A Clean Industry Package for the EU

Making sure the European Green Deal kick-starts the transition to climate-neutral industry

IMPULSE

Agora Energiewende

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Making sure the European Green Deal kick-starts the transition to climate-neutral industry

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Preface

Dear reader,

To align with the Paris Climate Agreement, the European Commission has recommended that the European Union reduce emissions by 55% by 2030 (relative to 1990 levels) and achieve climate neutrality by 2050. To achieve these goals, the EU and its member states must redouble their efforts to support the greening of the industrial sector, especially its energy-intensive sub-branches, such as cement, steel and chemicals.

Industry accounts for approximately 20% of the EU's net annual CO_2 emissions. In the 2020s, a large portion of Europe's industrial installations will be up for major reinvestment decisions. Since these are investments in very long-lived capital assets, the EU must make the most of the opportunity if it is to have a serious chance of achieving climate neutrality by 2050.

Capitalizing on the opportunity will require urgent action by member states and by the EU as a whole. As explained in this report, the EU will need to devise a comprehensive "clean industry package" to unlock transformative investments in the upstream, midstream and downstream segments of the industrial value chain while providing a level playing field for European industrials with respect to foreign competition.

I hope you find this report informative and stimulating.

Patrick Graichen,
Executive Director, Agora Energiewende

Key findings at a glance:

1. **By 2030, between 30 and 53% of cement, steel and steam cracker plants in the EU27 will require major reinvestments.** Based on existing policies, there is no credible business case to make investments that are compatible with climate neutrality by 2050. As a result, the EU faces a serious risk either of plant closures and job losses or the lock-in of CO_2-intensive technologies.

2. **EU ETS carbon prices and a carbon border adjustment will not be enough to create a business case for key low-carbon technologies before 2030.** Many "breakthrough" technologies will require carbon prices on the order of 100 to 170 €/tCO_2 if they are to be competitive. To make these technologies economically viable, supplementary policies such as carbon contracts-for-difference will be needed.

3. **In 2021, the Commission needs to propose a clean industry package of genuinely transformative policies, unlocking investments in the upstream, midstream and downstream segments of the value chain.** The package should include carbon contracts for difference; planning and financing tools for clean-hydrogen infrastructure in industrial clusters; free ETS certificates and protection against carbon leakage; and standards to create markets for climate-neutral and circular products.

4. **Europe must begin to transform its industrial sector even before EU legislation is passed.** Member states can accelerate economic recovery in the short term by supporting investments in industrial decarbonisation. With comprehensive clean-industry legislation, the EU can drive investment in low-carbon transformation and create economic resilience in the medium term.

Content

List of Figures

List of Tables

List of Boxes

1 Introduction

Under the 2030 Climate Target Plan and the European Green Deal, the European Commission has recommended that the EU reduce its greenhouse gas emissions by -55% by 2030 (relative to 1990 levels) and achieve economy-wide climate neutrality by 2050 (European Commission, 2020a). Achieving these targets is technologically and economically achievable with the right policies in place (Agora Energiewende & Oeko Institute, 2020a). Meeting them will also keep the EU on track to fulfil its commitment to climate neutrality under the Paris Agreement. During the post-COVID19 recovery, more ambitious climate action can boost the economy by stimulating investment in green infrastructure and technology, creating new jobs and laying the foundations for long-term industrial competitiveness.

The **European industrial sector has a vital role to play in delivering this vision of the European Green Deal**. Direct emissions from the EU27's industrial sector accounted for 719 MtCO_2eq in 2017, equivalent to 20% of annual net EU greenhouse gas emissions (Eurostat, n.d.)[1]. By far, the greatest emitters are the cement, steel and chemicals sectors, making up approximately 60% of the total. By 2050, the EU will need to reduce its combined industrial emissions by approximately 95% and offset residual emissions with carbon sinks to achieve climate neutrality.

The **transition to a climate-neutral industrial sector can contribute to economic recovery and secure long-term prosperity**. Between 2020 and 2030, between 30 and 53% of the EU's aging industrial plants in the cement, steel and steam cracker sectors will require major reinvestment and refurbishment.[2] Existing, high-carbon technologies must be replaced with low-carbon technologies. Moreover, significant investment is needed in strategic infrastructure such as clean power, hydrogen, biomass and carbon capture and storage. New skills and jobs will be required to facilitate this transition to innovative, climate-neutral technologies and business models. The next 5 to 10 years thus represents a major window of opportunity in which Europe can combine the transition to climate neutrality with economic recovery and long-term stability. Given the urgency posed by the climate crisis, member states must begin to make these investments during the next several years and the EU must follow up with robust legislative policies.

Border carbon adjustments and expected carbon prices will not be sufficient to initiate investments in climate neutrality over the next 10 years. The industrial sector has yet to invest in key low-carbon technologies at industrial scale. This is not primarily because of international competition but because carbon prices are not expected to be high enough during the next decades to justify the economics of these technologies. Even with carbon prices averaging 45-60 €/tCO_2, as proposed in the recent Impact Assessment of the 2030 Climate Target Plan, nearly all of the key low-carbon technologies would not be profitable. Moreover, carbon prices or border adjustments alone will not create the conditions needed for investment in clean power, hydrogen, CCS infrastructure and other technologies. Likewise, the development of efficient, circular value chains requires lifting a range of price and non-price barriers.

With between 30 to 53% of the EU's energy-intensive industrial assets will be up for major re-investments during the next 5 to 10 years, policymakers must act now. The EU needs a strong regulatory framework that provides clear incentives for investment along the entire value chain, from

1 The figure excludes emissions from energy sectors such as upstream power and heat production, refining, and solid fuel production.

2 See Wuppertal Institute (2020; forthcoming).

infrastructure and production to final products and recycling.

With genuinely transformative policies, the EU can shift the course of global efforts to decarbonize industry. From vehicle emissions standards to energy labelling, the EU is a recognized leader in environmental regulation. Recently, the People's Republic of China put forward its own plan for achieving carbon neutrality by 2060 (NYT, 2020). By demonstrating what is feasible in so-called "hard to abate" industrial sectors, the EU can also have an outsized influence on policy to decarbonize industry globally, including among major emitters like China, whose industry accounted for 5.17 gigatons of CO_2eq emissions in 2014, or 46% of China's total for that year (UNFCCC, n.d.). Moreover, if the EU acts boldly now, it can become a technology leader and effectively set the global standards for climate-neutral production and products.

The purpose of this paper is to explain why the legislative package which will be proposed in 2021 to implement the 2030 Climate Target Plan and the European Green Deal must consist of a transformative and comprehensive policy package to drive investment and job creation in clean industrial technologies. The next section explains in more detail why a policy package is required. Section three then sketches some concrete proposals for a clean industry package.

