the High Level Group agreed to go a step further and develop an Industrial Transformation Masterplan for the implementation of EIs’ transition towards a climate-neutral and circular EU economy by 2050. The Masterplan is the result of this collective work inspired by the shared ambition of seizing the opportunities of the transition to a climate-neutral economy while addressing the challenge of a fragmented international climate action. The Masterplan is both a contribution to the new Industrial Strategy and a basis for continued collaborative work.

The Masterplan is an outcome of work of the HLG EI organised in three thematic subgroups on (1) creation of markets for climate-neutral, circular economy products, (2) developing climate-neutral solutions and financing their uptake, (3) resources and deployment. The HLG agreed that the social dimension of industrial transformation is a crosscutting issue across all subgroups. The subgroups, which in addition to EIs include representatives of the European Commission, Member States, the European Bank for Reconstruction and Development (EBRD), European Investment Bank (EIB), other relevant industrial sectors, NGOs and think tanks, met in March and June 2019. The presented Masterplan identifies strategic priorities in each of these areas.

An observatory should monitor industry’s progress towards climate-neutrality and circularity as well as the enabling framework to support the transition.

1 The Czech Republic wishes to note that it has not yet agreed to the objective of EU climate-neutrality by 2050.

2 A Union that strives for more. My agenda for Europe. Political Guidelines for the Next European Commission 2019-2024 (16 - 07 - 2019)

3 Conclusions – European Council meeting (21 and 22 March 2019). EUCO 1/19.

4 Strengthening Strategic Value Chains for a future-ready EU Industry, Report of the Strategic Forum for Important Projects of Common European Interest (2019): <https://ec.europa.eu/docsroom/documents/37824>

5 Final report “A vision for the European industry until 2030” (June 2019): <https://ec.europa.eu/docsroom/documents/36468>.

6 Vrije Universiteit Brussel (VUB) - Institute for European Studies, https://www.ies.be/files/Industrial_Value_Chain_25sept_0.pdf

Role of Energy-intensive Industries in the transition towards climate-neutrality

Ells represent the foundations of critical and strategic value chains that enable the EU economy and society, including transport, construction and power generation. Ells produce goods that enable the reducing emissions in other sectors of the economy. Ells have a strong record in reducing greenhouse gas emissions - between 1990 and 2015 they reduced emissions by 36%. This accounted for 28% of the total EU economy-wide emission reductions even though the Ells represented 15% of EU total GHG emissions (excl. LULUCF) in 2015 (18.4% in 1990)⁷. Studies have indicated that a more circular economy can make deep cuts to emissions from heavy industry.

Ells are committed to playing a proactive role in competitive industrial transformation, in cooperation with other actors across the various value chains, policy makers at EU, national and regional level, local communities and other relevant stakeholders. Today, EU Ells are already at the forefront of low-carbon solutions and have the ambition to use the opportunities of transition to climate-neutral economy to strengthen their competitive position, while addressing the challenges. The Ells have collectively identified a range of technological pathways that can deliver deep emission reductions and companies are working at concrete projects to progress further.

An industrial transformation strategy for Ells to reap the benefits and address the challenges of the transition towards climate-neutrality by 2050

Looking ahead, the overall transition of society towards climate-neutrality and a circular economy that uses resources sustainably could create new or additional business opportunities for Ells, for instance in the fields of renewables, building energy performance, digital economy, new energy systems, etc. Furthermore, a competitive transformation of EU Ells is a key element to contribute to EU worldwide leadership on climate neutral solutions and sustainability.

At the same time, such a transition needs to recognise the challenging business environment in which Ells operate, characterized by complex, often interlinked value chains, and exposure to international competition. Therefore,

a successful transformation of EU Ells is instrumental for achieving the Paris Agreement's objective. Both the environmental integrity of the EU climate policy and industrial competitiveness are important. The EU should reduce emissions at global level while avoiding carbon and investment leakage and respecting the EU's international obligations.

Digital technologies will also act as crosscutting enablers for industrial transformation. This will result in greater resource efficiency via increased automation, process control and demand-side response. Digital technologies can speed up the deployment of breakthrough processes and product innovation. Machine learning and artificial intelligence are strategic technologies for the development of new or advanced materials and catalysts. Blockchain technologies can facilitate tracking of supply chains and products' carbon footprint. They can also be an enabler for greater circularity.

The successful research, development, upscaling and deployment of technologies that will put Ells on the path towards climate-neutrality requires a fully integrated industrial strategy, underpinned by a strong governance. This will need to address the research, development and financing challenges, foster the creation of markets for climate neutral, circular economy products, and secure access to low carbon energy and non-energy sources. This industrial strategy will have to build upon the strengths of the EU industrial base to optimise existing and upcoming assets. It should be implemented through concerted efforts between Ells and all levels of decision (local/regional, national and EU) to make sure all enabling conditions are in place, allowing Ells to achieve more drastic GHG emissions reductions.

The overall objective should be to make Europe more attractive for investments in a climate-neutral and circular economy in the face of increasing global competition and the unprecedented levels of industrial investments. In particular, the demonstration of first-of-its-kind breakthrough technologies needs to accelerate in the coming decade. An enabling policy and regulatory framework, and availability of required infrastructures, should facilitate this deployment, considering the short time left until 2050.

The National Energy and Climate Plans (NECPs), as well as long-term strategies, need to include concrete actions to supplement the EU-wide strategy and create the enabling conditions for industrial transformation.

7 "Industrial Value Chain: A Bridge towards a Carbon Neutral Europe" (2018)

Enabling framework and strategic priorities

I. Creation of markets for climate-neutral, circular economy products

The large-scale deployment of breakthrough technologies by ELLs on the supply side will need significant changes to incentives and consumption patterns of industrial materials on the demand side. A supportive policy framework needs to define a proper mix of pull and push measures that shape new business models and create markets for climate-neutral, circular economy products. Such measures need to take into account firstly, the environmental footprint including GHG over the full life cycle – beyond manufacturing (cradle to cradle) and secondly, a level playing field with third countries' producers. Product information, including product labelling, can be a useful tool to empower consumers, from simple awareness to active involvement.

At least in a transition phase until the new products and solutions reach a sufficient level of maturity and become cost competitive, there would be a need for demand-side instruments including financial support and normative measures. Considering its relevance in total EU consumption, public procurement can play an important role in accelerating the market creation, in particular in sectors like construction, transport, energy and telecommunications. Supply-side measures can also promote the creation of lead markets for low carbon products, notably through the demonstration of first-of-a-kind breakthrough technologies, support for early deployment such as Important Projects of Common European Interest (State Aid) or instruments to bridge the initial cost gap between conventional and low-carbon products. Once innovative technologies and solutions are developed and reach a sufficient market penetration, standards may support their further market uptake and consolidation against conventional solutions.

A balanced combination of offensive and defensive trade strategies should accompany this process in order to create reciprocal market access and maximise the benefits for EU's economy and society.

Carbon pricing instruments are relevant tools to provide investment signals and support the creation of the markets that are necessary for the long-term climate objectives. At the same time, for as long as there is a fragmented international climate action, carbon pricing mechanisms need to take into account their possible impact on global emissions and investments at EU level in order to ensure that they deliver emission reductions globally and promote the competitiveness of EU ELLs. This report explores possible options for carbon pricing mechanisms as well as relevant criteria for assessment. In order to provide regulatory visibility for future investments, a timely and inclusive assessment of such options is required.

The Masterplan identifies the following strategic priorities:

- **Fostering demand for and competitiveness of climate neutral, circular economy solutions through demand-side measures;**
- **Investigating and developing alternative or complementary options for carbon pricing mechanisms considering their impact on emissions, markets and investments, both at EU and international level;**
- **Empowering customers and consumers in transition to climate-neutrality.**

II. Developing climate-neutral solutions and financing their uptake

Ells have identified several technology pathways that could enable deep emissions reductions and companies are working at concrete projects to implement them. Considering the additional time required for their uptake and deployment, it is essential to test the most promising technologies at industrial scale as soon as possible in the coming decade.

These solutions entail high technology risks, very large capital requirements and often higher operating costs than conventional technologies. Furthermore, major brownfield conversions of existing sites will be required, which will be frequently more expensive than greenfield. Finally, the accelerated transition may lead to dismantling and rebuilding assets that, even if fully depreciated, still guarantee returns on investments.

In order to face successfully these unprecedented financing challenges, it is essential to ensure a consistent and coordinated framework of the funding opportunities at EU, national and regional level, to attract private investment and to use taxation policy to support the implementation of low-emission solutions. Different EU funding programmes and instruments, including Horizon Europe, the Innovation Fund, the Connecting Europe Facility, and InvestEU should optimise their synergies and complementarities.

In June 2019, under the Commission's Action Plan on Financing Sustainable Growth⁸, the Technical Expert Group proposed a set of economic activities in seven key sectors that can substantially contribute to climate change mitigation. This is an important first step towards establishing an EU-wide taxonomy for environmentally sustainable activities to facilitate green investments. It aims to deliver guidance for financial institutions to assess the performance of their investment portfolios in terms of potential for mitigating GHG emissions and identify green investment opportunities. This initial work will

be continued and expanded to other activities in other sectors and other environmental areas by a permanent platform from 2020 onwards.

Supportive state aid rules should help mobilise also national resources and allow for accelerated depreciation of the new assets, while de-risking instruments could facilitate access to private capital at competitive conditions.

The Ells are committed to pursue developing climate-neutral solutions towards uptake and deployment.

The Masterplan identifies the following strategic priorities that will enable the Ells to deliver on this ambition:

- **Developing industrial demonstrators of key breakthrough technologies by 2030;**
- **Establishing major R&D&I programmes across all technological readiness levels (TRL), with a focus on bringing solutions closer to the market, and achieving better integration with national programmes, properly supported by coherent state aid rules;**
- **Facilitating access to private capital at affordable cost, including through de-risking instruments.**

8 https://ec.europa.eu/info/publications/180308-action-plan-sustainable-growth_en

III. Access to resources and deployment

In order to abate their emissions, EIs will have to go through a profound transformation, including the switching to alternative climate-neutral energy and feedstock sources. Securing access to and availability of such sources at globally competitive prices is essential for the successful transformation of EIs. As a general principle, the energy efficiency first principle should apply.

Firstly, the transition of EIs and the energy sector requires a cross-sectoral approach, since EIs will require exponentially higher quantities of climate-neutral energy, including electricity and gas (e.g. hydrogen). Secondly, secure and sustainable supplies of alternative feedstocks such as biomass, waste, and other materials, especially critical raw materials, will be essential inputs to reduce significantly emissions in EIs.

This process needs a supportive legal framework allowing the transition at globally competitive conditions and a timely development of adequate infrastructure, notably in the fields of electricity, gas/hydrogen, CO₂ transport and storage, resource management (incl. waste and secondary raw materials). EIs need an integrated, digitalised and expanded infrastructure to transform the economy, including cross-sector, cross-border and regional co-operation. This means developing sector integration, a strategic and integrated long-term infrastructure plan, as well as reviewing infrastructure policies and related EU funding instruments to ensure that they support decarbonisation and competitiveness objectives.

In this context, increased circularity of materials becomes ever more important to reduce emissions, optimise raw materials' use and contribute to security of supply. Cooperation between sectors across borders in an industrial symbiosis model is already strong. It will increase in the future, reaping the benefits of digitization tools. This process will lead to new business models, new technologies and industrial eco-systems that may further optimise resource and energy efficiency.

The Masterplan identifies the following strategic priorities:

- **Ensuring access and availability of climate-neutral energy at globally competitive prices;**
- **Ensuring access to alternative feedstock sources, by promoting use of renewable and (carbon-based) recyclables beyond energy production;**
- **Mapping of energy and non-energy infrastructure and supply, underpinned by technologies for industrial transformation in support of climate-neutral industry**

The Masterplan for a competitive transformation of EIs needs to embed a strong social dimension, which encompasses several perspectives, such as workers, customers, and citizens in general.

While a successful transition holds the potential to retain the existing workforce, abrupt disruptions in the manufacturing processes may affect employment locally with important consequences at regional level. A smooth transition will require a well-designed transfer of competences and adaptation to new skills. Distributional impacts of adopted measures should be balanced and will need monitoring in order to secure social cohesion. Cohesion Policy funds play a crucial role in supporting regions to keep up with these transformations. Cooperation at local, national and EU level will contribute to public acceptance for breakthrough technologies and related infrastructure investments. Consumer awareness will be instrumental to better-informed choices and behavioural changes.

I. Creation of markets for climate-neutral, circular economy products

Strategic priorities

- **Fostering demand for and competitiveness of climate neutral, circular economy solutions through demand-side measures;**
- **Investigating and developing alternative or complementary options for carbon pricing mechanisms considering their impact on emissions, markets, and investments both at EU and international level;**
- **Empowering customers and consumers in transition to climate neutrality**

European energy-intensive industries (EIs) are at the start of long value chains that provide products and materials including those that are essential contributors to the climate-neutral transition. EIs have already contributed to decreasing GHG emissions in the European Union (EU) in the past few decades. Between 1990 and 2015, the EIs have reduced their greenhouse gas emissions by 36% and accounted for 28% of the total economy-wide emission reductions by the EU even though they represented only 15% of EU total GHG emissions (excl. LULUCF) in 2015 (18.4% in 1990)⁹.

In order to reduce further (process) emissions of these industries that are unavoidable with the current production technologies and processes, some industrial and manufacturing processes will have to be adapted or redesigned and competitive solutions need to be widely deployed. Sections 2 and 3 address the challenges of this transition in terms of R&I and access to energy and raw materials.

It is clear, however, that large-scale development of breakthrough technology on the supply side will need complementing by significant changes to incentives and consumption behaviour of industrial materials on the demand side.

Indeed, when it comes to the creation of markets for climate-neutral and circular economy products, this section discusses possible supportive product and market-related policies as well as the options for carbon pricing mechanisms. These measures need to take into account the business environment in which EIs operate, which is characterized by complex value chains, often interlinked and exposed to international competition.

Furthermore, they need to consider products' footprint over their entire production, use and end-of-life phases across the value chains.

The EU needs a robust route of transformation clearly differentiating no-regret measures and points-of-no-return, prioritising measures accordingly. In an analysis prepared as the contribution to the European Commission Communication "A Clean Planet for All"¹⁰, EIs identified a number of opportunities and enabling framework conditions to facilitate their transformation¹¹.

A supportive and stable policy framework needs to define a proper mix of pull and push measures that promote the transition to a low carbon economy through breakthrough technologies as well as climate-neutral and circular solutions while preserving the global competitiveness of EU industry. While taking into account the relevant differences with EIs such as availability of low carbon technologies and exposure to international competition, the experience of the power sector to transition to renewable energy in the last decades indicates that a combination of push and pull policies can support the deployment of alternative solutions.

A successful and competitive transformation of EIs will also be a key element to contribute to EU leadership on climate-neutral technologies, which can lead to new growth opportunities in overseas markets. At the same time, the overall transition of society towards climate-neutrality could create new or additional business opportunities for EIs, for instance in the fields of renewables, low carbon industrial products, building performance, digital economy, new energy systems, low carbon technologies etc.

In order to ensure a smooth and progressive transition towards climate neutrality, it is essential that the chosen

9 "Industrial Value Chain: A Bridge towards a Carbon Neutral Europe" (2018)

10 European Commission Communication "A Clean Planet for all", COM (2018) 773 final

11 "Industrial Value Chain: A Bridge towards a Carbon Neutral Europe" (2018)

policy mix promote innovative climate-neutral and circular solutions while not disregarding both existing products and system benefits related to customers and the global competitiveness of EU energy-intensive industries at each step of the transition, notably:

- In the short term, when production processes are still largely based on existing technologies while breakthrough technologies are being developed and tested at large scale;
- In the medium term, when upscaling breakthrough technologies and launching innovative products, but these still require heavy investments and represent a minor share of the overall production;
- In the long term, when breakthrough technologies are widely deployed and innovative products achieve deep market penetration, in and beyond the EU.

1. General principles for product and market-related measures

Already today, the energy-intensive industries provide the EU market with products and materials of outstanding performance that are often key enablers for the transition to the climate-neutral economy. As the manufacturing process leading up to these products and materials is often energy- and CO₂-intensive, there is indeed a challenge for the EU to reduce its manufacturing emissions. A wide range of research and innovation projects is underway in all ELLs to address that challenge and many of these innovation initiatives require a joint approach such as industrial symbiosis.

In addition to reduce emissions in the manufacturing phase, there is an opportunity to reduce emissions in the downstream operations of the energy-intensive industries. Changes in the composition and use of the products or absorption of CO₂ by materials (e.g. carbonation in construction products) contribute to emission reductions. Sound policies that acknowledge and assess the CO₂ footprint along the value chain and over the life cycle (including end-of-life) of the product can guide these opportunities. As stated above, the CO₂ footprint of a product does not necessarily end when placing the product on the market. It goes beyond that phase in that:

- The full CO₂ saving potential is often only achievable in a specific setting or installation, and if measured over the lifetime, taking into account end-of-life treatment.
- CO₂ emissions are avoided or absorbed when the manufactured product is in use. The durability of products should be taken into account.
- CO₂ emissions are also avoided when using alternative feedstock (waste, bio-based materials, by-products, CO₂) and alternative low energy carriers (biogas, H₂, etc.).