2 Why the EU needs a clean industry package now

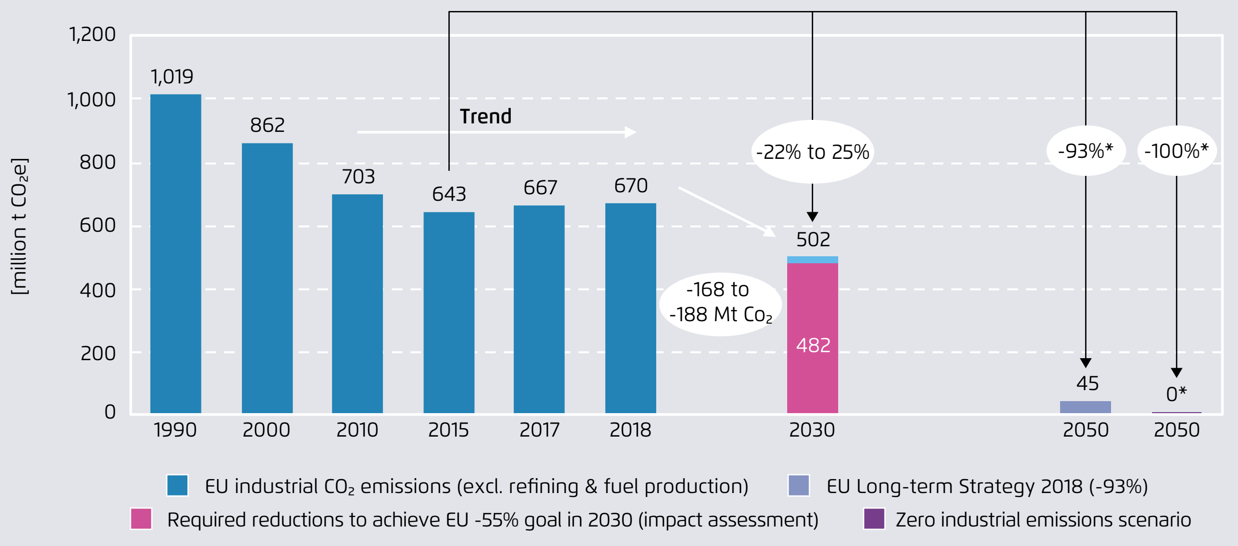
There are three basic reasons why the EU needs a clean industry package:

- → Continuing current policies until 2030 will lead to high-carbon technology lock-in in the medium term and will put jobs at risk in the short-term because there will be no credible business case for clean investment.
- → The EU is ready to begin investing in a portfolio of key low-carbon technologies during the next 5 years.
- → Only a coordinated set of policies across the value chain can ensure that the necessary investments will be made.

2.1 Continuing current policies until 2030 will lead to high-carbon technology lock-in and put jobs at risk

To stress again, the industry sector accounted for 719 $MtCO_2eq$ (or 20%) of the EU27's emissions in 2017. The total is even higher if one considers indirect emissions sources. To achieve the -55% emissions reduction target by 2030 and reach climate neutrality by 2050, the EU will need to make significant steps towards reducing its industrial emissions. For example, meeting the 2030 target will require the EU27 to cut its industrial CO_2 emissions by between 22 and 25% relative to 2015 levels (Figure 1).

CO_2 emissions of the EU27 industry sector from 1990 to 2018 and proposed sector targets for 2030 and 2050 — Figure 1



Agora Energiewende, based on data from Eurostat, European Commission & EEA

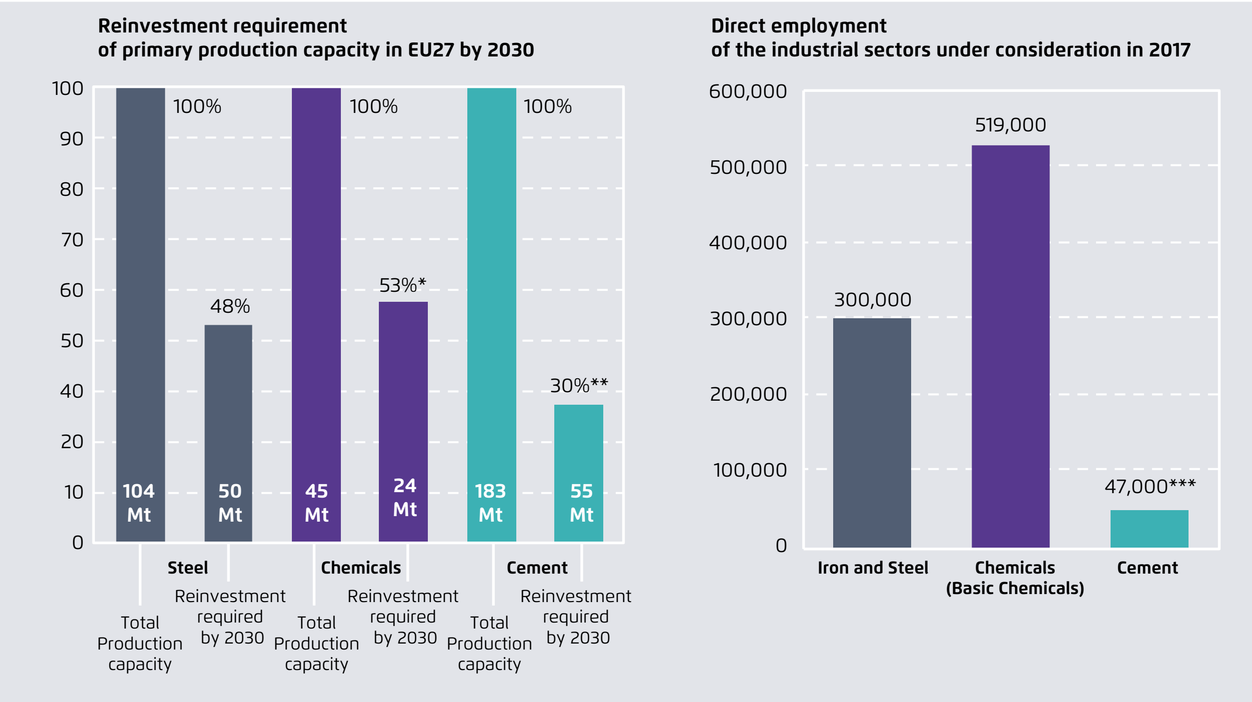
Note: Data are for CO_2 emissions only. They exclude non-CO_2 emissions from industry, from refining, solid fuel production for energy and non-energy uses.
* Residual Emissions will have to be compensated for climate neutrality by negative emissions technologies, many of which could be developed by the Industry (BECCS). Industry could potentially be a source of net negative emissions by capturing and using CO_2 from other non-industry sectors.

In one sense, this is not a very significant increase in expected business as usual reductions, since the introduction of the Clean Energy Package and the 2018 carbon market reforms are already expected to decrease industrial emissions by 18% by 2030 relative to 2015 levels. The European Commission's Impact Assessment of the 2030 Climate Target Plan has shown that the most energy-intensive industry sectors in the EU Emissions Trading Scheme (EU ETS) could deliver a 29.4% reduction in emissions by simply adopting the best available current technologies, which are already used by 10% of EU installations (Figure 1).

But what matters is not only that the EU industry reduces emissions by 2030 but also, more importantly, how it does so. The EU's overarching goal must be to reduce industrial CO_2 emissions by ~95% by 2050. In one scenario, the EU industry could reduce emissions by approximately 25% by 2030 through a range of marginal improvements to the efficiency of existing technologies. But doing so would have the perverse effect of locking in technologies and energy sources unable to achieve climate neutrality by 2050. It is critical, therefore, that the 2030 goal is met with low-carbon technologies that are compatible with climate neutrality in 2050. Policymakers must encourage the industrial sector to invest during the next 10 years in ambitious abatement options for climate neutrality in 2050. This means implementing policies that go beyond the ETS.

The EU's energy-intensive industrial assets are slated for major reinvestment and refurbishments during

Re-investment needs by 2030 and direct employment in cement, steel and basic chemicals in the EU — Figure 2



Agora Energiewende/Wuppertal Institut, 2020

* Steam crackers are normally maintained and modernised continuously so that they are not completely replaced at one time. However, the need for reinvestment gives a rough impression of the need to modernise existing facilities.
** Indicative: Cement data represent numbers for Germany only. We estimate that the reinvestment requirement for EU27 is in a similar range.
*** Own estimate for 2017 based on Cembureau 2015

the coming decade. It is imperative that the sector make new investments in technologies that are compatible with climate neutrality by 2050 (Figure 2). Based on the ages of current plants, some 48% of blast furnaces (primary steel), 53% of steam crackers, and roughly 30% of cement kilns will require modernisation to remain in operation and avoid carbon leakage. A policy framework is urgently needed to make sure that the right climate-neutral investments are made. Otherwise, the industry risks stranding its assets and increasing the costs of achieving its climate targets.

The flip-side of this equation is that the upcoming investment cycle in energy-intensive industries presents a unique opportunity for advancing the EU's economic recovery, provided that the right policies are in place.

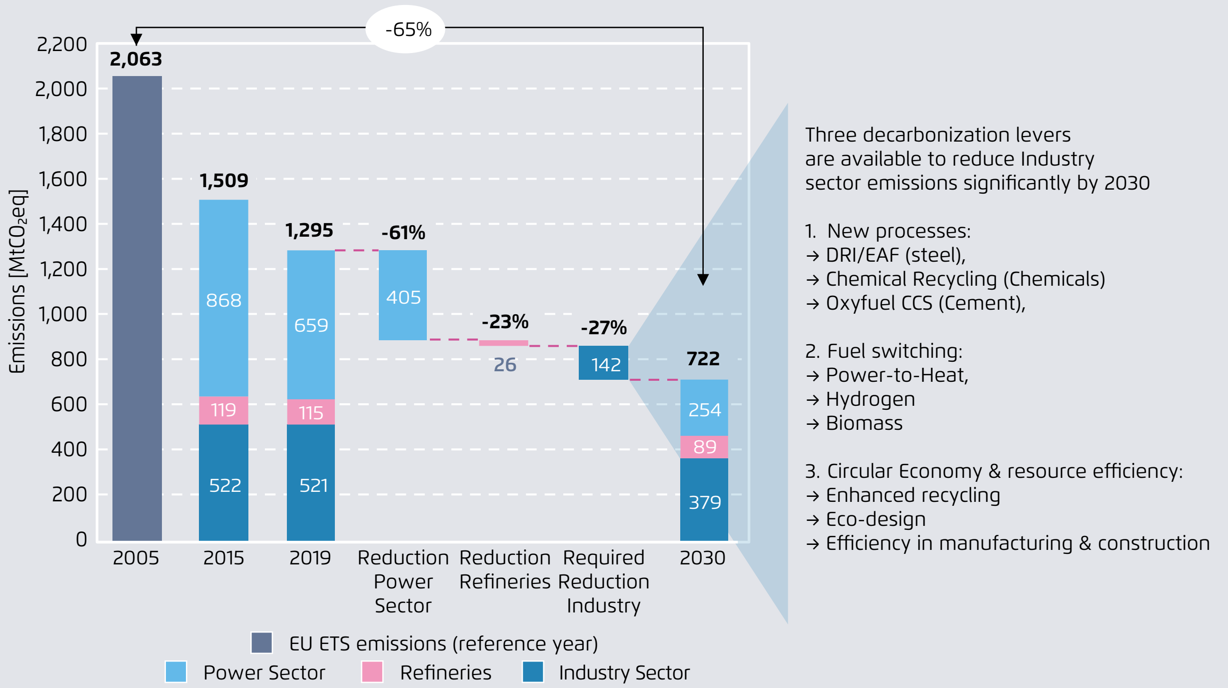
2.2 The EU is ready to begin investing in a portfolio of climate neutrality-compatible solutions

Despite the lack of progress in reducing emissions (Figure 1), the European industry has at its disposal a growing number of key low-carbon technologies and other levers to reduce emissions. Though some technologies are not fully mature, there is no reason why the EU cannot begin to deploy some key technologies already during the next 5 to 10 years.

Figure 3 shows estimates for the necessary emissions reductions by industry in the EU ETS. Using data from the European Commission and European Environment Agency, we estimate that energy-intensive industries will need to

Expected emissions reductions from EU ETS industry under a -55% 2030 EU climate target and decarbonization levers to deliver those reductions

Figure 3



Agora Energiewende, based on data from European Commission, EEA, and Eurostat.

Note: Emissions that relate to industrial processes such a coking plants and power plants for industrial use are accounted for in the industry sector and not in the transformation sector. ETS emissions in 2005 are notional base year emissions with respect to the 2030 target, i.e. they account for the change in the ETS scope and size of the EU since 2005.

reduce their emissions by approximately 27% by 2030 relative to 2019 levels. The figure lists three broad categories of solutions that can be deployed to achieve these reductions in a manner compatible with climate-neutrality in 2050:

First, industries can reduce emissions significantly by **starting to commercialize key low-carbon production technologies**. These include direct reduced iron (DRI) for steel production, chemical recycling, and carbon capture and storage (CCS) in the cement industry, which are all near-zero-carbon technologies and have sufficient technological maturity for commercial-scale deployment during the next 5 years.

Second, industries can achieve massive reductions by **fuel switching** from fossil fuels to net-zero alternatives such as direct electrification with decarbonized electricity, biomass, and, clean hydrogen in steel and chemicals production.

Third, **circularity and efficiency in the use of basic materials** (such as steel, aluminium, plastics, cement and concrete) have the potential to reduce emissions in energy intensive industries by up to 50% by 2050 (Materials Economics, 2018). While some of these measures will not have an effect until after 2030 due to long product lifetimes, a number of measures can already begin to yield benefits before then.

Implementing these solutions at the 30–53% of cement, steel and chemical production sites slated for refurbishment during the next decade can dramatically shift industrial production facilities towards climate neutrality.