Therefore, ELLs need a supportive and stable policy framework to ensure a successful transition towards a climate-neutral and more circular economy. The ELLs have been encouraged by the strong emphasis on life-cycle thinking in a recent Communication of the European Commission¹², which assesses the potential for further contribution to the circular economy by a set of identified priority sectors and products. The ELLs are keen to engage with the Commission to assess regulatory barriers that could be removed, regulatory gaps that could be filled and to unleash the opportunities that were identified by ELLs to facilitate their transformation. We look forward to assessing how the relevant pieces of legislation will address the principles and solutions identified by ELLs to:

- Provide a level playing field between European and foreign producers on import and export markets;
- Create market incentives for climate-neutral and circular economy products and production processes with low GHG footprint and solutions using an entire value chain approach;
- Influence market demand and consumer awareness.

A facilitating regulatory framework for bringing products with low GHG footprint to the market can be found in rules on public procurement, labelling or in standardization efforts. In each of these regulatory initiatives, it is essential to understand what “product” means: the CO₂ performance does not stop when placing the product on the market, it extends to its use and its treatment at the end of life. The development of a life-cycle assessment that provides a fair treatment for all materials equally is a necessary precondition for the development of further regulatory measures.

¹² Commission Staff Working Document – Sustainable Products in a Circular Economy. Towards an EU Policy Framework Contributing to the Circular Economy, 4 March 2019, SWD(2019), 91final

In this context, the collection of data from the industries plays an essential role. While it is correct that previous attempts for an industry-wide accepted LCA methodology have not been successful, there is now clearly a sense of urgency with policymakers and industry alike that spurs initiatives such as “Building Levels” which assesses CO₂ performance over the life-cycle and across different materials as part of the built environment. There is no doubt about the need for a transparent and robust accounting methodology throughout the value chain and product life cycles, which empowers consumers to make informed choices.

Supporting cost competitiveness of climate neutral and circular economy solutions

Solving the challenges related to R&I, investment, and access to energy and non-energy inputs (addressed in sections 2 and 3) is a necessary condition to facilitate the development, upscaling and deployment of breakthrough technologies. Nonetheless, it is not sufficient for a successful transformation of EIs if the market conditions needed to create a business case for the climate- neutral and circular solutions are missing.

Materials produced with breakthrough technologies may be more expensive than the ones produced with conventional processes, at least in a transition phase until the new technologies reach a sufficient level of maturity and become cost competitive. This will require investigating and developing incentives that foster the uptake and cost competitiveness of innovative products. This may include financial support to help new technologies reach a higher level of maturity, measures to incentivise consumers to secure sufficient demand for the innovative products, or measures to disincentivise unsustainable processes.

Furthermore, the market creation needs a policy framework that values and rewards new business models that allow the development of climate-neutral and circular solutions. Section 3 of this paper addresses the relevant legislation that concerns access to energy and non-energy inputs that are necessary for such business models.

Market uptake is one of the most important challenges for bringing low carbon products to the market and requires a mix of consumer awareness measures, driven digitization initiatives and regulatory push and pull

measures. In addition, these products will need to be accessible at an affordable price. Recommended actions appear below.

The European Commission

- *Update the 2015 Circular Economy Action Plan and assess potential follow-up actions based on recent initiatives by the European Commission to foster the circular economy potential;*
- *Investigate and develop framework demand- and supply-side conditions (including in the field of state aid) that allow supporting the cost competitiveness of climate neutral, circular economy solutions*
- *Monitor market penetration over time of low-carbon, carbon-neutral and circular products, including imports, with a view to developing corrective measures if necessary*

Member States

- *Support use of materials that allow climate neutral and circular solutions, including adaptation to climate change, based on GHG footprint of their full life-cycle*
- *Establish frameworks and standardised databases to collect data related to material use and properties*
- *Develop national guidelines for best practice material use*

Energy-intensive industries

- *Enhance collaboration with the value chain and government partners*
- *Support identification of circular and low-carbon techniques with low other environmental impacts*

Public procurement and standards supporting market creation

Public procurement accounts for a large proportion of European consumption (nearly 15% of EU GDP)¹³, in particular in sectors like construction, energy and telecommunications. It can, therefore, play a key role in creating markets for climate-neutral and circular products in such sectors. The further use of procurement could help in developing green value chains. Valuable experience exists with procurement approaches by public institutions, combined with companies

13 Green Public Procurement and the EU Action Plan for the Circular Economy (2017) Directorate General for Internal Policies, European Parliament

requesting (minimum) carbon certification levels along their production chain and when subcontracting (CO₂ performance ladder system).

When setting out criteria for the assessment of a product, system or service, the methodology should shift from the “value-for-money” to the “value-for-money assessment across the entire life-cycle of an asset”. The European Commission has also recognized the need for a life-cycle approach and scientific evidence base. This approach could be a default methodology, with a proper justification required if not applied. It is essential to stress aspects relevant to the circular economy, such as durability, reparability, recyclability and functionality, and climate neutrality, taking into account the appropriate life cycle based approach.

In addition to public procurement, corporate procurement as well as due diligence systems for sustainability may also be useful tools for the creation of new markets.

Improved data and life-cycle insights will be important in developing benchmarks, understanding best practices, facilitating optimal decisions in the design stages that consider the life-cycle impact and developing programmes that incentivise material efficiency¹⁴. Therefore, tracking and reporting of material use data should be improved, particularly via nationally or internationally standardised databases that are publicly accessible (subject to necessary conditions to address data privacy concerns) and of high quality. This could come in support of a life-cycle based approach at the design stage¹⁵.

A performance-based approach could promote efficient resource use by the EILs. This would require the assessment of resource efficiency potential already in the early stages of design. The proposed approach, which could be based on an agreed procedure for an appropriate life-cycle assessment, would need to be harmonised in Europe and apply to all products and structures (e.g. buildings) sold on the EU market to enable the integration of sustainability criteria into the design process.

Once innovative technologies and solutions are developed and reach a sufficient market penetration, standards may support their further market uptake and consolidation against conventional solutions, for example by exploring the setting of ecodesign requirements for

non-energy-related products. The Sustainable Product Policy will also contribute to this aim, progressively implementing a single systemic, integrated, approach based on the entire life cycle of the product, service or organization to define and monitor sustainability.

Moving from prescriptive to performance-based standards (including design, health, and safety) taking the full life-cycle of products into consideration would open the possibility to various use of materials efficiently while still ensuring their intended objectives are achieved. As checking compliance will be more complex for performance-based requirements than prescriptive requirements, coordination along value chains will be needed to develop and implement testing procedures and downstream due diligence requirements¹⁶.

The European Commission

- *Develop harmonised measures, in particular in the design stages (design for long lifespans, repurposing, reuse, and recycling), to promote climate-neutral, circular products, based on a life-cycle approach, including trade-offs between production and use-phase emissions. Where possible this should include relevant reporting systems, with metrics and indicators.*

Member States

- *Revise the public procurement criteria taking into account the introduction of a harmonised appropriate life-cycle based approach set of principles*
- *Consider a transition to life-cycle-based regulations for supply chains*

Energy-intensive industries

- *Assess solutions to improve the track and report material use data as a basis for an appropriate life-cycle based approach*
- *Normalise resource efficiency considerations in business practices*
- *Participate in incentive and green certification programmes*
- *Provide training to employees*
- *Share best practices and guidance among fellow industry participants, including through professional bodies and associations*

14 International Energy Agency (IEA): Material efficiency in clean energy transitions

15 International Energy Agency (IEA): Material efficiency in clean energy transitions

16 Wyns et. al., (2019), Industrial Transformation 2050 – Towards an Industrial Strategy for a Climate Neutral Europe, IES.

Empowering customers and consumers

Consumers need transparent information about product performance. Even though most of the products that EIs place on the market pass through intermediaries before reaching final consumers, the consumer policy framework should set stronger incentives to support the shift to climate-neutral and circular solutions. Product information, including product labelling, can be a useful tool to empower consumers, from simple awareness to active involvement. This might also increase acceptance of paying a higher price for products that have a lower carbon footprint and for measures increasing the price of products with a higher footprint, including imported products. Sustainability claims should be well substantiated and verifiable, which may require improving the rules on product claims and their enforcement.

The carbon footprint of marketed products, where appropriate, should use harmonised methodologies based on the appropriate life-cycle based approach. In particular, this approach has to take into account all the stages of the products' life beyond manufacturing. Lack of unified methodologies could lead to footprint-based market distortions. In addition, EU regulations and footprint assessing methods should apply equally to imported products. Otherwise, the absence of global level playing field will distort the market.

Policy makers should consider impact indicators widely accepted by both industry and scientific communities when developing and adopting methodologies for products. In addition, such methodologies for product assessment have to be peer-reviewed. Last, but not least, particular attention should be paid to the quality of environmental data used for the assessment. The development of harmonized methodologies for determining the carbon footprint should also take into account the feasibility of using them at international level, including for imported materials.

Digital technologies will naturally lead to a further integration of supply chains and shorten the link between manufacturer and end consumer. Transparency of supply chains will increase through the application of blockchain technology that allows tracing of products in every part of the supply chain. A carefully designed communication strategy about material streams and production processes may also contribute to influence consumers' awareness and behaviour.

The European Commission

- *Update the 2015 Circular Economy Action Plan*
- *Introduce measures to assess products based on the appropriate and standardised life-cycle approach*

Member States

- *Encourage and incentivise the adoption of circular, climate-neutral and resource efficient principles by designers, manufacturers and construction companies on the basis of a harmonised EU system*

Energy-intensive industries

- *Develop business models that optimise the use of materials*
- *Cooperate with the relevant actors of the value chains to develop technological solutions (e.g. tracking of substances in products) and design products that help achieve a higher circularity of materials*

Exploring the potential of intellectual property to foster innovation

Safeguarding intellectual property rights incentivises industry to continue investing in research and development of new solutions. Protection of intellectual property, therefore, needs to be an integral part of efforts to foster innovation.

In the European Union, impact assessments of new regulatory proposals are already mandatory and take into consideration the promotion of greater productivity and resource efficiency, as well as their impacts on R&D and on intellectual property rights. Nevertheless, Member States should make sure that any investment frameworks for climate neutral investment are safeguarding intellectual property and protection of technologies¹⁷. In addition, European legislators have to protect the patents and innovative processes via intellectual property tools. The disclosure requirements linked to EU funding should also be adapted accordingly.

¹⁷ Meeting of the OECD Council at Ministerial Level (2015) OECD

European Commission/Member States

- *Safeguard intellectual property of low carbon innovation technologies, processes, and materials*

Energy-intensive industries

- *Continue exploring and implementing low carbon innovation technologies, processes and materials*

Because of their value chains deeply embedded in the “real economy”, European EIs have shown significant vulnerability to global economic disruptive events. When faced with the deep transformation required by the climate-neutrality goal, the challenge for EIs is not only to avoid investment leakage out of the EU but also to increase the current level of EU investments towards the deployment of low-CO₂ technologies¹⁸. Such a level of investment is only achievable when companies return to reasonable levels of profitability and have comparable regulatory costs to those incurred by their competitors in third countries.

Trade defence instruments can address subsidies that affect the price of products imported into the EU. However, these instruments do not cover all potential effects of unfair subsidies or support by third countries¹⁹ and are subject to lengthy and complex procedures. In addition, there are proof burdens that are very difficult to meet in order to have these procedures initiated, especially in relation to support from governments, which are not complying with their WTO subsidies notification obligation.

As indicated in the political guidelines of the President-elect of the next European Commission 2019-2024, it is important that the EU lead the efforts on updating and reforming the WTO, also in view of reconciling the climate and trade agendas.

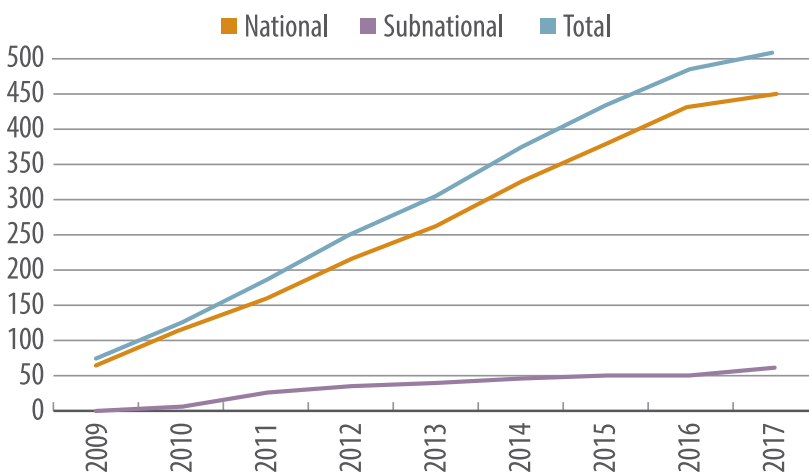
Furthermore, the European Commission needs to identify how the EU could appropriately deal with the distortive

Combining defensive and offensive international strategies

The legal framework for products should bridge the current situation with the development of future markets without creating distortions or competitive disadvantages. During the transition, continued support for EIs should safeguard competitiveness and investments in Europe. This process requires a smart combination of offensive and defensive market creation strategies in order to maximise the benefits for EU’s economy and society. Recent experiences in other sectors, such as photovoltaics, testify the need for such a balanced approach.

Throughout the transition, all elements contributing to an unlevelled playing field for EU industry need tackling, including EU unilateral regulatory costs, unfair trade practices by third countries’ competitors, and foreign state ownership of companies within the EU in strategic sectors and/or at non market-based conditions.

Figure: Discriminatory public procurement measures by level of implementation



Source: GTA database (2017). Total reflects the sum of measures at national and subnational level.

18 “Industrial Value Chain: A Bridge towards a Carbon Neutral Europe” (2018)

19 Communication of the European Commission “EU-China – A strategic outlook”: https://ec.europa.eu/commission/publications/eu-china-strategic-outlook-commission-contribution-european-council-21-22-march-2019_en

effects of non-market-based foreign state ownership and state financing of foreign companies on the EU internal market. To this end, the European Commission and the High Representative invited the European Council to address fully such distortive effects. The European Commission is to identify before the end of 2019 how to fill existing gaps in EU law.

The Ells support the actions suggested by the European Commission's in-house think tank, the European Political Strategy Centre (EPSC). It suggested developing offensive trade strategies. To create reciprocal market access and building up leverage²⁰, the European Commission should launch a wide-ranging mapping exercise covering all its tools and policies – e.g. access to the Single Market, development aid and free trade agreements among others. This should identify other areas that could create further leverage in levelling the playing field, while staying true to EU and international laws and values.

In addition, public procurement as a hidden trade barrier is another area for improvement identified by the EPSC. There has been a steady increase in the number of discriminatory procurement measures globally over the years. EU Member States (see Figure 1) are among the most affected. Initiatives in the pipeline such as the International Procurement Instrument could offer additional impetus by providing the EU with greater leverage to level the playing field.

The European Commission

- *Use all relevant tools (e.g. international procurement rules, access to the Single Market, development aid, Free Trade Agreements) to create reciprocal market access*
- *Apply effective trade defense instruments in case of unfair trade practices*
- *Identify and tackle the distortive effects of foreign state ownership and state financing of foreign companies on the EU internal market*
- *Monitor and tackle the impact of unilateral regulatory costs affecting the competitiveness of Ells*

Energy-intensive industries

- *Continue exploiting the market opportunities offered by the global value chains*
- *Contribute to business cooperation at international level*

Transparent and harmonised GHG accounting framework for CO₂ emission avoidance

The utilisation of CO₂ as carbon feedstock is known in the Ells while still requiring significant R&I efforts and large quantity of affordable low carbon electricity (section 3). Interest in CCU has grown over the past years across different sectors. CO₂ can be an alternative source of carbon for the production of a wide range of chemicals and e-fuels in gaseous or liquid form. CO₂ utilisation through the carbonation of solid raw materials or concrete curing to valorise CO₂ is advancing²¹.

Reuse of CO₂ makes economic and technological evolutions of the GHG flows more complex. This is why transparent and harmonised accounting rules should effectively reflect real CO₂ emissions of the new industrial processes. In addition, these accounting rules should enable addressing the transport of carbon embodied in materials across borders.

Pursuing the pathway towards climate neutral economy will require a systematic structural recognition of emission avoidance in the production of CO₂-derived products.

The recognition of the mitigation impact resulting from utilisation of alternative carbon source through chemical valorisation of CO₂ or chemical recycling of waste requires an appropriate evaluation based on avoided CO₂ emissions.

The European Commission

- *Define clear monitoring and transparent accounting rules for the utilisation of CO₂ and waste as an alternative carbon source*
- *Ensure carbon-neutral solutions do not come at the expense of other environmental objectives*

Key Performance indicators to assess product and market related measures

- market share of climate-neutral/circular economy solutions in public procurement
- discriminatory public procurement measures applied by third countries, including on climate neutral/circular economy solutions
- number of IPs on breakthrough technologies
- measures addressing trade distortive practices, including on climate neutral/circular economy solutions

20 European Political Strategy Centre (EPSC): EU Industrial Policy After Siemens-Alstom https://ec.europa.eu/epsc/publications/other-publications/eu-industrial-policy-after-siemens-alstom_en

21 "Industrial Value Chain: A Bridge towards a Carbon Neutral Europe" (2018) VUB-IES

2. Long term carbon pricing issues

The European Emissions Trading System (ETS), as adopted and last amended by Directive 2018/410 of 14 March 2018, is the primary instrument of the EU climate policy for emission reductions. The detailed rules on free allocation, auctioning and indirect costs compensation governing the next trading period of the EU ETS (2021–2030) are currently being discussed and implemented.

Because of the measures adopted, carbon prices have already increased significantly in the last year, reaching around 25 €/t. To drive innovation, safeguard investments in EU EITs, and allow for the necessary emission reductions in EIT sectors, carbon price exposure needs flanking measures that maintain a level playing field and thereby protect the global competitiveness of European industry. Currently the free allocation under the EU ETS contributes to this objective.