2.3 A coordinated set of policies along the value chain is needed

Border Carbon Adjustments are often proposed as sufficient solutions to kick-start the low-carbon transformation of the industrial sector. But, as noted previously, this is far too simplistic. One of the main reasons is that companies that use low-carbon technologies must compete not only with foreign producers but also with domestic manufacturers using conventional technologies. This requires carbon prices that are higher than those currently planned.

Figure 4 shows that the current carbon price – 27 €/tCO_2 – is well below the levels required to drive investment in breakthrough technologies. Not even the 45-60 €/tCO_2 proposed by the European Commission's Impact Assessment on the 2030 Climate Target would be high enough to ensure the proper investments.

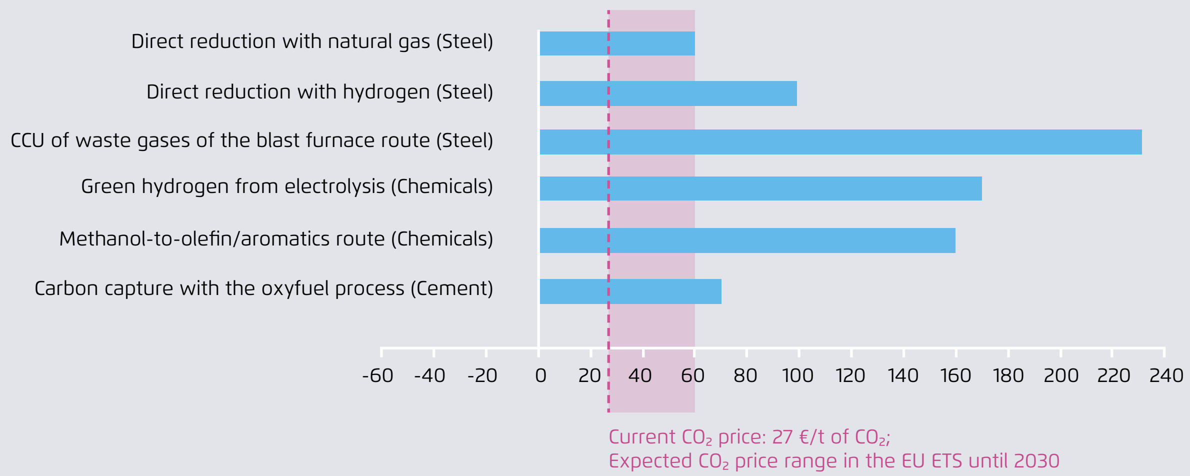
But even if carbon prices rose enough for these technologies to be profitable in the short term, uncertainty surrounding ETS pricing would still create a barrier to investment. After all, the ETS price has fluctuated dramatically, going as high as 30 and as low as 0€/tCO_2, and there is no guarantee that it will remain high. Additional instruments to support the economics of expensive key low-carbon technologies are therefore needed.

The conditions needed for the industrial sector to invest in decarbonisation measures go beyond the simple question of carbon price levels or the risk of carbon price volatility, however. Specific needs can be identified along the value chain:

→ **Upstream:** The industrial sector needs reliable access to clean energy and basic materials at competitive prices via new infrastructure. It also requires additional infrastructure planning and financing for industrial clusters and cross-border, pan-European solutions when appropriate.

Estimated CO_2 abatement costs of selected key technologies versus today's conventional reference process for 2030

Figure 4



Agora Energiewende/Wuppertal Institute, 2019

Note: CO_2 abatement costs depend very much on assumptions about electricity costs. For the calculation of these values, electricity costs of 60 euros per MWh were usually assumed. The estimates here are based on Agora Energiewende/Wuppertal Institut 2019 and represent the lower bound of CO_2 abatement costs in 2030. Higher CO_2 abatement costs are to be expected before 2030, compared to after 2030, because the technologies must still undergo learning curves for cost reductions.

- → **Midstream:** The industrial sector needs the right economic and financial conditions in order to develop, implement and operate investments in key breakthrough technologies and in order to address the risks of carbon leakage.
- → **Downstream:** The industrial sector needs demand and scalable markets for decarbonized and circular products, markets that have internalized the higher costs of decarbonized products, and incentives to integrate the circular economy and resource efficiency all along the value chain.

A detailed discussion of these requirements is beyond the scope of this paper, but Table 1 summarizes the ten most urgent considerations.

The new European Commission has already proposed policies that could, if well-implemented, address some – but not all - of the industrial sector's specific needs. These include the Hydrogen Strategy, the Sustainable Products Policy Initiative and the Circular Economy Strategy. However, to create a business case for truly climate-neutral investments, these broad initiatives must be turned into strong economic and regulatory incentives.

In some areas, such as infrastructure planning in key industrial clusters, implementing instruments to support the high operating costs of ultra-low carbon technologies or creating new markets for ultra-low carbon products, the Commission has yet to make concrete proposals. Accordingly, key gaps still need filling.

10 essential conditions for industry to transition to climate neutral products, processes and business models

Table 1

Upstream	Midstream	Downstream
→ Access to sufficient, affordable clean energy → Access to key infrastructure (e. g. hydrogen, clean power & CCS) → Planning, financing and regulation of energy networks, esp. to support industrial clusters	→ Investment risk mitigation for unproven technologies → Recovery of higher operating cost of ultra-low carbon technologies. → Protection from carbon leakage under higher carbon & production costs	→ Funding costs of decarbonization internalized in final product prices → Standards and demand for climate- neutral basic materials → Stronger incentives to increase the quantity and quality of recycling → Incentives for material CO_2-efficiency in final product design, manufacturing & construction

Agora Energiewende (2020)

* These carbon pricing systems generally apply to fossil-fuel emissions not covered by the EU-ETS and include varying exemptions, especially for the industry due to competitiveness concerns.

** Effective carbon rates, including carbon taxes, energy taxes and price of emission permits, but excluding emissions from the combustion of biomass in the emissions base.

*** Provided that targets are not met.

3 Policy needs for a comprehensive European "clean industry package"

The preceding section outlined the reasons the key conditions needed to kick-start investment in climate-neutral production, products and business models. In general, these conditions cannot be created by the industry sector itself. Rather, the EU will need to create them by enacting new policies. This section proposes a clean industry package of eleven key policies to satisfy these conditions.

Figure 5 summarizes the eleven key policies that we propose. The policies are broken down by their position in the value chain, i.e. upstream, mid-stream and downstream.

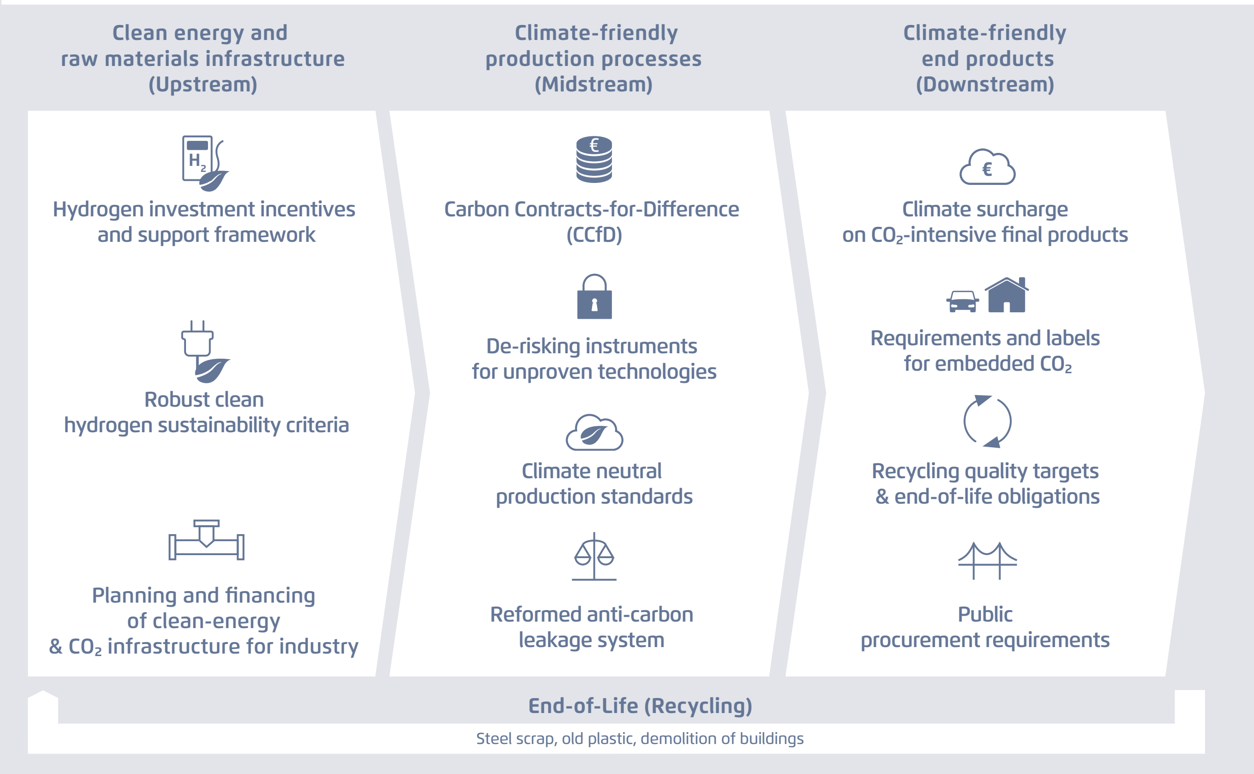
3.1 Upstream Policies

The key conditions for enabling the transition of the upstream value chain are:

→ access to sufficient, affordable clean energy
→ access to key infrastructure (e.g. hydrogen, clean power and CCS)
→ the planning, financing and regulation of energy networks, especially to support industrial clusters

To meet these needs, we identified the following policy priorities for EU and member-state policymakers:

Policy needs at the different parts of the value chain — Figure 5



Agora Energiewende, 2020

Policy need 1. Economic support instruments to create a business case for investments in clean hydrogen production infrastructure:

If a decarbonized industrial energy infrastructure is to be built, it needs a business case to exist. For clean hydrogen production and transport, policymakers must create demand for a product that is currently more expensive than existing alternatives. Three main types of instruments can incentivize investments in the production and transport of clean hydrogen.

The first is to provide a **feed-in premium**, or what we might call a "hydrogen contract-for-difference," to support the production of competitive clean hydrogen. This is a payment that would be given to producers to close the price gap between clean hydrogen and existing hydrogen that is already produced in Steam Methane Reformers today. "H-CfDs" might be appropriate for supporting early-stage investments in greening the existing production of hydrogen and thus for specific industrial processes that already use hydrogen, where it is only a matter of switching from "grey" to "green" energy sources.

The second type of instrument is to provide *downstream industrial users of hydrogen* with a more comprehensive **carbon contract-for-difference**. This could either be used to cover the cost of switching from grey to green hydrogen (e.g. for existing hydrogen use in ammonia and fertilizer production) or to support the transformation of industrial technologies and processes, generating a previously non-existent demand for clean hydrogen.

For example, steel producers require major investments to move from conventional blast furnace-based processes (which use coking coal) to DRI/EAF-based steel production processes (which use hydrogen). Similar examples also exist for breakthrough technologies in the chemicals sector (e.g. low-carbon ammonia or H_2-based methanol-to-olefins routes). These downstream users will face higher investment and operating costs when switching to hydrogen in new production processes. They will require support to cover the incremental cost of these new investments and operating costs. Simply providing clean hydrogen at the price of "grey" hydrogen will not be enough to justify the economics of these new low-carbon operations. Hence, a carbon contract for difference, offered at the level of the industrial hydrogen user, is a more appropriate instrument in these cases.

A key factor for introducing clean hydrogen to the industrial sector is to account for investment needs in both upstream hydrogen production and in downstream hydrogen offtake. This is especially necessary for steel or chemicals manufacturing and other industries that must invest in new industrial processes while upstream hydrogen production is being developed. These investors need to see hydrogen infrastructure investments moving ahead with high certainty to be able to move ahead with their own site transformations. Similarly, upstream infrastructure providers will also need to see firm commitments and policy instruments such as CCfDs being created to be able to invest in upstream infrastructure with confidence. *Close coordination of policy support relating to both the supply infrastructure and downstream investment decisions to create demand will be essential for the design of effective support instruments.*

The third and final option is to set **clean hydrogen quotas** on sellers of maritime and aviation fuels. Here the private sector absorbs the cost of blending a share of renewable fuels in the end product. This option is not appropriate for industry because the higher cost of hydrogen blending would make it difficult to compete with foreign competitors that do not use renewable hydrogen.

A possible difficulty posed by quota systems – one experienced by renewable energy support schemes (IEA, 2011) – is that the price of quotas tends to fluctuate based on supply and demand, which themselves depend on other government policy

Policy options to support investments into clean hydrogen — Figure 6

Policy Instrument	Hydrogen-Contract for Difference	Carbon Contract-for-Difference	Hydrogen Fuel Quota
Potential application	Greening existing hydrogen production	Greening industrial processes req. green hydrogen (e.g. steel and chemicals)	Blending in aviation and maritime fuels
Remarks	Requires low downstream costs of clean H_2 integration by end user & pre-existing demand	Appropriate where higher downstream H_2 integration costs	Requires maturing electrolyser costs & stable policy framework

Agora Energiewende, 2020

interventions. On the plus side, quota systems avoid the need for direct subsidisation, allowing the internalisation of innovation costs in broader market prices for transport fuels.

A number of actions at the EU level can help member states implement one or more of the above three instruments both effectively and sustainably:

- The EU Environmental and Energy Aid Guidelines for State Aid, to be revised in 2021, must unambiguously open the door to the three options, including H-CfDs, CCfDs for industrial users of clean hydrogen and quota for clean hydrogen-based fuel blending.
- Reform of the Renewable Energy Directive, and supporting regulations, to clarify the conditions under which member states can support investments and scaling up of clean and decarbonized hydrogen (more on this below, Cf. point 2).
- Development of European projects of common interest, integrating hydrogen development and the transformation of industrial processes in the steel and chemicals sectors, as a model for future projects.