EU institutions and relevant stakeholders need to reflect on an appropriate regulatory framework that allows climate-neutral investments to be made against a globally competitive rate of return. Considering the long-term emission reduction objectives, it is clear that incremental change is not sufficient and there is the need to accelerate the uptake of disruptive solutions. This reflection will include the possible continuation or enhancement of the carbon-leakage risk mitigation system, but may also go beyond and include the assessment of potential alternative and complementary regulatory mechanisms taking into account the criteria presented in this paper. Any alternative or complementary measures need to be analysed well in advance to provide regulatory stability for future investments as well as consistency with climate neutrality objectives.

Existing carbon pricing framework

The European Emissions Trading System established by the ETS Directive (2003/87/EC) and further amended, sets out rules for the ETS phases. To achieve the EU's overall greenhouse gas emissions reduction target for 2030, the sectors covered by the ETS must reduce their emissions

during phase 4 (2021-2030) by 43% compared to 2005 levels. Since 2012, the system also applies to the aviation sector.

The ETS is an EU-wide “cap and trade” scheme, in which there is a fixed annual number (the cap) of emission allowances, which can be traded among GHG emitters from different sectors (power generation, industry, aviation). One EU allowance gives its owner the right to emit one tonne of CO₂ or equivalent. It covers emissions of CO₂, nitrous oxide (N₂O) and perfluorocarbons (PFCs). It applies to more than 11,000 power stations and industrial installations in the 28 EU Member States as well as Iceland, Liechtenstein, and Norway, thereby accounting for around 40% of GHG emissions in these 31 countries²².

This cap decreases each year by a linear reduction factor. In phase 4, the cap on emissions will be subject to an annual linear reduction factor of 2.2%.

The system provides for the protection of industries classified at significant risk of carbon leakage through free allocation based on benchmarks reflecting the average best 10% installations as a starting point. The European Commission establishes a list of industries that are at risk of carbon leakage, while other industries receive a lower share of the required allowances free.

The ETS Directive gives Member States the possibility to compensate partially the sectors significantly exposed to carbon leakage due to indirect ETS costs on the power price, through national state aid schemes. If a drive to further electrification of industry is the goal, compensation for indirect ETS costs will still be needed.

Investigating carbon pricing mechanisms and their impact on investments in innovative technologies

European climate policy incentivises companies to work further on emission reductions if part of a comprehensive and effective industrial strategy. Carbon pricing is an essential tool to promote emissions reductions and to provide investment signals and the pass through of carbon costs support creation of markets that are

22 Post-2020 reform of the EU Emissions Trading System (2018) European Parliament

necessary for the long-term climate objectives. At the same time, it needs to take into account the specificities and the business environment of EU EIs.

Regulatory stability should be an integral part of the overall industrial policy, ensuring that companies can benefit from innovative investments. Any significant changes to the existing framework should account for any necessary transition period. Better knowledge of barriers to implementing economically beneficial measures would also trigger the demand-response potential of consumers.

Limitations of the existing rules

While a cap and trade mechanism such as the EU ETS provides legal certainty on the achievement of an agreed emissions reduction target set on domestic emissions, there needs to be a debate around carbon pricing mechanisms.

As CO₂ streams and value chains grow into greater complexity, some limitations of the current ETS legislation become apparent. The monitoring and reporting of emissions at the manufacturing stage fail to capture emissions from cross-sectoral technologies (e.g. recycling of CO₂) and more generally emissions along the value chain.

Drawing on the current experience (in EIs but also in the power sector), it also appears that there is a structural difficulty to foster investments in low carbon technologies through the ETS without any supporting complementary policies. The Innovation Fund mechanism established under the revised ETS Directive will help in that perspective.

In the medium- to long-term, it can be expected that a system that is focusing purely on the emissions from manufacturing of energy-intensive products but not recognising the emissions that are effectively consumed in the EU through imported goods and services might result in leakage of emissions and industrial investment.

In addition, a linear trajectory covering only emissions from production in the EU has a very limited impact on worldwide emissions. To date, none of the major CO₂ emitters around the world has adopted a mechanism

of similar scale that imposes a comparable burden on their local industry, although a growing number of constituencies are considering implementing various types of carbon pricing mechanisms. An economy-wide carbon price applied at global level that allows for giving a cost to carbon in a reliable and transparent manner would be desirable. However, it seems to be an unrealistic option in the near future.

Concerns have been raised over the application of the same unilateral policy measure (though mitigated by the carbon leakage measures) to sectors (power and industry) with very different market characteristics, exposure to international competition and abatement potential. This leads to a possibly different reaction to the carbon price signal within the sectors covered. In this context, the effectiveness of these carbon leakage provisions will have to be monitored and ensured in the medium/long term.

The current legal framework allows for (partial) direct and indirect cost compensation for several EIs. However, the compensation system for the indirect costs of the EU ETS needs to be adapted to be in line with the revised ETS Directive and market developments. The compensation for the indirect costs of the EU ETS is, for the time being, partial, voluntary, short-term and declining. The voluntary nature of the compensation means that the Member States may choose not to implement such support. The transition of EIs towards climate-neutrality via electrification will entail a shift from direct to indirect emissions, while at the same time electricity will be increasingly decarbonised. The consequences in terms of indirect costs and carbon leakage will require further investigation.

Criteria for assessing the policy options

Given the limitations of the existing policy framework, complementary and/or alternative policy options to carbon pricing should be considered. In order to assess alternative and/or complementary carbon pricing mechanisms from a long-term perspective, a complete set of analytical criteria should apply. As mentioned above,

this assessment is required well in advance to provide regulatory stability for future investments. The following criteria are proposed for policy-makers' consideration:

- Delivering the EU climate targets while mitigating carbon leakage risk – assess to what extent a proposed measure ensures the overall effectiveness of meeting the domestic GHG emission reduction targets against the risk of leakage of emissions, thus possibly resulting in higher global emissions, while taking into account the abatement potential of sectors and the requirements of the Paris agreement
- Reflecting the value chain approach and appropriate full life-cycle approach – examine whether a mechanism takes into account the complexity of CO₂ emissions and reuse in industry
- Preserving international competitiveness – ensure that a long-term policy safeguards the European energy-intensive industries throughout the climate neutral transition and beyond, as long as there are no equivalent measures developed in the jurisdictions of key competitors, where all sectors are faced with comparable costs
- Reflecting levels of performance within the sectors while taking into account the complexity of technological transformation within EIs – measures need to balance the need for rewarding first movers while addressing the fact that breakthrough technological transformation is more complex than incremental process optimization and will require a transition phase
- Boosting consumer acceptance and awareness – the rationale behind any proposed policy should be easily understandable and its overall functioning accepted by the public
- Stimulating low carbon investments and creating markets for low carbon products – explore the extent to which a carbon pricing mechanism, or measures complementing carbon pricing might have the ability to attract investments in Europe in products which enable the mitigation of climate change

- Addressing the overall abatement costs of the transition (considering CAPEX and OPEX) – investigate the impact for society of a measure individually and combined with all other implemented measures on the total costs for the industry to transition towards the climate neutral economy, taking into account both private and public finance
- Providing consistency and possible complementarity with the existing regulatory framework, including any decarbonisation target set as part of a long-term strategy, while taking into account the overall administrative burden
- Impact on value chains and global trade – measures need to be assessed taking into account their interaction with and impact on the value chains and trade flows of EIs, while fulfilling also the relevant requirements of international trade (WTO) law

Alternative or complementary carbon pricing mechanisms

There are a number of alternative or complementary options for a carbon pricing mechanism that deserve considering in this debate. Please see the non-exhaustive table below.

Carbon pricing mechanism to be assessed	Description & related elements to be considered
Continuation of the existing framework of the ETS (with possible adjustments)	<p><i>Description – see chapter “existing carbon pricing framework”</i></p> <p>Elements to be considered:</p> <ul style="list-style-type: none"> • The limitations mentioned in this chapter are likely to become more visible in the absence of equivalent schemes in major competing economies. Therefore ensure that EU climate diplomacy measures strongly support uptake of equivalent schemes • Adjustments to be considered to address those limitations <ul style="list-style-type: none"> › Share between industry and power sectors’ emissions and related distribution of allowances would need to be evaluated › Structural recognition of emission avoidance in the production of CO₂-derived products › Reflecting the electrification of industrial processes and the changing electricity generating landscape in the future compensation mechanism for indirect carbon costs › Complementary (product-related) policies become essential to create markets and foster investments
EU ETS complemented with carbon inclusion mechanisms	<p><i>Description:</i></p> <p><i>The EU cap & trade system is complemented with measures that establish equivalent carbon costs requirements for EU competitors</i></p> <p>Elements to be considered:</p> <ul style="list-style-type: none"> • The measure should be envisaged as a possible complementary instrument to address the (environmental and competitiveness) concerns about leakage • Enhancing competitiveness of EU exports throughout value chains • Both direct and indirect carbon costs should be considered • A robust global accounting and verification mechanism would be necessary • A transition phase with the existing framework would be probably necessary
Taxation of products based on their CO ₂ footprint	<p><i>Description:</i></p> <p><i>Charge based on the CO₂ embedded emissions</i></p> <p><i>Possibility to develop it with an appropriate life-cycle based approach taking into account the full life-cycle such as production, use (including CO₂ avoidance), end-of-life treatments</i></p> <p>Elements to be considered:</p> <ul style="list-style-type: none"> • A commonly agreed and appropriate life-cycle based methodology would be necessary, including data quality requirements • Likely to require a transition phase (e.g. initially it can be used as a tool to communicate the embedded carbon emissions) • the functioning of the measure on EU imports and exports would need to be designed • the interaction of the measure with the achievement of a certain emissions reduction target would have to be investigated

Further options of indirect carbon pricing such as reduction targets on carbon footprint of final products sold on the market are worth examining. Such options, which may lead to shadow carbon pricing, would also need an appropriate life-cycle based methodology and a transition phase. In addition, a sequestration scheme for carbon contained in produced and imported fuels could be considered.

The desired options may change over time with the evolution of the situation. The optimal solution should be a globally uniform, economy-wide and LCA based cost of GHG²³.

The European Commission

- *Facilitate a timely debate and assessment of the carbon pricing options with all relevant stakeholders*
- *Continue to promote internationalisation of carbon pricing mechanisms*
- *Coordinate climate pricing policies at EU level*

Member States

- *Adopt ambitious policies to boost demand for materials contributing to GHG emission reductions*

Energy-intensive industries

- *Contribute with their expertise to the consultations on the relevant regulations*
- *Contribute to discussions on carbon pricing mechanisms in international fora*

Key performance indicators on carbon pricing mechanisms

- EU and worldwide GHG emissions, both related to production and consumption
- Countries with comparable carbon pricing measures and equivalent regulatory costs on EIs
- trade balance of EU EIs

3. Social dimension

In the transition to climate-neutral economy, one must not forget about the social dimension of industrial transformation. EIs are an essential part of our economic and industrial structure. Strong EU EIs are fundamental to the competitiveness of EU industry and related services, and to allow value creation downwards in

the value chain. European EIs combined provide direct employment to around 2.6 million²⁴ people and contribute to around 15% of EU manufacturing added value²⁵. Special attention should be paid to sectors of the industry needing adaptation to the new “climate-neutral” way of performing their activities, by providing adequate tools and financial support in order to ensure swift transition and avoid substantial / unjustified social and economic costs. Adjustment will also cause shifts on regional labour markets that will be difficult to manage, particularly in regions with underdeveloped or worn-down training capacities. Here social partners can play an important role in cushioning the consequences. While pursuing a climate-neutral economy ambition, the social pillar of sustainable development will have to be safeguarded as well.

Transformation of the labour market

The transition can be seen as an opportunity and challenge for the energy-intensive industries. It holds the potential to retain the existing workforce, which might need to acquire new skills, and additionally generate higher levels of employment. However, skills development will be a particularly important challenge²⁶ and it will be crucial to adopt an inclusive approach whereby low-skilled, semi-skilled and high-skilled workers have opportunities to adapt.

Abrupt disruption in the manufacturing processes may affect employment, most of the cases in remote areas affecting mainly blue collars. A well-designed transfer of competences and adaptation to new skills will be required to cope effectively with a smooth transition.

There will be occupational groups for which the transition will change the task profile and there will be completely new occupations. In order to align education and training with these emerging skills needs (professional and transversal) it is necessary to know which skills will be needed, and it is necessary to be better at building feedback loops that ensure that education and training provision can anticipate – and react to – industry needs. Strong provision of skills in a region is an important factor to attract investment. Therefore, bringing together the industries involved in integrated innovation strategies and education and training institutions is of utmost importance for the proper labour skills development and reallocations.

23 Poland supports the development of a carbon pricing mechanism to prevent carbon leakage and protect European competitiveness during transition period, but considers it essential to have an in-depth analysis of the possible unintended consequences of introducing an LCA-based approach before significant progress of decarbonization in cohesion economies.

24 Based on estimations by industrial associations of the EIs. According to Eurostat NACE two-digit classification, there were 5.9 million employees in 2015 in sectors that include energy-intensive sub-sectors. Further work is required to define three-digit NACE codes representing energy-intensive sub-sectors.

25 The High Level Working Group on Competitiveness and Growth (2017) data.consilium.europa.eu/doc/document/ST-8263-2017-INIT/en/pdf

26 “Industrial Value Chain: A Bridge towards a Carbon Neutral Europe” (2018)

The transformation that the EIs are and will be going through will necessitate a workforce “notably linked to digitisation, decarbonisation, innovation, internationalisation, and resilience”²⁷. Engineers, specialists and business professionals that are experts in the emerging technologies will be in particular demand.

The EIs face a mismatch and gap in skills. Access to a qualified workforce with specific and sometimes new skills, throughout regions and sectors, is a prerequisite for realising innovation. The EU’s “New Skills Agenda for Europe” initiative encompasses a “Blueprint for Sectoral Cooperation on Skills” which can be a good basis to address skills development between the EI and the EU²⁸. Proper attention will need to be paid to the development of regional development plans to boost local and regional labour markets.

The European Commission

- *Develop an EU Skills Strategy that sets out broad guidelines/priorities to Member States and regions for the development of national skills strategies and of skills in local smart specialisation strategies to support the transition to a climate-neutral economy*

Member States and energy-intensive industries

- *Anticipate and map the needs of industry for a skilled work force in order to prevent shortages and mismatches at regional and national level.*
- *Promote employability and adaptability, to give current and future workers the skills to adapt to a changing work environment, technologies and fields of expertise (Industry 4.0, digitalization...) and ensure adequate support (incl. social protection) for those affected by restructuring and transformation.*
- *Invest in skills development and life-long learning to ensure continued employment and adaptation to industry evolution in Europe. In this context, the EU funds and programmes Erasmus, InvestEU and the ESF+ could play an important role.*
- *Establish strong and effective partnerships between vocational education and training, business, social partners, sectoral stakeholders, academia and civil society*

Role of consumers and acceptance of the climate-neutrality transition costs

Consumer choices will have an impact on driving the transformation toward a climate-neutral, circular economy. Further research is needed to gain further understanding of the behavioural and social barriers to the climate-neutral, circular economy and how these could be overcome by both legislation and the industry²⁹.

It is challenging for energy-intensive industries to convey the benefits of the higher cost of products with a low GHG footprint if any improvement comes only long after purchase, sometimes too far off to justify a higher price, and of limited benefit to users. For example, a 15–20-year-old product would be out of date, lagging behind in technology, safety, and design³⁰.

Short lifetimes of some products and behavioural patterns geared towards acquiring more new and modern products may in fact increase demand for other materials. This is why, longer lasting product feasibility is not only about changing the product characteristics, but also the consumer behaviour needs to be changed. Product design and engagement of economic actors having direct contact with final consumers, for example retailers, can help consumers to choose climate-neutral and circular solutions.

It can be foreseen that public acceptance for additional costs of products with a lower carbon footprint, or measures increasing the price of products with a higher footprint, will need to be addressed. When such costs become unaffordable, they may have a strong adverse impact on public support for climate action. Understanding the reasons for support for and resistance to climate action will be crucial to policy formation. European legislators will need to present any changes to the carbon pricing design in a manner that is understandable to and acceptable by the public.

European Commission/Member States

- *Communicate on the challenges and opportunities of a climate-neutral and circular economy*

Energy-intensive industries

- *Engage in the debate on challenges and opportunities of climate-neutral and circular economy*

27 “Industrial Value Chain: A Bridge towards a Carbon Neutral Europe” (2018)

28 The High Level Working Group on Competitiveness and Growth (2017) data.consilium.europa.eu/doc/document/ST-8263-2017-INIT/en/pdf

29 International Energy Agency (IEA): Material efficiency in clean energy transitions

30 “The Circular Economy – a Powerful Force for Climate Mitigation” (2018) Material Economics

II. Developing climate-neutral solutions and financing their uptake

Strategic priorities:

- **Developing industrial demonstrators of key breakthrough technologies by 2030;**
- **Establishing major R&D&I programmes across all technology readiness levels (TRLs), with a focus on bringing solutions closer to the market, and achieving better integration with national programmes, properly supported by coherent state aid rules;**
- **Facilitating access to private capital at affordable cost, including through de-risking instruments.**

The pressing question that decision makers in the EU will need to answer is how to make Europe attractive for investments in the **development of innovative climate-neutral solutions and financing their uptake in the face of increasing global competition**. This would require increasing (and sometime even doubling) current levels of investments in order to step up industries' efforts in developing and implementing new technologies, while re-inventing their business models. All this while continuing to compete on a global level and respecting the EU's international obligations.

To face this sizeable challenge in a timely manner, Energy-intensive Industries (EIs) need a package of policy, financial, innovation and regulatory provisions to mobilize the needed investments. An enabling framework is needed to support Energy-intensive Industries, as well as to scale up private investments, de-risk investments of pioneers, provide the right signals to the markets, and ensure a just transition. To foster such investment, it is crucial for the EU and the Member States to offer clear, long-term signals to guide investors, raise sustainable finance, set clear policies towards climate neutrality to avoid stranded assets and direct it to investments in innovative technologies.

1. The Research and Innovation challenge: timely bringing new solutions to the market

EU's industrial competitiveness needs to be boosted through purpose oriented research and innovation. This is particularly important for the transformation of energy-intensive industries. As part of this enabling framework

for industry and investors, guidance on those economic activities which make a substantial contribution to reducing GHG and climate change mitigation is crucial. The EU's work on a European-wide classification system for environmentally sustainable economic activities could help identify investments opportunities and mobilise private capital for such investments.

The R&I outstanding challenge

The management of the transition will require a scaled-up policy effort, and the transformation of the economy will create considerable additional investment needs. Technological innovations and breakthrough technologies will need to develop and scale up in all sectors.

A detailed technology assessment conducted across all energy-intensive industries has come up with more than 80 low-CO₂ technology options (multiple options per industrial sector), showing the main technological pathways applicable to most industries³¹.

Studies have identified several technological solutions to reduce GHG emissions of energy-intensive industries and their products and allowing them to contribute to the transition to climate neutrality³².

The main pathways, applicable to most industries, include:

- Further energy efficiency improvements, energy savings and demand side management techniques, where relevant
- Process or solutions service integration and optimisation, digitalisation and artificial intelligence

31 Addendum to the Institute for European Studies (IES) report from September 2018: https://www.ies.be/files/Industrial_Value_Chain_25sept.pdf

32 IES study, overview of technology solutions to reduce EIs greenhouse gas footprint – page 9.

- Further electrification of heat
- Further electrification of processes
- Use of climate-neutral hydrogen
- Valorisation of CO₂ (Carbon Capture and Utilisation)
- Use of sustainably sourced biomass and bio-technology, where available
- Carbon Capture and Storage
- Improving circularity through waste prevention, higher valorisation of waste streams, recycling and materials efficiency, including improved durability of products

Table 1: Overview of low-CO₂ technology potential for energy-intensive sectors (table i from the Institute for European Studies report, 2018)

	Electrification (heat and mechanical)	Electrification (processes: electrolysis/ Electrochemistry excl. H ₂)	Hydrogen (heat and/ or process)	CCU	Biomass (heat and feedstock)/biofuels	CCS	Other (including process integration)
Steel	xxx	xx	xxx	xxx	x	xxx	Avoidance of intermediate process steps and recycling of process gases: xxx Recycling high quality steel: xxx
Chemicals fertilizers	xxx	xxx	xxx	xxx	xxx	xxx(*)	Use of waste streams (chemical recycling): xxx
Cement Lime	xx (cement) o (lime)	o (cement) x (lime)	x (cement) xx (lime)	xxx	xxx (cement) x (lime)	xxx	Alternative binders (cement): xxx Efficient use of cement in concrete by improving concrete mix design: xxx Use of waste streams (cement): xxx
Refining	xx	o	xxx	xxx	xxx	xxx	Efficiency: xxx
Ceramics	xxx	o	xx	x	x	o	Efficiency: xxx
Paper	xx	o	o	o	xxx	o	Efficiency: xxx
Glass	xxx	o	x	o	xxx	o	Higher glass recycling: xx
Non-ferrous metals/ alloys	xxx	xxx	x	x	xxx	x	Efficiency: xxx Recycling high quality non-ferrous: xxx Inert anodes: xxx

o: Limited or no significant application foreseen

xxx: high potential

x: Possible application but not main route or wide scale application

xxx: Sector already applies technology on large scale (can be expanded in some cases)

xx: medium potential

() in particular for ammonia and ethylene oxide*

The work on technology assessment is ongoing. Individual sectors are updating their views on the most prominent technologies. The links to the latest updated versions of these reports are available on the website of the High Level Group on Energy-intensive industries³³. In addition, DG CLIMA has organised workshops on different sectors in the framework of work on the Innovation Fund³⁴, and the report of the Strategic Forum of Important Projects of Common European Interest³⁵ further examines technological potential in the sectors concerned.

Table 1 gives a basic overview of the potential to apply the main technology pathways mentioned above at sectoral level. The goal is to visualise pathways that apply across multiple sectors, but this does not imply that the actual pathways will follow this assessment (e.g. due to further R&D barriers and other framework conditions not materialising). The mitigation potential of the technologies presented is not always cumulative and in some cases one technological pathways might exclude another.

The table is non-exhaustive and focus only on the main cross-sectoral solutions with the highest potential.

The table does in particular not pre-empt major research and innovation needs due to digitalisation. Digitalisation of energy-intensive industries can tremendously accelerate disruptive changes to resource management and process control (e.g. via cognitive plants). Global competitiveness can only be maintained by adopting technologies related to artificial intelligence (ranging from machine learning in process controls, better demand forecasting on storage requirement up to AI-based demand sensing).

Table 2 presents an assessment across these main pathways identified in terms of technology status, impact on energy use, CAPEX (relative to investments in current state of the art), OPEX (relative to current operations), infrastructure needs and possible co-benefits.

In any case, the assessment of technologies shall also take into account the integration costs (i.e. investment both in expanding electricity grid and in energy storage) that a strong electrification of final uses could imply.

Some of these solutions are more mature than others. Yet, innovation is flexible by nature therefore hard to frame from a timing and roadmap perspective (e.g.,

a high TRL of today is not necessarily providing a guarantee of success). It can be that some promising solutions do not materialise, or that some solutions still at early stage suddenly find a breakthrough that boosts them in the front-line. Alternatively, unsuccessful solutions tested in a certain context may become relevant in another context/sector.

It is therefore important to embed flexibility in future developments of climate neutral solutions and ensure **technological neutrality** without excluding upfront technologies with significant potential to achieve significant GHG emission savings during the transition. By doing so, the most cost-efficient path is available to achieve CO₂ reduction. Nevertheless crowding out of future proven clean technologies, such as climate-neutral hydrogen, should be prevented. Integrated innovation strategies work as a key aspect in terms of avoiding the trap “one size fits all” in terms of an EU strategy for EITs that might compromise the long-term strategy. It also might mitigate the impact from unavoidable uncertainty and heterogeneity within low carbon and circular innovations for the EITs and/or industries that are highly dependent from them.

Investors shall be provided with the right investment signal: the ability of the energy-intensive industries to help achieving the GHG objectives, improve their sustainability track record and remain competitive throughout the transition.

From a governance point of view, it is best practice for companies to integrate exposure to climate risks into their future development strategy as well as to disclose the GHG emissions of their economic activities in a climate neutral economy context along with other considerations in light of Sustainable Development Goals. A voluntary uptake of the Task Force on Climate-related Financial Disclosures recommendations is an action for companies to consider with a view to attract investors. However, a number of enabling conditions need to be met in order to significantly boost R&D and attract investment in the EU.

Developing advanced production technologies for low carbon circular manufacturing is highly risky and requires great levels of investment, considering the innovation processes involved. Sharing the risk and scale economies and synergies within integrated innovation strategies is, on one hand, one way of lowering the burden of this transition. On the other

33 <https://ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupDetail&groupID=3326>

34 https://ec.europa.eu/clima/policies/innovation-fund_en#tab-0-2

35 Strengthening Strategic Value Chains for a future-ready EU Industry, Report of the Strategic Forum for Important Projects of Common European Interest (2019): <https://ec.europa.eu/docsroom/documents/37824>

Table 2: Assessment of main technology options vis-à-vis technology status, energy use, CAPEX, OPEX and infrastructure needs (Table ii from the Institute for European Studies' report)

	Technology status	Energy use - compared to current operations	CAPEX – relative to conventional technologies	OPEX – compared to current operations	Infrastructure needs	Possible co-benefits
Electrification heat	High TRL except for high T furnaces (glass, cement)	Higher electricity demand but primary energy use can be lower	Depends (replacement of boilers relative low additional CAPEX, (high T) furnaces major investment)	Depends on (favourable) electricity vis-à-vis natural gas prices and efficiency improvements from electrification.	medium	Higher potential for electricity demand response. Possible energy savings.
Electrification processes	In most cases not reached demonstration stage	Higher electricity demand but primary energy use can be lower	High	Highly dependent on electricity prices	Low/medium (might be need for more/ upgraded HV connections)	Higher potential for electricity demand response
Process integration	Move towards pilot and demonstration plants	Medium/high	Medium (unless combined with CCU or CCS)	higher	Medium (unless combined with CCU or CCS)	Recycling/ process internal use of generated process gases
Hydrogen	Move towards pilot and demonstration plants	High electricity consumption for electrolysis based production	High	Higher (dependent on electricity prices)	High (unless H ₂ production happens on site)	Possibility of power storage (e.g. use of ammonia as carrier)
Biomass	Diverse, move towards pilot and demonstration plants for newest technologies	Can be notably higher	High for feedstock applications (new process technologies) Low/medium for fuel applications (compared to e.g. natural gas based furnaces)	Higher for feedstock applications Comparable to conventional for some fuel applications (depends on price of biomass)	Medium/high (need for new and reliable logistics chains for sustainable biomass from within and imported into the EU)	Industrial symbiosis (e.g. use of biomass waste streams)
CCU	Moving towards commercialisation for carbonation and synthetic fuels.. Other processes see move towards pilot and demonstration plants.	Can be very high for H ₂ based routes. Limited for carbonation and mineralisation.	High (but lower for some carbonation technologies)	Can be High (esp. when H ₂ from electrolysis is required. depends on renewable electricity price). Limited for carbonation/ mineralisation.	High	CO ₂ becomes resource instead of cost
CCS	Move towards pilot and demonstration plants	Will be higher	High	Higher	High	Possible process integration benefits

hand, we believe that at early stages, funding schemes are necessary to guarantee the desired economic and social stability, and the commitment with the 2050 long-term strategy.

The lack of the proper funding and regulation many times hampers the capacity building within manufacturing sectors to develop advanced production technologies for low-carbon and circular manufacturing, and therefore makes the innovation process more difficult to happen. Additionally, considering the great heterogeneity within these industries concerning readiness for transition, one should have in mind the need for great variability of investment levels and risk. Future R&D programmes will also have to focus on achieving CAPEX and OPEX cost reductions in key enabling low-CO₂ emission processes.

In addition, it needs to be kept in mind that the research and innovation phase, as well as its uptake into large-scale production, will not follow a linear trajectory and that many pathways can help to achieve climate neutrality and sustainability objectives.

In any case, bringing these solutions to the market is not straightforward. Designing and building a pilot or demonstration plant at scale, forms indeed one of the biggest challenges for most of the low-CO₂ options on the horizon, some of them being clearly cross sectorial. The main reason for this is the large capital requirements together with the still high **technology risks** related to this part of the research phase. The combination of both elements makes it highly unlikely that the private sector will be able to engage in this on its own. Bridging this so-called valley of death will require significant financing support through e.g. grants including the willingness of the public sector to participate in the risk taking of this process. [(Institute for European Studies (IES), 2019)].

Most promising climate neutral technologies will need to prove industrial scale demonstration by 2030 at the latest. Many are still at pilot stage or earlier. The key strategic objective is therefore to provide adequate innovation support to bridge these innovation valleys of death.

The Commission delegated regulation on the operation of the Innovation Fund estimates the potential investment volume for demonstration projects at

between EUR 55 to 68 billion in the eligible sectors, of which Energy-intensive Industries (incl. industrial CCS and Carbon Capture and Use CCU) around EUR 31-42 billion according to the Ecofys³⁶ study. Those figures are quite conservative.

Moreover, the Ecofys study refers only to the demonstration stage and does not cover the proof of concept to pilot phase that other funds and programmes ought to cover.

Therefore, the EUR 42 billion resulting from the Ecofys study should be considered as a floor in terms of estimation of the future public and private financial needs.

The European Commission

- *Establish a **major innovation and technology development programme across all TRLs** with strong public financial and other relevant support to enable the adequate technology experience that is needed for the timely deployment of the right technologies that will enable the energy-intensive industries' contribution to the climate neutrality objective. There is an urgent need to clarify the innovation agenda³⁷.*
- *Align eligibility criteria between different funds, both on EU and national level and also interoperability of funding mechanisms. State aid rules should not hinder national funding.*

Member States

- *Establish national developments programmes, to identify potentials and possible synergies with EU programmes*

Energy-intensive industries

- *Develop regional plans, addressing specific sectorial potentials, needs and barriers hindering the development and deployment of innovative technologies*
- *Ensure that substantial investment is made in innovation, technological development and implementation of solutions towards climate-neutrality*

36 Fraunhofer ISI, Ecofys (2018) Impact on the Environment and the Economy of Technological Innovations for the Innovation Fund (IF) in the Fields of Energy-intensive Industries, Renewables, CCS/CCU and Energy Storage

37 Material Economics, Industrial Transformation 2050. Pathways to Net-Zero Emissions from EU Heavy Industry, 2019

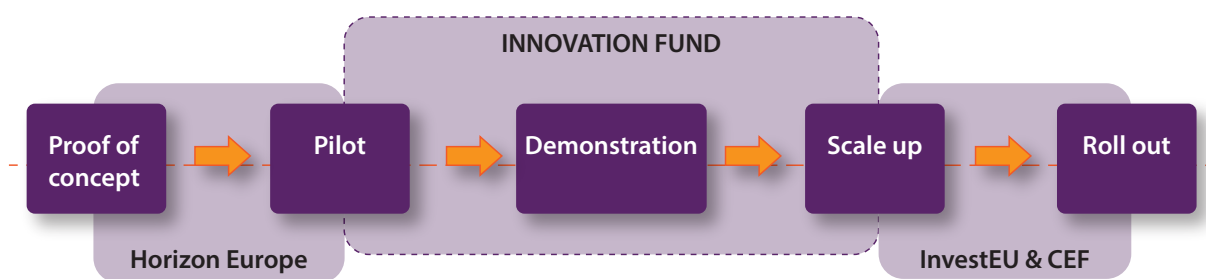
Navigating through the EU funding instruments

While the European Commission has a broader innovation architecture in mind when setting up the innovation fund, practical implementation is not there yet. Horizon Europe will fund early stage innovation. The Innovation Fund will step in when (much) higher levels of capital are required to scale up towards pilot and demonstration levels. Further rollout and deployment of technologies that are successfully demonstrated will be supported by Invest EU and the Connecting Europe Facility, the latter to focus on necessary infrastructure for new Technologies³⁸ (Institute for European Studies (IES), 2019).

will be able to contribute to blending operations under InvestEU (e.g. topping-up the risk-coverage provided by InvestEU).

The optimal combination of financing from the Innovation Fund, InvestEU, other Union programmes, and the Member States should ensure a large coverage of the additional costs and risks linked to the demonstration of innovative climate neutral technologies or products (European Commission, 2019). Synergies in funding with national programmes (notably for large-scale demonstrators at higher TRL levels) should also be established because fragmentation in programming

Figure: Possible EU industrial innovation financing instruments from proof of concept to roll out.



Source: European Commission, 2019

Horizon Europe will also be complemented by the European Regional Development Fund, which supports innovation and its wider uptake (e.g. energy efficiency solutions for SMEs and buildings, renewable energy projects) but does not support any activities listed in Annex I of the ETS Directive (2003/87/EC). Connecting Europe Facility could support the infrastructure elements of the projects financed by the Innovation Fund such as construction of CO₂ and hydrogen pipelines or grid connections. The Innovation Fund will also operate in synergy with the Union investment support programme (the InvestEU proposed by the Commission): InvestEU will be able to provide additional investment support (e.g. loan guarantees or equity contributions) to projects financed by the Innovation Fund. The Commission proposal for InvestEU foresees that the Innovation Fund

between European and national levels are no longer a solution to the global challenge of climate change where Europe as a whole wants to take the lead.

However, in practice there may be gaps and misalignment to be addressed. For example, some industrial pilot projects may not move seamlessly between Horizon Europe and the Innovation Fund. Similarly, at the other end of the scale on large-scale deployment there is a barrier with some of the large structural and development funds prohibiting these funding mechanisms from being used for activities listed under the EU ETS.

Research and innovation investments from the European Regional Development Fund (ERDF) should be in line with the smart specialisation priority areas identified and developed in the process of entrepreneurial discovery,

38 European Commissions, 2019a

which will thus vary from one Member State or region to another. The main focus of ERDF business investment in R&I is on SMEs, although R&I activities enabling SMEs to cooperate, for example through clusters, with larger enterprises, usually having greater R&I capacities, can also be supported.

All these funding instruments need **integration and coordination**. In this respect, the work done by the European Technology Platforms in developing their industry focused Strategic Research and Innovation Agendas (SRIA) and Public-Private Partnerships needs to be matched by awarding criteria that enable project to move forward on the TRL scale (SPIRE, 2019). Such integration and coordination should provide visibility and stability of the financing opportunities and ensure multi-annual synchronisation. Innovation does not happen at a predetermined point in time.

A changing business environment requires flexibility. There should also be consistency across different funding programmes: complying with different rules, different timelines and different EU Institutions makes it very difficult for companies to engage in EU funding programmes. Recently the Innovation Fund experts welcomed the open dialogue between the different available instruments, although raising concerns on the complexity of the EU innovation funding landscape, and the burden on innovators navigating it. There is a need for policy coherence, enhanced cooperation, flexibility, complementarity and consistency across the different EU Funds. The Commission has mapped the different funds available for low carbon innovation and will update this mapping. This tool should also help enabling innovators/operators/industry identifying how to best use the financing tools that coexist.