Besides direct support mechanisms, a broader set of conditions must be in place to enable hydrogen in the energy system and direct electrification in the industrial sector. For example, national governments may also need to review power market design, hydrogen gas infrastructure regulations and taxation policies that facilitate the effective introduction of direct and indirect electrification in the industrial sector.

Policy need 2. A robust sustainability framework for clean hydrogen production and use

To develop clean hydrogen that does not contribute to increasing emissions along the industrial value chain (scope 3 emissions[3]), the EU will also need a robust sustainability framework. This could be made part of a revised Renewable Energy Directive and related regulations on the definition of renewable hydrogen. A robust sustainability framework for clean hydrogen would need to set rules determining when hydrogen production is classifiable as "clean" and eligible for state aid. These include:

- rules governing guarantees of origin for clean hydrogen;

3 That is to say, emissions that result from producing hydrogen with non-zero carbon electricity.

- → rules governing the "additionality" of renewable or decarbonized energy for clean hydrogen production;[4]
- → rules ensuring that clean hydrogen is allocated first to the most appropriate "no-regret" options, beginning with steel and chemicals;
- → rules governing the safety of hydrogen deployment and the technical requirements of transport pipelines.

Policy need 3. Planning and financing of decarbonized energy infrastructure, especially for industrial clusters

Presently, responsibility for the planning and funding of public utility electricity and public gas infrastructure falls to the National Energy and Climate Plan (NECP) under the EU's Energy Union Governance Regulation, where it is then delegated to entities at the national level. Introducing hydrogen, carbon capture and storage and clean power infrastructure for the decarbonization of industry requires revisions to existing national governance systems. At a minimum, future versions of National Energy and Climate Plans should include planning and reporting on the financing of strategic industrial infrastructure – which the existing NECP template does not explicitly cover.

Much of the infrastructure planning and development will need to begin by focusing on the micro-scale, i.e. at the industrial clusters, in each member state and on solutions for decarbonizing them. Ideally, member states should develop decarbonization strategies for industrial clusters in accordance with existing regulations. Such strategies should be summarized in future NECP revisions and serve as a reference point for other planning and EU financing instruments such as NECPs, Regional Just Transition Plans, Projects of Common Interest approvals, state aid approval requests, etc.

Cross-border infrastructure will also become increasingly relevant to the decarbonization of industrial sites and clusters across Europe. Decarbonized industrial energy and the CO_2-storage and transport infrastructure are critical for European policies such as the Trans-European Networks for Energy regulation ("TEN-E") and the Projects of Common Interest framework. The need for a decarbonized industrial energy infrastructure must be reflected in national and regional planning processes.

3.2 Mid-stream policies

The preceding sections identified three key requirements for the mid-stream part of the value chain:

- → Investment risk mitigation for unproven technologies
- → Recovery of the higher operating costs for ultra-low carbon technologies.
- → Protection from carbon leakage under higher carbon & production costs

We identified the following EU-level policy priorities for meeting these requirements.

Policy need 4. An EU policy framework for carbon contracts-for-difference to cover the higher operating costs of key technologies

Carbon contracts-for-difference (CCfD) would be awarded only to projects implementing technologies deemed compatible with achieving economy-wide climate neutrality by 2050. In effect, they are a guarantee that the EU or the host member state will cover the difference between the actual EU ETS carbon price and the carbon price required for the project to be profitable.

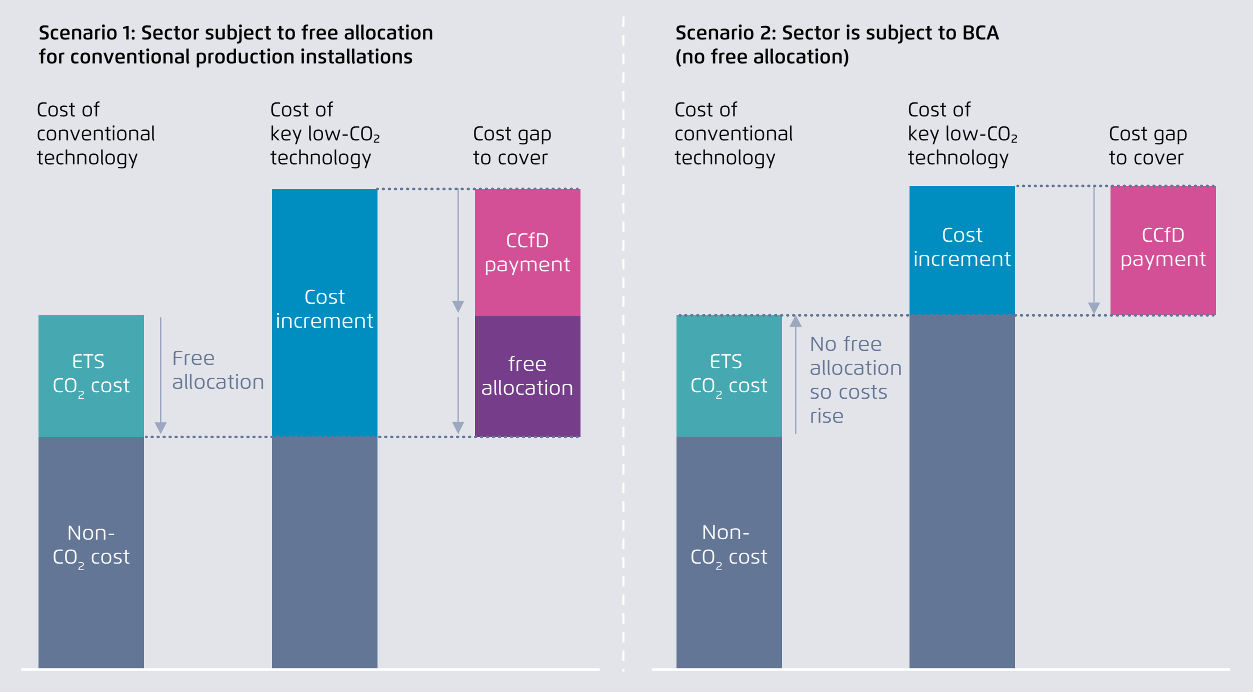
4 "Additionality" means that the renewable hydrogen is sourced from additional renewable energy production in the EU instead of from existing or new renewable power resources dedicated to decarbonising power for other end usages.

Figure 7 illustrates how a CCfD works using either free allocation or border carbon adjustments as the main anti-leakage measure.[5]

Payments to the projects would be calculated based on the difference between the EU-ETS carbon price and a pre-agreed "strike price," the breakeven carbon price necessary to make the low-carbon technology project commercially viable in relation to a given conventional technology. At the end of each year, the project owner reports the annual production level.
If the carbon price average was below the strike price, the project receives the difference multiplied by a) the production cost using the low-carbon technology multiplied by b) the abated emissions from the new technology (relative to a conventional benchmark). Conversely, if the carbon price is above the strike price, then the project owner pays back a share of the "excess" income.