The European Commission

- *Given the size of the challenges, develop **European Partnerships on Climate-Neutral Industry & Low-CO₂ Emission Technologies** under the EU's innovation flagship Horizon Europe (i.e. a large and ambitious mission oriented R&D&I program for industrial low-CO₂ technologies, including funding for industrial demonstration and scale up) in coordination with national industrial R&D programmes to address outstanding basic R&D gaps (in particular with focus on cost reduction of new technologies)*

both from supply side (process technologies) and demand side (materials efficiency, energy storage). [source IES, 2018]

- *Ensuring **complementarities and synergies between different EU funding programmes** and instruments is currently under discussion in the Multiannual Financial Framework 2021-2027 context, bearing in mind that different programmes and instruments have different objectives and management and implementation arrangements.*
- ***Synergies/coordination between financing tools should be fostered to support promising industrial demonstration projects**, made from complementary EU and national instruments (e.g. funds, grants, guarantees) and financing from private investors to provide loans and/or equity financing to the underlying projects (depending on their specific needs). This approach, acknowledging this is extremely challenging, would facilitate a procedure with a simplified application to get access to the funds and minimal bureaucracy, i.e. avoiding staged applications at both national and EU levels, or a pre-approval requirement by national governments.*
- *Develop a **harmonised approach with regard to the selection criteria** under financing instruments geared at climate neutral technologies and related application processes (staged calls with a pre-selection process based on simplified application), considering the estimated cost per ton of CO₂ avoided on the full life cycle of products -process and end use and favouring when possible the replicability and the spill over effects on other sectors, and a careful assessment of the full cycle impact of the alternatives and compatibility with climate neutrality.*
- *Set up an **industrial transition observatory** which is composed by relevant stakeholders, including civil society organisations, to monitor progress and advice course corrections with regard to development and deployment of industrial low-CO₂ innovations taking into consideration the ongoing work in particular under the cohesion policy (see Industrial transition no region left behind) and ensuring consistency from a scope point of view (Institute for European Studies (IES), 2019)*

From pilot to scale up

The Innovation Fund represents an important opportunity to finance the uptake of innovative solutions in industry. It is therefore of paramount importance to ensure that the fund is fit for purpose. The work done so far in the experts' group in preparing the legal basis is an important step in this direction, but more still needs to be done.

The Commission delegated regulation on the operation of the Innovation Fund estimates the potential investment volume for demonstration projects at between EUR 55 to 68 billion in the eligible sectors.

Although the volume of the Innovation Fund is expected to be substantial (€6 billion (at carbon price of €15/tCO₂) to €11 billion (at a price of €25/tCO₂)), the funding demand goes well beyond the expected available resources. Hence, the Innovation Fund support should be combined with the support provided by other EU programmes, including for example the European Investment Bank, and by programmes from the Member States resulting from other instruments like charges and levies.

The Innovation Fund is designed on a technology neutral basis, with the GHG emission reduction potential as one key selection criterion. A number of technologies can already be targeted for support. Nevertheless, new promising innovations could be identified in the next few years, and therefore, as part of the functioning of the **Innovation Fund**, a review in 2023 should help assess whether it needs to be scaled up.

Innovative investments can result in higher CAPEX compared to conventional technologies, for which the additional costs need addressing. Where conventional production does not exist (e.g. the final product is not the same), the total costs are relevant. Elsewhere, innovation could also lead to potentially lower CAPEX, but these solutions need to be properly tested before deploying them into running production processes. If no guarantee, they will not be deployed.

By defining "relevant costs" only as additional costs compared to the costs of a conventional production with the same capacity in terms of effective production or the respective final product, the Innovation Fund regulation is not addressing adequately the risks associated with

building a full, highly innovative project. There is also no reason to believe that innovative technologies are always significantly more expensive than conventional ones. Some of the biggest hurdles for operators when implementing a non-proven technology are rather associated with the risk of building a demonstration project that, in the end, could not work adequately and therefore to face production disruption, with potentially devastating consequences. Moreover, financial consequences often include the accelerated depreciation of the conventional production.

The **Innovation Fund** should also promote **cooperation within and across sectors** as well as support **partnerships** with technology service providers. For instance, although support mechanisms are needed for sector specific technology options, carbon capture or electrification of heat and processes, CCS and CCU have applications across several of the energy-intensive industries, and therefore a common framework and supporting mechanisms need to be developed across all sectors.

Cooperation at a local level, especially with communities and local authorities, will also be a key driver since some projects will require full acceptance, engagement and participation from numerous local stakeholders.

The European Commission/Member States

- *Turn parts of the European Investment Bank into Europe's climate bank. The Bank is already the largest multilateral provider of climate finance worldwide, with 25% of its total financing dedicated to climate investment. This figure should be doubled by 2025.*
- *Establish a platform with all relevant stakeholders to exchange views and elaborate further on:*
 - *Setting up an **insurance scheme** for those early-birds industries introducing innovation and new technologies that can put existing industrial operations at risk (of technological, operational, market, price nature) should be considered.*
 - *Innovation-focused taxation policy could be developed, to encourage the allocation of resources to develop and deploy climate neutral solutions*

- *Risks have to be taken by all those who invest or support the development of innovation. Innovation cannot be rewarded only upon delivery of expected results: **funds must however be released against clearly identified milestones and expected cost-effectiveness.***

Member States

- **Complement EU funding with national financing tools**, including where appropriate auctioning revenues from the ETS as well as other instruments like green investment schemes, improvements in the regulatory environment, charges and levies and any type of budgeting forms, to support the deployment of innovative low-carbon projects

Energy-intensive industries

- To **raise awareness**, among member associations and companies, of funding opportunities available at European level
- **Engage with other sectors and across the industrial value-chains** to develop synergies and partnerships in developing innovative climate neutral solutions

Coordination EU – Member States

Several **Member States have developed R&I programmes for low-carbon innovation**, highlighting that these national programmes are important to ensure projects are ready for funding through larger, later development stage EU programmes such as the **Innovation Fund**. Those programs cover a wide range of development stages from small-scale innovation projects to large-scale demos.

The Integrated SET-Plan has identified ten priority areas for ambitious R&I on energy technologies and Member States and the European Commission have agreed targets for each topic. These priorities are highly relevant to EIs and as the SET-Plan targets are reviewed and updated, they should take account of the conclusions of the HLG on EIs.

National funding programmes need to match research and Innovation programmes at the EU level in order to support the deployment of innovative technologies in

industry. An important trait d'union could be to channel part of the Modernisation Fund, Regional and Structural Funds towards low CO₂-emissions industry.

In this regard, the two Strategic Value Chains, namely "Low CO₂-emissions Industry" and "Hydrogen Technologies and Systems", selected by the Strategic Forum of Important Projects of Common European Interest (IPCEI) in January 2019, provide the necessary conditions and concrete recommendations to facilitate agreements between Member States and the private sector.

The European Commission/Member States

- *All those funding mechanisms need to be properly supported by **coherent state aid rules that are fit for the purpose.** Bringing first-of-its-kind innovative projects to the market is in line with the IPCEI and/or regional State aid rules allowing Member States to adequately complement the support provided by them in a manner that does not distort competition.*
- *The Report of the Strategic Forum of **Important Projects of Common European Interest**³⁹ should be taken into account. In particular:*
 - *Member States could consider the setting up of IPCEI to accelerate demonstration of technologies and prepare EIs for future rollout.*
 - *Could support IPCEI proposals identified under the Strategic Value Chain in Low CO₂ emission Industry, which was selected by the European Commission and Member States as one of the six key Strategic Value Chains for the EU in February 2019.*
 - *Consider other IPCEI proposals on technological pathways in EIs, complementary to financing of the Innovation Fund.*

Energy-intensive industries

- *Commit to co-finance eligible IPCEI projects*
- *Identify a matrix, at sectorial and national/regional level, with needs and priorities for R&I programmes to deploy innovative climate neutral solutions.*

39 Strengthening Strategic Value Chains for a future-ready EU Industry, Report of the Strategic Forum for Important Projects of Common European Interest (2019): <https://ec.europa.eu/docsroom/documents/37824>

2. The investment challenge: deployment of innovative solutions

The level of industrial investment implied by the long-term strategic vision is enormous, certainly in the hundreds of billions of Euros (Institute for European Studies (IES), 2018).

For most EIs, the current production location has significant strategic value (e.g., connections to infrastructure and logistics, proximity to raw materials supply chains and/or customers). Most investments in low-CO₂ processes will therefore likely happen at the same location. Greenfield investments, if any, will be the exception.

While retrofits of existing process installations towards low-CO₂ emission processes are likely to have priority, this will however not always be possible. This implies that major brownfield conversions will have to be part of an industrial low-CO₂ transition. This type of transition will always be more expensive compared to greenfield developments. Existing productive assets will have to be dismantled and sites will have to be prepared for installation of new process facilities.

Moreover, early stage deployment of new technologies typically carries additional risks and higher costs. Building confidence and experience in new industrial technologies, at scale, and achieving cost reductions, will require financial support and more flexibility in the permitting.

The framework should effectively protect industry against unfair international competition, as well as promote and reward investments in climate neutral solutions.

The European Commission/Member States

- Establish a platform with all relevant stakeholders to identify how to provide long-term certainty and lower the risks for investors, and to exchange views and elaborate further on:
 - **Risk sharing models** to de-risk investments of pioneers, both short- and long-term.
 - **Special Purpose Vehicles for off-balance sheet financing.** Capital-intensive investments can be a burden on the balance sheets of companies. For companies that operate in cyclical markets this can lead to very strict demands on expected rates of return. Using Special Purpose Vehicles e.g. sanctioned or supported by the EIB, companies could be allowed to create separate entities that own the new low-CO₂ assets. This type of off-balance sheet financing would limit the exposure of the parent companies and can hence help accelerate investments in climate friendly assets with a longer payback time.
 - **Fiscal policies, state aid guidelines and regulations should be reviewed to stimulate early adoption of innovative first-of-its-kind solutions.** Moreover, in the context of the on-going State aid fitness check, the issue of supporting the timely transition to a climate neutral economy should be examined. In particular, the climate neutral transition of EIs should be addressed and supported also in the Environmental and Energy Aid Guidelines.
 - **The Industrial Emissions Directive** permitting process should be adapted to support GHG abatement measures in energy-intensive installations throughout the transition. The low carbon emission technologies under development should be assessed as potential emerging techniques during the BREF drawing and reviewing process.

Member States

- Public funding instruments, including where appropriate **auctioning revenues** as well as other instruments like charges and levies and any type of budgeting forms to be used to support industry in the deployment of innovative solutions

The ongoing work on **sustainable finance** and other current or future work streams promoting sustainable finance such as in the area of environmental accounting should lead to identify economic activities and investments that help address climate change and other environmental challenges, and attract finance to such investments also in energy-intensive industries. Sectors or activities should not be excluded a priori from access to sustainable finance as long as the economic activities in these sectors are in line with the objective of a transformation towards achieving climate neutrality in 2050. In this respect, it is worth stressing that innovation should be the result of creative thinking, not of a prescriptive set of predetermined criteria. A technological neutral approach involves the utilisation of all relevant emission-free technologies. The Action Plan on financing sustainable growth aims to provide decision tools for the financial sector on where to direct their investments.

Industrial sectors aiming at contributing to the achievement of EU's climate goals should not be excluded from investment schemes but must rather be encouraged to deliver the products needed by the economy, while evolving in a sustainable energy transition. Sustainable finance should support competitiveness of the EU industry and avoid any sort of "brown listing".

Member States

- ▶ **The principles of technology neutrality, cost effectiveness and free competition** should be the basis of the upcoming sustainable finance regulation to consider all the technologies and activities that can contribute to the achievement of the environmental objectives while preventing the lock-in into technologies that conflict with climate-neutrality.
- ▶ **A flexible approach is needed** to consider the role of individual sectors and technologies across value chains as well as the scalability of a given technology and its possible market evolution.

Financial support for engineering studies: as industrial sites are often complex, solutions need to be customised for the specificities of that site. This makes it difficult and costly to scale up solutions. A case-by-case analysis will typically be required.

As one introduces new technology or processes, as well as new raw materials, there is a risk of upset to the existing operations. Technological developments to ensure safety

in the industrial operations are mandatory. Furthermore, insurance type support could address those operational risks.

Financing the uptake of climate neutral solutions (demand-side measures)

Solving the challenges related to R&I and investment is a necessary condition to facilitate the development, upscaling and deployment of breakthrough technologies. However, as mentioned in the introduction (see "the demand challenge: creation of lead markets") it is not sufficient for a successful transformation of ELLs if there are no market conditions justifying a business case for the climate neutral and circular solutions.

Materials produced with breakthrough technologies will be more expensive than the ones produced with conventional processes, at least in a transition phase i.e. until the new technologies reach a sufficient level of maturity and become cost competitive. In this transition phase, financial support measures need to secure sufficient demand for the innovative products so that a business case can be justified. This will require investigating and developing incentives that foster the cost competitiveness of innovative products. The focus is on creating long-term effects and building of scale and volume of low carbon emission products to sustain the market for green products in the future, by making these products a viable economic choice beyond public financial support after the transition.

One option is to support the production of basic materials (e.g. steel, chemicals, and cement) with significantly lower emissions. At least two different mechanisms can be considered. First, producers of basic materials using new processes with low or no CO₂ emissions can get a fixed premium per unit (e.g. tonne) produced. Such support would be calculated as the price difference between the production of materials with incumbent processes and the production of the same with low-CO₂ processes. In practice, different premiums will have to be applied for different materials and likely for the different alternative processes. These premiums must be phased out as soon as technologies become mature and can compete on the market (i.e. there is not anymore a risk of market failure). They should also be market-based in order to secure cost-efficient support.

Second, a low-carbon project could sign a contract for difference with a national public authority on the carbon price for the scale of emissions saved compared to the benchmark of a conventional technology. This secures a stable price per tonne emission savings delivered by the plant and thus stabilizes the revenue stream, making it bankable for financing incremental investment costs. It also secures the operation of a climate friendly production process against carbon price uncertainties. If desired, the reference price (strike price) of the project-based contract for difference can be set above current carbon price levels to provide a credible signal of government expectations regarding long-term carbon price developments.

Other options could be based on different VAT tariffs, life cycle requirements or targets and contracts with a national public authority.

The European Commission/Member States

- *Establish a platform with all relevant stakeholders to exchange views and elaborate further on:*
 - *Setting up an **insurance scheme** for those operators who introduce innovation and new technologies that can put their existing operations at risk should be considered.*
 - **Temporary de-risking measures** (e.g. premium or contract for difference) supporting immature low carbon technologies that would prove to be non-competitive at the early development and market penetration stage should be considered.
 - Identify **fiscal or regulatory policy tools** to promote the early uptake of new solutions and to create lead markets
- *Risks have to be taken by all those who invest or support the development of innovation. Innovation cannot be rewarded only upon delivery of expected results: **funds must however be released against clearly identified milestones and expected cost-effectiveness.***

Member States

- *The development of National Energy and Climate Plans (NECPs) is an appropriate avenue to*

pursue an integrated industrial decarbonisation roadmap and coordinating the finance mix of public (National and EU) and private sources

Energy-intensive industries

- *A bottom-up approach is also needed whereby **industry indicates areas where and what level of financial needs will be needed.** Sustainable finance and policy interventions should also aim at reducing cost of capital for investments in clean innovative technologies, which are by definition riskier*
- *Identify and make use of new business opportunities involved with the creation of climate neutral products markets and the transition towards climate neutrality in 2050*

The time challenge: accelerating investment cycles

The challenge is not only to develop new climate neutral solutions in the EU, but to increase the current level of investments towards the deployment of low-CO₂ technologies.

This will pose major economic **accounting issues** for companies and can make the business case of climate neutral projects unviable (even with attractive financing programmes).

Shortening the investment cycles will inevitably lead to **stranded assets**⁴⁰, as investments decisions last for several decades ahead and cannot wait for unproven technologies to become commercially available. This issue is even more challenging if one considers that the deployment of most of breakthrough technologies in EIs relies also on factors that are outside the direct competence of these sectors, such as the necessary infrastructure for low carbon electricity, H₂ and CO₂ storage.

EU and national financing instruments will therefore need to consider the additional constraints that come into play during the conversion of existing process installations that have been written off.

⁴⁰ The concept "stranded asset" is often coupled with the "carbon lock-in" effect. However, industry is always in a position to introduce alternative energy technologies when cost-competitive. Therefore, we do not see the carbon lock-in being a major concern through the transition.

The accelerated transition will also require dismantling and rebuilding assets that, even if fully depreciated, still guarantee returns on investments. This will constitute a major obstacle from a shareholders' perspective.

The European Commission/Member States

- *Establish a platform with all relevant stakeholders to exchange views and elaborate further on solutions to address these challenges which can include :*
 - *accelerated depreciation of the new assets (to lower taxation basis) which are being developed,*
 - *other tax abatements and financial support for preparation of site conversion*
 - *new opportunities for investments and on sustainable finance to accelerate the transition.*
- *Those solutions might not be covered by the current scope of energy and environment state aid guidance. Therefore, it is recommended that these guidelines be reconsidered and aligned with industrial climate neutral transition.*
- *Member States should also in the future be able to provide state resources that contribute to the realization of European CO₂ reduction objectives. The state aid framework should allow for all relevant greenhouse gas reduction measures, such as to CCU/S, bio-recycling and hydrogen, which contribute to the realization of a climate neutral society in 2050, whilst still critically assess the level of state aid in order to avoid over compensation and safeguard fair competition in the EU internal market.*

The international challenge: attracting investments in Europe

To deliver a timely industrial transition, solutions would have to be commercially available by around 2030. This will require major R&I efforts. It also requires a favourable environment for deploying investments in Europe. While public support will be key to support the deployment of products with a low carbon footprint, high CAPEX investments in new processes with significantly higher OPEX in comparison to conventional/international competitors will not happen without a clear market/business case.

A market for low-carbon and circular products would certainly help. As well, developing low-carbon and circular industrial value-chain, to strengthen the linkages and synergies among industrial players.

Winning the international competition in making Europe the most attractive place to deploy first-of-its-kind should also be a top priority. Which in turn may encourage other regions of the world raising their climate ambition and prevent investment leakage.

3. The social dimension: managing the impact of industry transition on collectivities and local communities

Another important aspect is the very close link that the industry should maintain with education and training institutions and research units, to create knowledge networks that might increase the innovation potential and facilitate the appropriate skills development needed for labour relocation.

These knowledge networks will require the proper funding to prosper and support the integrated innovation strategies based on material streams and value chains. By saying this, the Industrial Masterplan should have a solid funding scheme to support the transition for climate neutral and circular economy closely linked to the RTD funding, both taking into considerations the differences between regions', sectors' and innovation life-cycle stages towards the common long-term 2050 goal.

The social dimension encompasses several sub-dimensions (customers, workers, regional impact and, more in general, how taxpayers and citizens will be impacted by the transition). The energy transition will impact the social dimension of the European economy as a whole with consequences at the all territorial levels. In order to cope with this challenge, we have to take into account three key elements: social and economic costs, consequences of inaction, plus the public acceptance of the current policies.

Firstly, special attention should be paid to sectors of the industry adapting to the new "climate-neutral" way of performing their activities, by providing adequate tools and financial support in order to ensure swift transition

and avoid substantial / **unjustified social and economic costs**. While a climate-neutral economy by 2050 can be the ambition, the social pillar of sustainable development will have to be safeguarded as well.

Secondly, options to deliver deep GHG emission abatements need exploring. To this end, the necessary research, innovation and demonstration needs to accelerate, and issues regarding its **public acceptance** have to be addressed based on fair and transparent public participation and support for communities to be able to take part to these consultations.

Most of the solutions to significantly abate GHG emissions in industry require actions “beyond the fence” of industrial sites. Reinforcing or creating new energy-related infrastructures will have a direct or indirect impact on local communities. It will require significant labour reallocation and related changes in future skill requirements while opening new employment opportunities. Addressing the legitimate concerns from local communities will also have an impact on the costs and on the possibility for industry to invest in low-carbon solutions. Industry cannot be left alone, squeezed between a top-down policy imperative to transform, and a bottom-up opposition from local communities. It is also the duty of policy-makers at all levels to explain the need for a change to local communities and sit together to find solutions to move forward.

Challenges such as **access to skills, training and finance** will equally need to be addressed, to ensure social support from both workers and local communities. Energy-intensive sectors will see a shift to new production processes with **new skills required**. There will be occupational groups for which the transition will change the task profile and there will be completely new occupations. New jobs will require mostly medium and high skills – while low-skilled adults are already, and will be even more, exposed to unemployment. In order to align education and training with these emerging skills needs (professional and transversal) it is necessary to know which skills will be needed, and it is necessary to be better at building feedback loops that ensure that education and training provision can anticipate – and react to – industry needs. A strong skills tissue in a region is an important factor to attract investment.

The European Commission

- *Develop an EU Skills Strategy that sets out broad guidelines/priorities to Member States and regions for the development of national skills strategies and of skills in local smart specialisation strategies.*
- *Support the transition of carbon-dependent regions with EU funds and instruments, including the upcoming Just Transition Fund, for example via the coal and carbon-intensive regions in transition initiative.*

Member States and Energy-intensive industries

- *Take into account the distributional implications of the transition and corresponding financial support measures*
- *Promote employability and adaptability, to give current and future workers the skills to adapt to a changing work environment, technologies and fields of expertise (Industry 4.0, digitalization...) and ensure adequate support (incl. social protection) for those affected by restructuring and transformation.*
- *Anticipate and map the needs of industry for a skilled work force in order to prevent shortages and mismatches at regional and national level.*
- *Reskilling and Upskilling in both, professional/technical competences and 'key competences'⁴¹ – Life-long learning programmes to support workforce in responding to a changing work and technological environment. In this context, the EU funds and programmes such as Modernisation Funds, Erasmus, InvestEU and the Regional Development and Cohesion Fund could play an important role.*
- *For the two actions above, strong and effective partnerships between vocational education and training, business, social partners, sectoral stakeholders, academia and civil society are needed at regional level.*
- *Raise awareness of the role of energy-intensive industries in providing qualified jobs in local areas.*

41 Also referred to as “21st century skills”: they comprise basic and digital skills as well as a mix of cognitive and socio-emotional skills (problem solving, creativity, communication and collaboration). Furthermore, they include STEM subjects (science, technology, engineering and mathematics)

III. Resources and deployment

Strategic priorities

- **Ensuring access and availability of climate-neutral energy at globally competitive prices;**
- **Ensuring access to alternative feedstock sources, by promoting use of renewable and (carbon-based) recyclables beyond energy production;**
- **Mapping of energy and non-energy infrastructure and supply, underpinned by technologies for industrial transformation in support of climate-neutral industry.**

In 2018, in a study by the Institute of European Studies (IES) for the High-Level Group 'Industrial Value Chain – A Bridge towards a Carbon Neutral Europe' – the researchers looked at both how energy-intensive industries can contribute to the transition but also the necessary conditions to ensure the transition.

One of the key takeaways from the study was that the industrial transition of energy-intensive sectors depends on several factors which are beyond their immediate own control. Indeed, discussions often focus on specific sectoral targets, with the simplistic question asked: by how much can your sector reduce its GHG emissions? But industry is reliant for example on the EU power sector achieving its pledge to climate neutrality objectives, whilst ensuring electricity remains globally cost-competitive.

Elsewhere what the study identified was a lack of availability of alternative feedstocks and climate-neutral energy. Indeed, the shifting to alternative energy and feedstock sources represents one of the key options for significant GHG emission abatement in industry.

Alternatives for fossil fuel feedstocks (oil/gas) might not be cost-competitive or available yet. Alternatives for fossil energy sources for low- and medium temperature requirements are available, but more difficult for high-temperature processes. Cost competitiveness — compared to current gas prices for energy consumption — is indeed an issue.

Studies indicate that a more circular economy can make deep cuts to emissions from heavy industry. A study by Materials Economics indicates that ambitious demand-side measures in the form of materials recirculation, increased product efficiency and circular business

models - prompted by changes in consumers' behaviour and preferences- can reduce emissions significantly in heavy industry by up to 56% in 2050 compared to 1990⁴².

This section of the report looks in more detail into the resources and deployment needed to ensure that the necessary enabling conditions are available for energy-intensive industries in the transition.

In order to significantly abate their GHG emissions, energy-intensive sectors (EIS) will have to go through profound transformation including the switching to alternative energy and feedstock sources, with far-ranging impacts on existing processes, supply routes / logistics and eco-systems surrounding industrial sites.

In the first place, industry will need access to **significant amounts of climate-neutral electricity** in order to develop solutions for both 1) direct electrification of heat and processes and 2) indirect electrification; hydrogen-based production, CCS etc. The IES study estimated the combined electricity needs of energy-intensive industries at between 2,980 and 4,430 TWh per annum. Such demand estimates are not too dissimilar to the European Commissions' in depth assessment accompanying the "Clean Planet for All" Communication, where the FORECAST model sees electricity demand increase to maximum levels close to 3000 TWh, while the PRIMES 1.5 TECH scenario reaches 4808 TWh⁴³. While estimations vary, all studies are consistent that industry's demand for electricity will grow significantly in the transition.

At present low-carbon energy solutions are typically more expensive than high carbon solutions. Therefore, it is important that the shift from fossil-based energy to climate-neutral electricity does not result in higher OPEX, as this will otherwise act as a barrier to further electrification of industry and several technological solutions envisaged by industry (hydrogen-based

42 Material Economics AB (2018). The Circular Economy. <http://materialeconomics.com/latest-updates/the-circular-economy>

43 In depth analysis in support of the Commission Communication "A Clean Planet for all"- Page 155

production, valorisation of CO₂, CCS). This means that energy carriers, which will become the main vectors for low-CO₂ processes (e.g. electricity and H₂) need to remain competitively priced in Europe for EIs.

A big share of climate-neutral electricity will come from 'variable' sources⁴⁴. New challenges related to variability, infrastructure and storage are therefore inevitable. Such challenges include:

- Variability of supply: Most often industries are baseload consumers, resulting from a flat stable production profile. Taking more variable RES supply and matching it with a flat production profile will present a challenge for baseload industrial consumers. However, through demand response, it can also offer opportunities⁴⁵.
- Storage: looking ahead, given the variable nature of the electricity supply, we will face more and more periods of over and undersupply of electricity. Thus, solutions are necessary upfront for storage and backup. A huge challenge lays ahead to displace large volumes of energy in time (winter – summer, intraday) in energy storages.

While electricity is expected to represent a higher share on the EIs energy consumption, industry will still rely on gas as an energy and feedstock source. Whilst climate-neutral hydrogen is a marginal carrier at present, greater flexibility of gas as an energy carrier (compared to electricity) could make it an attractive solution for EIs.

Today, hydrogen produced via electrolysis or Steam Methane Reforming combined with CCS, are not yet competitive in comparison to conventional hydrogen production⁴⁶ (additional possible technologies are still at low technology readiness level (TRL) but could develop successfully in the future e.g. methane pyrolysis). Depending on the process, producing hydrogen will also require additional energy i.e. more investments in new production facilities and in more infrastructure, including in the power sector. To transport the same amount of energy with hydrogen as with natural gas (i.e. for industrial purposes), much higher volumes or high pressure would be required. This will require different grid specifications.

Next to energy, **raw materials** (including feedstocks) form the main input for the EIs, representing the highest or second highest cost category⁴⁷. Notwithstanding the high uncertainty related to the future demand of

raw materials and taking into account technological development, material substitution and recycling, the industrial transformation of the EIs can be expected to require increased amounts of primary and secondary raw materials.

Although biomass as an alternative feedstock is not an option for all sectors (sectoral specific limitations will have to be taken into account), many of them do consider the use of bio-based feedstock as a key option to reduce the GHG footprint of feedstock consumption. While the development of the bio-economy represents new market opportunities, access to conventional biomass feedstock (such as food and feed-based crops) can be restricted because of competition between biomass as a feedstock and land use for other purposes, such as for food and feed production. New technologies and processes are needed to enable the use of advanced biomass feedstock, such as bio-waste, ligno-cellulosic materials, agricultural and forestry residues. Looking ahead, demand for sustainable biomass will rise significantly. Even with active forest management, existing EU forests have a limited potential for additional supply without negatively affecting the forest sink. Increased biomass production thus will need to come from a combination of sources, including the domestic agriculture and waste sectors. In particular, following the implementation of Circular Economy waste management provisions, it is expected that important bio-waste quantities will become available. Given that the supply of biomass is limited at the global level and biomass production may have negative environmental impacts, it is questionable if it can be made available sustainably, at sufficient scale and at cost competitive prices.

Manufacture of products made from recycled CO₂ will require access to **high purity streams of CO₂**. Concentrating and capturing these streams of CO₂ will also result in increased energy use and cost.

Security of supply of **critical raw materials** is also indispensable for some sectors that rely heavily on raw materials imports. In a similar fashion to the Battery Initiative, it will be important to identify the key raw materials needed for tomorrow. Building upon and integrating the work of the European Commission's ongoing 'raw materials initiative' and Member States' efforts to increase supply from European sources will go a long way towards achieving this goal.

44 The Commission's in-depth analysis in support of the "Clean Planet for All" Communication foresees that wind and solar energy will represent between 65 and 72% of total electricity production by 2050 (Page 75 and 76)

45 Changing a variable profile to the industry's flat profile is what industry calls "firming costs". At present, beyond the Nordic electricity market, these "firming costs" are not available in the market at sufficient scale. This will need to be addressed.

46 IEA Report on the Future of Hydrogen - Chapter 2: Producing hydrogen and hydrogen-based products

47 VUB-IES (2018), Industrial Value Chain. A bridge towards a carbon neutral Europe

Furthermore, although material flows are complex, one constant is the need to preserve the entirety of value chains in Europe. European Energy-intensive Industries benefit from a high level of integration. Big production facilities are sometimes even located inside the same industrial zone sharing similar infrastructure, logistics and resources. EU's industrial strategy should build on this as a strength, putting **industrial symbiosis** at its forefront in the context of the new circular economy. This however will not be the only solution required because many industries are local to the market needs or sited next to the raw material source and not sited in industrial hubs.

Looking ahead, **increased circularity of materials** will become more and more important as an option to reduce emissions (including process and end-of-life emissions), to optimize raw material use and to, contribute to security of supply. Resource efficiency is also an important competitiveness factor as it can reduce costs related to raw materials and energy sourcing.

In contrast to the metals and paper sector where recycling is already well established, plastic produced from waste still represents a minor share of total production⁴⁸. In order to achieve significant progress, "waste" carbon must evolve from being a societal "problem" to becoming a valuable resource, whose productivity must be increased. This requires improvements in both waste collection and waste sorting for all sources to enable improved and innovative recycling solutions.

An important challenge for some value-chains will be maintaining the quality of the recycled materials in line with quality and functionality requirements of the final products. Although circularity is already widely embraced by all the EIs, there remain a number of factors that contribute to further realization of the circular economy.

Deployment of all the resources outlined above will require the **timely development and financing of adequate infrastructure**:

- higher levels of electrification will need strengthening of high voltage networks close to industrial consumers
- building of new and further reinforcing of existing electricity Interconnections between Member States
- accomplishment of EU smart grid network. Smart grids can automatically monitor energy flows and adjust to changes in energy supply and demand

accordingly. By providing information on real-smart grids ensure flexibility and efficacy of the grid

- pipeline network for CO₂ transport
- processes using climate-neutral hydrogen, CCS and to a lesser extent recycling of CO₂ will require reliable transport and storage infrastructure
- supply and logistics chains for enhanced use of biomass resources will also need to be developed⁴⁹
- infrastructure will also be critical to guarantee reliable access to waste streams and secondary raw materials
- to ensure industrial symbiosis opportunities are more systematically identified and seized

At present, most of this infrastructure is not in place across the EU. Developing new networks will require a significant amount of capital and time (e.g. planning, permitting and getting public acceptance).

EIs will also have to make some strategic choices regarding sourcing of their energy consumption, will they:

- Opt for a system of exclusively decentralised renewable energy production? For industrial operators, this could have the benefit of being less dependent on the gas and electricity grid. For example, several companies could start producing their own electricity from wind or solar and storing this in the form of hydrogen generated via electrolysis. Decentralised energy production can also take place within industrial symbiosis including e.g. heat exchanges between installations.
- Continue to rely mostly on centralised energy production to keep benefiting from economies of scale?
- Opt for a hybrid system combining own production supplemented by grid supply?

The future will probably consist of all these approaches where some installations continue to rely on central energy production while others produce (part of) their own energy. Factors such as the location of these installations and the costs related to each option will impact on these choices. "Firming costs"⁵⁰ need to be considered; depending on the regional energy mix, pooling balancing costs for EIs could incur the benefits

48 According to Material Economics, only 10% of plastic waste is recycled today

49 VUB-IES (2018), Industrial Value Chain. A bridge towards a carbon neutral Europe.

50 Firming costs is the term used for the cost of taking variable renewable electricity and matching it with a more stable, baseload profile

of economies of scale, while maintaining the option of decentralized RES sourcing.

Since more and more private consumers are also opting for self-production, this could have serious implications for the financing of the electricity and gas grids (i.e. fewer and fewer consumers remain to finance it). In the longer-term, energy-pricing mechanisms may need to adapt in order to follow these trends.

1. Access to key energy and non-energy inputs

The National Plans on Energy and Climate and long-term strategies will be a useful opportunity for Member States to clarify their intentions regarding the deployment of new energy production and the supporting infrastructure. As competitiveness is one of the five dimensions of the Energy Union, Member States in future plans should also outline in more detail how the envisaged measures will impact on industrial competitiveness.

At the EU level, the upcoming revision of State Aid Guidelines on Energy, Environment (EEAG 2014 – 2020) and State Aid Guidelines for compensation of the indirect ETS costs, as well as the planned reform of gas market rules, will have to consider the availability and access of industry to climate-neutral energy and their affordability. Industrial transformation will also require access to alternative feedstock sources. Access to these “non-energy input” will also require a supportive framework and must be treated with the same level of urgency as for energy inputs, building on the Circular Economy Action Plan and Raw Materials Strategy.

Securing climate-neutral energy at globally competitive prices

Improving power sector investment frameworks and addressing electricity pricing issues

Additional risk-hedging instruments for climate-neutral electricity investments providing long-term price signals will be critical. The energy transition involves very significant investments that need efficient risk management in order to reduce capital costs. But there is currently a lack of instruments and counterparts to trade big volumes in the long-term. Even though industrial

consumers may need big volumes, their visibility is seldom longer than 2-3 years in most EU countries, while investors in electricity generation and storage have longer time horizons. Corporate Power Purchase Agreements (PPAs) are expected to play an important role but will not be sufficient to deliver on all the investments needed.

European Commission and Member States

- *Establish a more predictable framework to encourage future investments.*

Market and competition rules to foster competition in the energy sector

Direct and indirect electrification of industry will bring both opportunities and challenges in the transition. On the one hand, if Europe can decarbonise its electricity supply, EIs - as the frontrunner of industrial electrification - will have the opportunity to reduce greatly their CO₂ footprint.