5 Technically, a third scenario is also possible: the national government could sell previously allocated allowances to the project and pay the full cost difference of the decarbonized technology. This scenario occurs when key-low carbon technologies do not receive free allocations.

The CCfD mechanism with two anti-leakage policies (free allocation vs BCAs) Figure 7



Agora Energiewende, 2020

Note: Under the current EU ETS anti leakage system, the EU's energy intensive industries with high trade exposure receive free EUA allocations to maintain the production cost at the level of international competitors with equally GHG intensive processes. This cost thus also represents the reference for the calculation of carbon specific cost differentials of key low-carbon technologies. This incremental cost can be covered with a combination of free allocations also for key low-carbon technologies and the payment of the CCfD. In case the system evolves towards a Carbon Border Adjustment without free allocations to energy intensive and trade exposed industries, the cost for producing or importing products produced from GHG intensive technologies would increase and the payment of the CCfD, without free allocations to key low-carbon technologies, will be sufficient to cover the cost gap. This illustrates, that a CCfD is compatible with a future border adjustment and increasing carbon prices but allows to mobilize urgent investments now.

In sum, CCfDs help cover the operational cost gap between conventional and climate-neutral or ultra-low carbon technologies. But they also help stabilize revenue streams by eliminating the CO_2 price risk for project investors. In this way, they help significantly improve the economic viability and bankability of projects.

Given their urgency, CCfDs for industry would initially need to be awarded at the member-state level. They would nevertheless require a strong European enabling policy framework. EU-level CCfDs should be developed as soon as possible to ensure that Europe does not experience a two-speed rollout at the member-state level.

An EU-level mechanism would bring other advantages as well: diversification of geographical and technological deployment, increased competition between technologies at auctions, solidarity with member states unable to pay for domestic CCfDs in the short term and facilitating the planning of pan-European infrastructure for industrial clean energy and CO_2 storage (avoiding a two-speed Europe).

Specifically, the EU should put in place the following elements:

- → Open the door to national CCfDs under revised Environmental and Energy State Aid Guidelines. The conditions under which member states could develop a policy with likely approval must be clear.
- → Develop guidance for minimum CO_2 performance benchmarks and relevant sustainability criteria to ensure that CCfDs are allocated only to projects that are genuinely compatible with the goal of climate-neutrality by 2050.
- → Introduce guidance and possible technical support on how to ensure that project costs are evaluated correctly, do not lead to overpayment and do not minimize the risks of internal market distortions.
- → Reform EU ETS provisions on free allocation and benchmarks in order to simplify CCfD implementation by member states and eliminate disincentives.
- → Identify new funding sources – either from ETS auctioning revenues and/or from a climate surcharge on basic materials – to fund large-scale European CCfD projects.

Box 1: CCfDs would be affordable for member states

In view of the budget constraints due to the COVID-19 crisis, some national governments may be concerned about the costs of carbon contracts-for-difference. In reality, however, such fears are mostly unfounded.

Initial estimates for the cement and steel sector are shown in Figure 8 below. The data explore two pathways for decarbonising steel and one for decarbonising cement. For steel, option one describes a first step towards climate-neutral production. It begins by investing in natural gas-based DRI technology, which will reduce emissions by ~66%. (Over time, clean hydrogen will replace natural gas.) The second option consists of immediately introducing much higher levels of clean hydrogen for DRI, which will reduce emissions by 89% relative to conventional blast furnaces. For cement, the option is based on an oxyfuel process with CCS at 90% capture rates.

Figure 8 presents the mid-range cost estimates up through 2030, with an assumed CO_2 price of 45€/tCO_2 and an average wholesale power price of 60 to 70€/MWh. Actual site costs could differ depending on local conditions.

Cost estimate for financing CCfDs of a hypothetical member state representing ~10% of the EU's primary steel or cement production

Figure 8

	Breaktrough Technology	Breakeven CO_2 price range & central estimate for 2030*	CCfD payment per tCO_2 avoided @ETS= 45€/tCO_2	Support per tonne primary steel/cement		10% of EU27 primary production		Annual Costs for CCfD (for greening 10% of EU market
STEEL	DRI (NatGas) (-66% t CO_2/t steel)	71 – 49; 60€/tCO_2	15€/t CO_2	17€/t CO_2	x	10Mt/yr	=	0.17 bn €/yr
STEEL	DRI (Green H_2) (-89% t CO_2/t steel)	165 – 99; 132€/tCO_2	87€/t CO_2	132€/t CO_2	x	10Mt/yr	=	1.32 bn €/yr
CEMENT	Oxyfuel-CCS (-90% CO_2/t cement)	131 – 70; 101€/tCO_2	56€/t CO_2	31€/t CO_2	x	16Mt/yr	=	0.50 bn €/yr
	CO_2 reductions refer to conventional process (steelmaking; cement)	Green Power price = 60€/MWh – 70€/MWh	Assumes 45€/t CO_2 average price in EU ETS			2017 EU primary steel (cement) production = 95 Mt (159 Mt)		Number will vary for bigger or smaller Member states & depending on capacity supported

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Note: Actual technology breakeven costs may differ from these estimates, depending on site-specific characteristics.
The required CCfD strike price and thus per unit cost can be lowered if combined with other support/funding. Costs depend critically on ETS CO_2 price, H_2, and power price assumptions, and size of national market. Exact emissions reductions per technology can vary depending on site specifics.

The projected annual payments to cover the incremental costs of CCfDs suggest that the costs are fairly moderate for individual member states. For example, a large member state, representing, say, 20% of the total EU market for primary crude steel and Portland cement, and looking to convert 50% of its national production capacity to climate neutrality-compatible processes, would need to calculate between 170 million to 1.32 billion €/yr for primary steel (depending on the share of gas vs. hydrogen in DRI production) and roughly 500 million €/yr for cement (to shift production to oxyfuel and CCS technologies). These amounts would be sufficient to cover the clean-energy modernisation needs during the next 10 years for the steel and cement sectors in Europe.

The above example was for a larger member state, but most EU member states do not produce more than 5% of the total EU supply of either cement or primary steel. In principle, therefore, these member states could convert their steel and cement sites to clean energy for less than 50% of the estimated cost.

Other factors can also affect costs. In practice, CCfDs are not likely to be the only support instrument, and infrastructure costs may be partially paid by other instruments. For example, the EU ETS Innovation Fund or national innovation funding tools would likely contribute to the capital cost of some projects, thus reducing the need for CCfDs to cover 100% of additional costs. In such circumstances, the above cost estimates would be on the high side. At the same time, costs would be higher if support is given to other sectors, such as certain basic chemicals or non-ferrous metals. Changes to assumptions regarding ETS or power prices could also increase or decrease the results, direction depending.