On the other hand, there is a major challenge to ensure the access and availability of climate neutral electricity at globally competitive costs. The adoption of the clean energy package including the new rules on the electricity sector represents a major step towards the integration of renewable electricity into the grid, encouraging more inter-connections and cross-border trade, and ensuring that the market provides reliable signals for future investment.

State Aid rules are also of great relevance to the future of EIs as they should support. Indeed, a sufficient and reliable access to competitively priced climate-neutral energy is one of the most important framework conditions for industrial transition. State Aid rules for environmental protection and energy will have an important role to play, by supporting the further deployment of carbon free energy sources while ensuring that energy costs remain globally competitive for industry. Established grid-competitive, energy sources including for new renewable energy production, should phase out subsidies and exemptions from balancing responsibilities. The impact of remaining exemptions for small installations will require assessment.

European Commission

- *Revise State Aid rules to stimulate further competition among various suppliers and bring further down the cost of renewable energy sources, while providing sufficient investment certainty in Europe*
- *Gradually phase out subsidies and exemptions from balancing responsibilities for all energy sources including established renewable energy sources, as foreseen in the electricity market design regulation⁵¹.*
- *Assess the cumulative impact of exemptions to existing rules (market-based and market-responsive support, balancing requirements, priority dispatch) for small renewable installations*

Until support mechanisms for RES are completely phased out, State Aid rules should maintain current framework to protect industrial competitiveness by reducing the impact of these regulatory costs on their energy bill. In particular, the minimum own contributions of the electricity surcharges are adequately set in the current Guidelines and should be maintained in the upcoming reforms.

Member States

- *Incorporate information on fossil fuel subsidies, measures and plans to phase them out in the NECPs, as requested by the Commission in [COM(2019) 285 final]*
- *Thorough implementation of the Clean Energy Package and new market rules, and full transposition into national rules*
- *Avoid exemptions to the principle of market-based and market-responsive support for renewable energy sources and balancing requirements*

A more globally focused EU competition policy

At the same time, it is essential to ensure that effective state aid controls safeguard fair global competition. State subsidies, market protection, and unfair trade practices that infringe market-based principles can give an unfair competitive advantage to competing firms (see section 1 chapter on “defensive and offensive international

strategies). To counter this, we need strengthened rules to address market-distorting subsidies, including indirect industrial subsidies in the form of tax cuts, cheap sovereign loans to state-owned enterprises and/or inflated procurement prices paid by local public authorities. Also, the reciprocity principle should apply to all free trade agreements between EU and third countries (see section 1).

Finally, it should not be forgotten that state-aid control is in fact a tool aimed at forging genuine competition. State-aid schemes should also consider the need for a level-playing field between EU EILs and global competitors, acknowledge the specificities of industrial sectors and avoid the unintended effect of compromising the global competitive position of European EILs. EU State aid rules only arrange for a level playing field within the EU, without also ensuring a level playing field for EU companies competing worldwide, apart from the existence of a so called “matching clause” in some situations (e.g. the Research, Development and Innovation framework) to compensate for the distortive third-country subsidy. However, this clause has never been applied because there is a lack of data regarding aid granted to competitors by third countries.

European Commission

- *Bridging trade, climate and competition policy including:*
 - *Strengthened rules to address market-distorting subsidies, including indirect industrial subsidies in the form of tax cuts, cross-subsidisation; cheap sovereign loans to state-owned enterprises and/or inflated procurement prices paid by local public authorities;*
 - *Improve the scope and implementation of relevant WTO rules and commitment to the Paris Agreement in the context of free trade agreements*

⁵¹ The priority treatment given to renewables distorts the electricity market while increasing the system balancing costs. Elsewhere, renewable generators should have the obligation to balance responsibly. This has been addressed somewhat in the recently agreed electricity market design and renewable energy directive and should be reflected in the new Guidelines. Under the new rules, priority dispatch for renewable generation is removed in the common rules with the exception of small scale renewable generation (Lower than 400Kw) and demonstration projects for innovative technologies which are still eligible for priority dispatch (Article 5 and 12 of the Electricity Market Regulation). This is correct and new RES units should be responsible for imbalances and should not benefit from priority dispatch

Indirect costs of the EU ETS

Looking ahead, rising price of Emissions Unit Allowances (EUAs) and pass-through of ETS costs from the electricity sector should not act as a deterrent to the electrification of industry. A regulatory framework is needed that takes into account this risk.

At present, compensation for the indirect GHG costs of the EU ETS is governed by State Aid Guidelines. The current system of partial, voluntary and degressive aid is being revised in order to continue to provide adequate protection for electro-intensive industries at risk of carbon leakage due to indirect costs (See section 1).

European Commission

- *Further alignment of the State Aid Guidelines on Energy and Environment and State Aid Guidelines for compensation of the indirect ETS costs*
- *A regularly updated compensation system for the indirect costs of the EU ETS while monitoring progress towards a fully decarbonized power sector, the functioning of marginal pricing and the impact on energy-intensive industries*

Long-term contracts and creation of a commercial and regulatory framework to encourage long-term power purchasing agreements (PPAs)

Signing long term Power Purchase Agreements is a win-win for both electricity providers and industry. For industry, it helps reducing the risk of price volatility and provides a long-term stability to invest. For electricity providers, it gives them the financial security to make the investment.

Elsewhere, the level of electricity interconnection, even between EU Member States, needs to be increased in order to enable energy-intensive industries to sign cross-border PPAs, thereby stimulating the uptake of climate-neutral sources of electricity.

Finally, it is important to factor into the equation that given the electricity pricing dynamics in Europe (marginal pricing mechanism) industry is still subject to indirect carbon costs even when they sign long term PPAs with climate-neutral sources of electricity; wind, solar, hydro or nuclear (Even though the electricity purchased doesn't

contain carbon). The price is indexed either directly or indirectly against the market price, which tends to be set by carbon-emitting generation units for most hours of the year.

European Commission

- *EU Competition law rules to provide long-term guidance and a supportive framework for the signing of long-term power purchase contracts and allow for long-term power contracting*

Member States

- *Increase inter-connections*
- *Ensure better usage of the net-capacity and of the capacity of interconnections*

Energy-intensive Industries

- *Maintain B2B exchanges with renewable project developers via the RE-Source platform*
- *To intensify cooperation between climate neutral energy and feedstock buyers, pooling the demand into large PPAs that enables economies of scale and deployment of innovative technologies on the supply side.*

Cost-effective deployment of climate-neutral hydrogen

Producing hydrogen without carbon footprint is costly today. Successful deployment of climate-neutral hydrogen as an alternative energy and feedstock resource will mostly depend on its ability to compete versus natural gas and hydrogen produced via Steam Methane Reforming (SMR).

The competitiveness of hydrogen from electrolysis will then depend on:

- First and foremost, the cost of electricity: Estimates by the IEA⁵² show that carbon free electricity prices for industry will have to be below the lowest current average price (e.g. around EUR 25/MWh) for H₂ based ammonia production, H₂ based steel production and CCU/H₂ based methanol production to remain competitive in global markets or compared to current production costs;
- The cost of technologies, which can potentially be reduced through greater automation, improving performance of the electrolytic stage.

Applying CCS on SMR can lead to CO₂ emissions reduction of up to 90% but on average, this leads to a CAPEX of around 50% and a doubling of the OPEX (transport and storage costs) compared to conventional production⁵³. Methane pyrolysis i.e. thermal cracking of methane to produce hydrogen and solid carbon could also be a key option for the future but is currently at low TRL level.

Further assessment of the future costs of renewable and decarbonised gases will be needed to provide industry with a robust forecast of the competitiveness of different energy carriers.

Hydrogen can become a globally traded commodity if economic conditions such as differences in carbon pricing favour imports (e.g. through liquid hydrogen, or ammonia as carrier molecule) over domestic production. In order to be competitive and play their role in industrial transformation, it is important that hydrogen, whether produced from electrolysis, biomass or hydrocarbons (during the transition), be protected from carbon leakage.

Deployment of hydrogen will also depend on the development of the corresponding infrastructure, either specifically dedicated to hydrogen or synthetic fuels. Existing energy infrastructure should be used to its maximum potential but investments in new technology and infrastructures are also needed.

Like for the electricity sector, gas market rules will also need to be adapted/complemented in order to secure a cost-effective deployment of renewable/decarbonized gas, facilitate the interaction of the electricity and gas sector, and evolution towards a “hybrid system”.

Finally, research and innovation support is needed to make progress on new technologies for hydrogen production that can improve the CO₂ footprint and OPEX but are at low TRLs like methane pyrolysis (TRL 4-5), thermomechanical process (TRL4) and photocatalytic processes (TRL 2-3).

European Commission and co-legislators

- *Clarify status and rules applying to changing market rules e.g. gas storage, transformation plants, etc.*
- *Establish a clear typology of gases coming from climate-neutral sources and ensure that a full LCA-based methodology is applied to quantify the carbon content of different options*

- *Foster competition in new markets (e.g. hydrogen) from the start (e.g. regulation of transport tariffs, non-discriminatory access...) in order to maintain competitive gas consumption costs for EUs*
- *Develop new network codes or update existing gas network codes to set the legal framework for a growing hydrogen market*
- *Consider a sensible development of the future framework for gas composition: too narrow gas specifications can hamper the liquidity of the European gas markets, while operation, safety and efficiency of certain industrial processes can already be corrupted by hydrogen contents as low as 1,5%*
- *Increase the attractiveness of long-term corporate energy purchase agreements for companies and self-production*
- *Define a roadmap, with clear milestones, for the use of climate-neutral gases in end-users*

Member States⁵⁴

- *Identify the role of climate-neutral hydrogen, especially renewable hydrogen in national long-term climate strategies*
- *Make sure national regulation (e.g. on networks) keeps pace with development of the hydrogen market and do not limit the development of a climate-neutral hydrogen industry*
- *Share knowledge and harmonise standards, including for equipment, safety and certifying emissions from different sources*
- *Build on the potential of industrial ports and existing infrastructure*
- *Establish first shipping routes to kick-start international hydrogen trade*
- *Ensure stable gas quality while blending higher shares of renewable and non-fossil gas in the natural gas network and provide phase-out plans for emissions from fossil gas, in line with the EU's climate neutrality objective^{55,56}.*

Energy-intensive Industries

- *Examine potential for increased share of renewable/decarbonized gas in energy and feedstock consumption*
- *Facilitate the deployment of renewable and decarbonized gas through sector integration between energy and industry*

⁵³ IEA Report on the Future of Hydrogen - Chapter 2: Producing hydrogen and hydrogen-based products

⁵⁴ Partly inspired from the IEA's 7 key recommendations to scale up hydrogen - IEA Report on the Future of Hydrogen

⁵⁵ CAN Europe and EEB are convinced that in order for Europe to make a fair contribution to the objective of the Paris Agreement to limit temperature rise to 1.5°C, all fossil fuel use in the EU will need to be phased out by 2040 and replaced by a fully energy-efficient and 100 % renewables energy system.

⁵⁶ Romania considers that this recommendation is premature, given the complexity and highly-sensitive nature of the issues and wishes to recall that the Council has asked the Commission to “undertake an analysis of sector coupling and sector integration technologies, including the production of hydrogen, in particular with regards to regulatory barriers and based on this analysis explore possible initiatives regarding the efficient integration and deployment of such technologies and carriers” (TTE Energy Council Conclusions of 25 June 2019) and the fact that the subject of sector coupling and sector integration technologies is still under discussion at political level in the Council of the European Union.

Sector integration and demand-side response

Sector integration involves the increased integration of energy end-use and supply sectors with one another. Through sector integration the EIs can assist in the transition through a 'virtuous cycle' between the transition of EIs and the transition of the EU. Cross-sectoral cooperation, not only between the gas and electricity supply, but also between the industry- and energy sector, as well as process innovation (e.g. high temperature electricity-based heat and CO₂-chemistry) and product innovation (e.g. electrolyzers) are major parts of the solution.

Where intermittent energy sources are more frequently used for power generation, energy consumers need to deal with an increasing volatility of electricity production. Looking ahead, the energy supply and demand will be imbalanced for an increasing number of hours a year, as a result of the growing share of renewable electricity generation and the changing energy production locations in Europe. Industry can offer flexibility solutions.

From a system perspective, demand side could contribute to balancing those intermittencies when the electricity system needs system support. Promising candidates to provide such services are Power-to-X technologies and demand side flexibilities from end users. Industry is one of the market players determining the energy demand including which energy carrier will play which role at any moment in time. Interlinking energy markets between the energy- and industry sector (producers, consumers and prosumers, aggregators) can offer solutions to balance the system.

European Commission and co-legislators

- *Electricity market rules to support and incentivize role of Energy-intensive Industries as "prosumers"*
- *Ensuring incentives for industrial facilities to participate in energy balancing markets*

Energy-intensive Industries

- *Provide demand response flexibilities (where possible and profitable)*

Key performance indicators on access to climate-neutral energy

- **Attractiveness and availability of climate neutral energy and competitiveness versus existing sources, including on a global basis:** This indicator (which consists of several sub-indicators), should clearly identify, for key processes, which price (including taxation and fees) is required for switching to an alternative energy/feedstock source, without increasing OPEX, while preserving global competitiveness and taking into account regulatory costs related to electricity.

These could include:

- › *Price of electricity required to switch from natural gas to climate-neutral electricity or renewable gas for heating*
- › *Price of electricity required to switch from current hydrogen consumption based on SMR (e.g. ammonia sector) to hydrogen from electrolysis or hydrogen from SMR using CCS*
- › *Price of climate-neutral hydrogen required to switch to alternative production methods: hydrogen-based metallurgy (carbon direct avoidance), ethylene production via low carbon Methanol-to-Olefins...*
- › *Price of sustainably sourced biomass versus current oil-based feedstock for the production of fuels and plastics*
- › *This indicator should be regularly updated in order to take into account technology developments and efficiency improvements.*
- › *Climate neutral energy generation covered by PPAs*

Ensuring access to alternative feedstock sources

EIs will be in competition for access to primary and secondary raw materials from other sectors of the economy, especially the energy and mobility systems. This could lead to bottlenecks in certain cases.

Promoting supply of sustainable biomass and create a level-playing field between different uses

Biomass is often used as a generic term, but it covers several types of renewable raw materials sourced from a wide range of sectors including agriculture, forestry, fisheries, aquaculture and algae. Stable and competitive supply of sustainable biomass is indispensable for some sectors to reduce their dependency on virgin fossil feedstock. In the chemical sector, the JRC⁵⁷ foresees that the current market for (biomass sourced) bio-based chemicals - excluding pharmaceuticals, energy-, traditional- (pulp and paper and wood products) bio-based chemicals - will grow at a yearly average of 3.8% from 4.7 Mt/a to 6.1 Mt/a in 2025. In the longer term, the chemical industry expects to double its biomass consumption by 2050 with respect to current use (2018), for the production of bio-based chemicals. The chemical industry identified high costs related to bio-based production as a major hurdle⁵⁸.

The use of biomasses for bio-based production in EILs is still very low today. There are several other competing uses, from combustion for heat or electricity, to co-processing to provide both heat and a raw material source, to the production of transportation fuels and materials. These uses are equally important for those sectors to decarbonize.

Biomass, which can be an alternative feedstock, is a resource that needs to be sustainably sourced and managed. In order to guarantee sufficient access to these alternative biomass sources and reduce import dependency, there should be a continued incentive to collect bio-waste. In some countries, there is potential to increase supply coming from agriculture and forestry, in a sustainable manner and preserving biodiversity. Industry should be able to compete on equal footing for access to biomass, also taking into account the efficiency of the use.

European Commission and co-legislators

- *The Common Agricultural Policy should stimulate the contributions of the agricultural sector to increase the share of bio-based feedstock while safeguarding protection of environment and mitigation of climate change*
- *Use of sustainable biomass should only be promoted for uses with the most positive environmental and climate impacts, taking into account the full life cycle and availability of alternatives.*
- *Legislation should adopt a technology-neutral approach and assess each solution according to its impact throughout its entire lifecycle*
- *Creating a reliable framework for certifying guarantees of origin for biomass imports*

Member States

- *In order to ensure a level playing field for the use of biomass (waste) preferential subsidies that favour unsustainable use must be removed*
- *Ensure full implementation of separate biowaste collection, as foreseen in the waste framework directive*
- *Include detailed analysis on availability of sustainably-produced biomass in their National Energy and Climate Plans (NECPs)*

Energy-intensive Industries

- *Ensure resource efficiency and maximize synergies between sectors*
- *Innovation into new processes that allow a better use of all non-food competing biomass sources*
- *Technical progress in lignocellulose extraction and white industrial biotechnology⁵⁹*

57 JRC Science for policy report "Insights into the European market for bio-based chemicals" P 65

58 Idem – P74-77

59 Fermentation of chemical compounds by genetically engineered hosts such as bacteria, fungi or yeast

A raw materials strategy

Transformation of the economy to climate neutrality will require access to more metals, minerals and biotic materials produced and used in low-emission technologies and products. The demand for some could double – the OECD forecasts that global material use will more than double from 79 billion tonnes today to 167 billion tonnes in 2060.

Global competition for resources will become fierce in the coming decade. China is already locking in its future supplies and dominating global markets e.g. for rare earths, metals and their refining. In order to avoid dependence from extra-EU providers, the EU industry needs a more proactive approach to critical raw materials and rare earths e.g. rebuilding the EU magnet capacity for energy transition technologies (wind turbines, etc.).

Mining and extractive industries will also have to become more circular and to reduce their carbon footprint.

All actors⁶⁰

- *Maintain and develop the EU's mining, metals refining and recycling value chain*

European Commission and Member States

- *Step up efforts to make available secondary raw materials to reduce dependency on (import of) virgin materials and related environmental impacts (including emissions)*
- *Continued risk assessment on raw material supplies based on level of economic and social relevance and environmental sensitiveness*
- *Detailed contingencies plans and strategies of diversification in order to coordinate policy and business efforts over the time horizon until 2050*
- *Developing economic partnerships with resource-rich countries to ensure access to sustainable raw materials especially where EU sources will be insufficient*
- *Make better use of the EU's domestic potential, building on the regular criticality assessments*
- *Secure long term access to domestic resources*

- *Incorporate in the EU economy and external relations the contractual and diplomatic framework to secure long-term raw materials through specific supply and investment agreements*
- *Ensure coherence of policies and regulation affecting raw material mining and extraction*
- *More predictable and faster permitting procedures to increase resource security and sustainability*
- *Raise public awareness on the need for raw materials and extraction activities (primary and secondary) for the EU economy in order to enhance public acceptance*

Energy-intensive Industries

- *Engage in strategic thinking involving their whole respective value chain to secure long-term supplies of raw materials from imports and domestic sources, collectively assessing where the pressure points are;*
- *Develop a strategic approach towards securing long-term supplies of raw materials from external and domestic sources, and apply the necessary risk management and investment policies, where necessary with active support from the EU and Member States in terms of developing economic partnerships with resource-rich countries*
- *Develop more sophisticated risk mitigation measures*
- *Develop - together with the raw materials sector and downstream industries - common practices and standards to manage and monitor the raw material supply and value chains with regard to the sustainability, reduction of CO₂ emissions and CSR*
- *Develop due diligence and transparency in raw material supply chains*

Key performance indicators on alternative feedstock sources

- EU share of global 'biomasses' and other raw materials production
- Import reliance

60 Recommendations are mostly based on the input of the European Innovation Partnership on Raw Materials and the Raw Materials Supply Group

Further areas of reflection for the medium/long-term**Electricity pricing**

With a fast-growing share of electricity with zero marginal cost, a bigger share of the costs will relate to capacities and infrastructure, as well as balancing costs for those that do not wish nor can adapt generation/consumption profiles.

Marginal pricing of electricity also represents a barrier for sourcing of renewable electricity: as long power of the marginal plant will be running on fossil fuels, Energy-intensive Industries will have to pay for the indirect CO₂ price even when they consume carbon free electricity. New subsidies for all technology-mature energy sources should be avoided incl. feed-in-tariffs for renewable electricity, as they take away the incentive for corporate sourcing of renewable electricity. Whenever possible, costs related to capacity and connectivity should not be socialised, but distributed according to the current principles for calculating tariffs. It is important that pricing of electricity should remain transparent, cost-reflective and non-discriminatory, in line with current rules.

A dialogue is required under the next Commission with energy market parties (producers and consumers) and regulators on the impact of costs distribution between fuel, capacity and connectivity on industrial competitiveness, in the medium to longer-term.

Will there be enough climate-neutral energy to satisfy demand in the longer term?

If global electricity prices are more attractive than in Europe, it could also make more sense to import renewable energy in the EU e.g. in the form of hydrogen or biomethane. In the coming decade, one could not exclude importing electricity, for instance as a product in the form of H₂, ammonia or synthetic fuels. In the longer term and if the necessary infrastructure is there (e.g. interconnections and a world grid), it could be imported directly e.g. from North Africa, Greenland. However, until now projects like DESERTEC failed to deliver due to feasibility problems and a lack of interconnections.

2. Circular Economy, resource- and energy-efficiency*Maximise the use of waste as a resource*

Greater circularity of materials represents a major opportunity for those sectors that rely heavily on raw material imports into the EU and/or wish to switch to alternative feedstock with a lower carbon footprint. In some sectors however, not all available technological options are currently economically feasible because of higher related costs. Cost reductions are achievable through higher economies of scale, once industry starts processing significant amounts of waste but there are already multiple competing claims for access to waste, especially from the district heating sector. There as well, industry should be able to compete on equal footing, still taking into account the efficiency of the use.

In order to tap into the full potential of circular economy and unlock potential feedstocks for industry, improvements are needed in the collection and sorting of waste streams. A large portion of mixed waste streams are still disposed of in landfill because they cannot be reprocessed cost-effectively or because of technical challenges. Other waste streams are off-shored to countries outside of the EU and often result in them being disposed in a way that creates a greater environmental impact globally.

In order to ensure that secondary raw materials get recycled into a much wider range of applications, it will be important to retain the value of high-grade materials for the next life, increase the quality of current waste streams and avoid product contamination.

The EU legislation concerning waste should shift, at least at the industrial level, from a pure waste management scope to resource use and valorisation. Implementation of the Circular Economy Action Plan should ensure a level playing field for the use of secondary raw materials, including bio-waste or other waste by removing subsidies that favour one use of those secondary raw materials over another. EUs recognize the importance of the waste hierarchy as an instrument and industry is evolving towards higher waste management options through innovation. Within this instrument, all options

that can contribute to value creation and improved conservation of resource, based on life cycle thinking, must be recognized in order to take into account ongoing developments in industry. Therefore, recycling options should be “material-loop” driven and should embrace all technical options and developments available from industries.

Because the main customers of Ells are other industries or businesses, many of the regulatory and other solutions will have to happen downstream. This includes: designing products for optimal use of materials including design for recyclability (preventing over-engineering); design for reuse (e.g. longer lifespan of final products, repurposing of the product or of its parts...); design for disassembly (i.e. to avoid contamination of materials and save costs in disassembly processes that enable reuse and recovery), and improved end-of-life processes (smart disassembly and demolition processes that allow for higher and less contaminated recovery of materials). Life-cycle thinking should give guidance in case of target conflicts between those various objectives. Improved reverse logistics and enhanced use of digital technologies to sort and track materials can also help.

Ells will also have to deploy solutions to process new feedstock streams, once they become available, to fulfil the “liver function” of the circular economy.

The current waste framework directive and sector specific directives such as those on packaging, e-waste and batteries already sets ambitious targets for recycling but there is still a need for more elaborate, ambitious European circular economy regulations.

European Commission and co-legislators

- *provide technical guidance and specifications for secondary raw materials*
- *support development of real market for secondary raw material*
- *assess how to facilitate the flow of waste products and allow a truly functional, pan-European market for legally-compliant waste sorting and recycling*
- *enforce EU ban on landfilling of recoverable and recyclable materials*
- *elaborate more precise and technically sound definition of recycling: recycling options should be “material-loop” driven and should embrace all the technical options available from industries (incl. chemical recycling, multiple recycling, co-processing, etc.)*

- *enforce regulation on waste prevention and recycling that supports material circularity and priorities, prevention as first level, as well as recycling over waste incineration (if technically and economically feasible)*
- *consider the inclusion of waste incinerators under the EU ETS or tax their emissions at the level of the EU ETS carbon price*
- *Improve access to knowledge base on historic extractive waste facilities*
- *enable access to funding for research and development to increase the use of secondary materials*

Member States

- *accelerate move to landfill free societies and improve separate collection*
- *remove hurdles to safe transport of waste across-borders*
- *harmonize “end-of-waste criteria” among member states*
- *reinforce market surveillance and enforcement of hazardous waste transport*
- *identify existing local regulatory barriers which block the development of economies of scale in recycling (e.g. lack of clarity over ownership of waste or local approval of large-scale sites)*
- *improve labelling schemes to simplify waste separation for customers*
- *consider modulation of EPR fees according to products requirements such as recyclability, reparability and durability taking into account the full life-cycle of products*
- *encourage investments into and improve MS permitting of recovery of materials from historic extractive operations*

Energy-intensive Industries

- *develop new business models to answer the needs of a circular economy*
- *increase productivity of carbon and carbon-based resources*
- *making better use of the EU’s domestic potential, building on the EU’s regular criticality assessments*
- *together with other value chain partners, improve reusability and recyclability of products;*
- *together with other value chain partners, improve tracking of secondary raw materials and chemicals*

- cooperate with other value chain partners to develop new and more efficient separation technologies
- support workforce training in order to have a circular economy-ready workforce

Waste management and treatment entities

- more precise sorting based on the quality of the basic (constituent) materials in end-of-life products they receive
- facilitate access to waste streams

Key performance indicators on circularity and resource efficiency

- Percentage of waste streams prepared for reuse and recycling
- Availability of waste and secondary raw materials as alternative feedstock, at required level of quality and affordable cost
- Number of hubs for circularity

Creating synergies between sectors in the transition and promoting industrial symbiosis as a horizontal solution

Greater synergies between governments and industry and between different industries can create new opportunities to recycle/recover more materials from waste streams to be used as an alternative source of raw materials and fuels.

Symbiosis will become more prominent as sectors seek to reduce GHG emissions by widening the range of technological and organizational options for making business and operations more efficient, competitive and sustainable across process sectors. Innovative solutions often derive from industrial cooperation, through industrial symbiosis models and exchange of waste streams, secondary raw materials or by-products. Co-generated waste and materials flow within the “Technosphere” among industries aiming at full optimisation of resources. These are industrial synergy or symbiotic business models. In order to promote the use of renewables/recyclables as feedstock, of industrial co-generated materials and energy sources in a circular economy and industrial symbiosis approach, policies should secure a level playing field between different uses.

European Commission

- Build on best practices of industrial symbiosis
- Promote clustering of EIs sectors able to jointly deliver in a certain area

Member States

- Promote regulatory frameworks that enable companies and sectors to work together and invest in new types of operations
- De-risking cooperation between companies
- Financing the infrastructure linking companies and assisting with back-up infrastructure

Energy-intensive Industries

- Improving knowledge sharing across industries
- Further assess opportunities of industrial symbiosis projects

Greater integration of EIs with the energy sector can also contribute to energy savings in a cost-efficient manner. For example, EIs can buy or sell excess heat from or to district heating networks - if such networks are available and accessible to competitors. Unfortunately, the district heating sector is not unbundled, which limits EIs' access.

Ensuring Energy Efficiency policies, which are compatible with deep GHG abatement technological options

While Energy Efficiency will be a must to make sure that limited energy resources continue to be used as carefully as possible, in the long term industry might need growth-compatible policies that include the possibility to increase the energy consumption in some technologies and explore when increased energy needs may be justified reducing the GHG-intensity of processes, in particular when excess renewable energy sources are used. There is still considerable potential for energy efficiency in industry; however, deep reduction of GHG-intensity in industrial processes might result in increased energy needs. The economy-wide EU-wide energy efficiency target formulated as an absolute limit on energy consumption needs to take account of the potential increase in industry's energy demand that may result from its decarbonisation. Future technology developments should be taken into count to assess potential trade-offs between a target to reduce absolute levels of energy consumption.

European Commission

- *Consider developing a waste heat market*
- *Assess potential interlinkages between the final energy consumption target and energy savings obligation on one hand, and the deployment of alternative energy sources in EIs on the other.*
- *Consider tailored policy tools for EIs, maintaining strong ambition on energy efficiency, while allowing the deployment of alternative energy sources. Baseline energy consumption under the Energy Efficiency Directive to take into account the significant increase in electricity/energy demand resulting from realistic estimation of the deployment of GHG emission abatement options in EIs (including impact of higher demand for “enabling” products in other sectors of the economy)*

Member States

- *Ensure the full implementation of the energy savings obligations and provide a policy framework that maximises the uptake of renewable energy in industry. Prioritise district heating development to which waste heat can connect*

Energy-intensive Industries

- *Maintain energy efficiency first as a guiding principle across all operations*
- *Plan industrial plants to make them ready for waste heat recovery and waste heat delivery.*

Energy-intensive Industries

- *Prepare and reskill the workforce for using these technologies*

3. Which infrastructure for 2050?

Transitioning towards climate-neutrality will require several adaptations and upgrades in the EU’s energy infrastructure, as well as the development of new infrastructures for hydrogen, CO₂ transport and storage (including cross-border transport of CO₂). This energy infrastructure will need to develop in an integrated manner in line with future developments in the transport infrastructure as well as digital networks. Industrial symbiosis will also require greater interlinkages between industrial facilities e.g. to transport CO₂, waste streams and other by-products. Currently, most of the required infrastructure is not in place across the EU and substantial investments will have to take place.

Electrification will lead to increased pressures on existing grids and there will be a need to build new grids to cater for this increasing electricity demand. On the gas side, system operators estimate that the infrastructure is currently capable of handling penetration of up to 20% hydrogen. However, the infrastructure that can hold 100% hydrogen is only (partly) available in a few member states.

There is therefore an urgent need to develop an integrated and cost-effective infrastructure strategy to support the transition of industry and energy towards climate-neutrality, building on the TEN-E strategy. In this context, revision of the 2013 TEN-E Infrastructure Regulations in light of the changing infrastructure and system security needs must take into account the potential of sector coupling as well as the importance of distribution systems.

The ENTSOs’ (Ten Year National Development Plan) scenarios must ensure that long term projections for the overall energy and gas demand are Paris Agreement compatible and in line with the most recent analyses. The approach should look in-depth into the role of a digital, strengthened and interconnected electricity grid, and include the development of “grid intelligent” renewables providing services to the network. Further, it must take into account the benefits of sector coupling.

Role of artificial intelligence (AI)

Digital technologies such as data mining and automated data analysis can support energy and resource efficiency in industry e.g. through machine learning-based optimization. It can also lead to new digitally enabled supply chains (e.g. for waste) and facilitate interactions within industrial clusters (industrial symbiosis). Finally, digital technologies can form the basis for new data-based business models such as leasing of products.

Embracing AI does not go without any risks and is faced with a number of limitations, which currently act as a disincentive: data security, lack of internal skills or capacity, lack of maturity of AI technologies, etc.

European Commission

- *Identify together with Member States and Energy-intensive Industries current and future infrastructure needs to support industrial transition by:*
 - *Mapping medium and large industrial sites and clusters in Europe and existing infrastructure which can be used for new energy carriers with limited upgrading costs*
 - *Carrying out a bottom-up assessment of future industry needs for key energy and non-energy inputs taking into account synergies at local or regional industrial clusters*
 - *Assessing the consequences and requirements of an integrated system (sector integration) and the need for storage capacity to balance the system*
 - *Assessing possibilities for cross-border infrastructure linkages*
 - *Performing gap analysis comparing today's infrastructure with 2050 infrastructure needs*
 - *Quantifying the costs attached to the new required infrastructures*
 - *Analyzing different scenarios (centralized vs. decentralized energy production, natural gas based vs. hydrogen-dedicated infrastructure, high direct electrification vs. lower direct electrification...) and assessing their cost efficiency*
 - *Identifying priority investments for the deployment of GHG abatement solutions (e.g. required infrastructure to support demonstration of key enabling technologies by 2030)*
 - *Considering milestones to ensure that infrastructure development is aligned with progress on delivering climate neutrality*
 - *Establishing a first list of European industrial projects of common interest related to infrastructure for further development and financing*
 - *Identify the national or regional availabilities for renewable and decarbonised gases, as well as the potential for using the existing infrastructures for new energy carriers*

Member States

- *Identify, prioritise and support the development of strategic infrastructure for industrial transformation, especially where important spill-overs may exist*
- *Minimise permitting procedure time requirements*

Energy-intensive Industries:

- *Launch a new EU platform consisting of industrial actors, research and technology organisations (RTOs), technology and infrastructure providers to support Commission and Member States*

Adapting to different regional starting points

Across Europe, often due to different geographical endowments (availability of hydro, etc.) regions have different starting points when it comes to their potential to decarbonize their power sector. The EU electricity sector is aiming to become carbon neutral by 2045⁶¹. The Seventh Report on Economic, Social and Territorial Cohesion⁶² looked at aspects related to Energy Union and climate change (See chapter 2). As shown in the related maps, some regions already produce a lot of renewable energy. For instance, many parts of the EU have regions with a high share of solar or wind energy. Nevertheless, the potential for renewables is not evenly spread. In some regions, electricity generation is still largely dependent on coal and lignite. This is particularly the case in most regions of Poland but also in Germany, the UK, Italy, Ireland, Spain, Czech Republic, Romania and Croatia (non-exhaustive list).

When developing the necessary infrastructure, different regions will have to coordinate their approaches to avoid possible supply chains incompatibilities (e.g. structural imbalances between supply and demand for H₂ and/or CO₂). No region must be left behind. Therefore, industrial clusters at risk of becoming isolated from new low-CO₂ infrastructure must be identified together with options to mitigate this.

Finally, EU funds and instruments can support the transition of regions that still heavily rely on coal and lignite for example via the coal regions in transition initiative.

61 Eurelectric Decarbonisation Pathways - <https://www.eurelectric.org/decarbonisation-pathways/>

62 https://ec.europa.eu/regional_policy/en/information/cohesion-report/

4. Social dimension

Transformation of the industry and energy sector will also need addressing from a social perspective:

- Development of new infrastructures for the production, storage and transport of climate-neutral energy may face resistance from local communities. Construction of new windmills, high-voltage lines, hydrogen pipelines or CO₂ storage sites often faces negative reactions (“not in my backyard”)
- Energy/electricity must remain affordable, secure and sufficient, otherwise deep GHG emissions reductions might not happen/or even fail with dramatic consequences for the future of EIs and their workers. Distributional impact of climate measures will also have to be taken into account in order to avoid that people with low income are disproportionately affected through their electricity/heating bills
- Coal phase out will impact on coal mining regions and result in job destruction. A successful industrial/energy transition is key in order to ensure that new jobs can be created as an alternative

Many of the new jobs that could develop as a positive result from the transition towards climate-neutrality will be in the energy sector according to the Commission’s analysis. Workers in the EIs will also need to be equipped with new skills in order to deal with new resource streams. One example is the “internet of electricity” in relation to electrification. Workers will also need to be educated in order to deal with increased circularity of materials and the related processes, supported by a strong social dialogue to ensure that workers are fully informed and can participate in the change.

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