Policy need 5. Financial de-risking instruments for capital expenditure in first-of-a-kind, large-scale investments

While CCfDs are an effective instrument for covering the operating cost gap between key low-carbon and conventional industrial technologies, they do not necessarily address the "capex risk" from the large-scale deployment of new unproven technologies. For this, CCfDs may need to be supplemented by capital de-risking tools. These instruments can take different forms. However, some powerful tools already exist at the EU level. One such tool is the EU ETS Innovation Fund, which provides up to 60% of the additional costs of large-scale demonstrators for innovative low-carbon projects in any sector.[6] Another useful tool is InvestEU, which provides loan guarantees that help reduce the risk of investment in innovation and in "strategic" projects in Europe.

But though both of these tools are already in place, they also are relatively small and are spread thinly across many sectors and priorities. For example, the EU ETS Innovation Fund is expected to offer €8-11 billion over the ten-year period to 2030 (roughly 1 billion per year) over all sectors of the energy system.[7] InvestEU can be leveraged since it provides loan guarantees rather than grants. However, its size was reduced dramatically during the recent EU Recovery and Budget negotiations.[8] Other initiativess, such as the proposed liquidation of the EU Coal and Steel Fund, make up only a small slice of the total pie.

To boost these instruments, the EU must devise additional funding mechanisms. An EU-wide climate surcharge on products with large amounts of basic materials sold in the EU market is one solution. An additional source of funding could be new revenues from ETS auctions. These could stem from expanding the ETS to additional sectors beyond maritime and aviation fuels. They might also come from the elimination of free allocations for certain sectors (such as those moving to border carbon adjustments).

Policy need 6. Set standards for climate-neutrality compatible production of basic materials

While carbon contracts-for-difference and financial de-risking mechanisms to support innovation will be essential for financing breakthrough technology projects, the EU also needs to send a clear signal dissuading new investments in industrial plants and technologies that are incompatible with achieving climate neutrality by 2050. Otherwise, EU companies may invest in half measures that reduce emissions in the short run but lock in technologies that cannot deliver economy-wide neutrality by mid-century.

The best way to tackle this problem is via setting standards for basic materials that are compatible with climate neutrality. Such standards are necessary for several reasons, including:

→ clarifying the project eligibility criteria for CCfDs (see above)
→ facilitating the creation of lead markets for climate neutral materials
→ facilitating green public procurement of climate neutral basic materials
→ providing a clear signal about the direction of future EU policy requirements to avoid lock-in of "half way solutions" that are not compatible with climate neutral industry in 2050.

Once standards are set and tech, the EU could determine CO_2 performance requirements for major re-investments and for license extensions of existing plants after a given date, say, 2030. Revisions to the EU's Industrial Emissions Directive could make the

6 See https://ec.europa.eu/clima/policies/innovation-fund_en

7 See https://ec.europa.eu/clima/policies/innovation-fund_en

8 See https://ec.europa.eu/commission/priorities/jobs-growth-and-investment/investment-plan-europe-juncker-plan/whats-next-investeu-programme-2021-2027_en

Best Available Reference Technologies post-2030 consistent with climate neutrality criteria.

Since IED regulations can take several years before coming into effect followed by a long, sometimes, 4-year phase-in period, new standards should seek to set climate neutrality requirements for all major new investments or license extensions after 2030. Doing so would send a very clear signal to industries, encouraging them to prioritize their decarbonization strategies and steer a course towards climate neutrality during the coming investment cycle.

Policy need 7. A robust package of anti-carbon leakage policies, enabling long-term alternatives to free allocation and state aid

Under existing policies, the EU ETS Directive provides two main measures for tackling the risk of "carbon leakage," i.e. when production, jobs and emissions move to countries with lower carbon prices. The first is the free allocation of emissions allowances to sectors at risk of carbon leakage, which include energy intensive industries.[9] The second is the possibility of state aid payments to compensate for higher electricity prices. But with higher carbon prices and declining free allowances likely in the future, these solutions will need to be revised and then eventually phased out in favour of alternatives. (See Box 2.) When it comes to maintaining a uniform carbon price along the value chain, phasing out free allocation and state aid will unlock additional downstream incentives for abatement. The phase-out can also help remove distortions created by certain regulations (such as the disincentive to substitute clinker for cement). [10]

In the medium term, therefore, the EU will need to replace its current carbon leakage instruments with more sustainable and more effective alternatives. In the absence of a G20 agreement on a global carbon price, two basic options exist: border carbon adjustments, which equalize carbon prices at the border, or carbon product requirements on all goods (imported or domestic) sold in EU. Unless a global carbon price agreement is reached, the EU will have to choose one of the two (or perhaps some combination thereof).

The exact speed with which the EU would need to move to these long-term alternatives will depend on how quickly free allocation and state aid cash payments become unsustainable in the EU ETS. This, in turn, depends on whether the EU decides to enlarge the ETS. As explained in Box 2 below, the point of unsustainability could be reached at any time between the mid-2030s and 2042.

In the short run, however, both border carbon adjustments and carbon product requirement present significant challenges. Carbon product requirements will not be able to be introduced immediately. Such policies are generally appropriate only once certain technologies become well-established. Likewise, border carbon adjustments require significant new administrative enforcement development and face political hurdles at the domestic and international level.

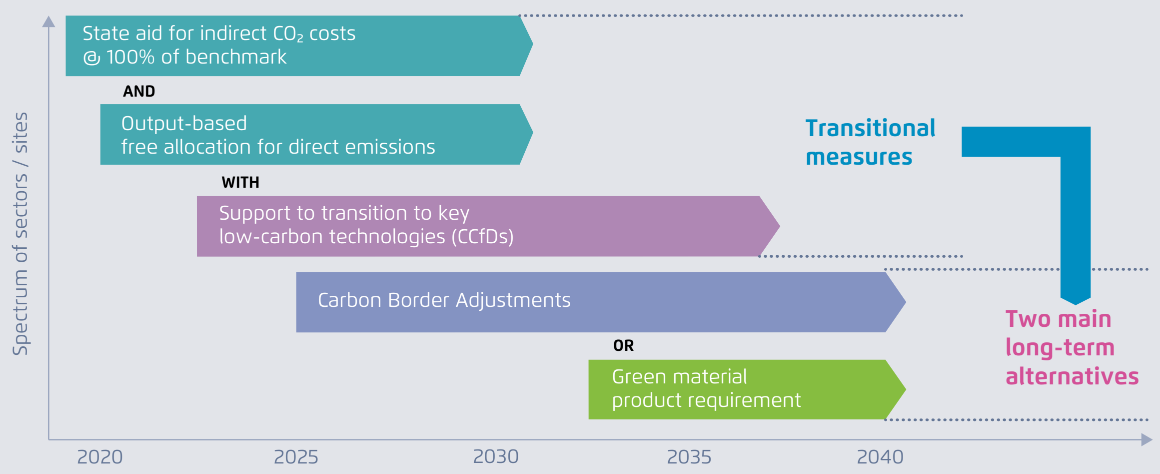
A likely scenario is that border carbon adjustments in the near term will be impossible for all but a small

9 See European Commission (2018): Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 (consolidated text, incorporating revisions).

10 If free allocation is to be continued, then efforts may be needed in some sectors to revise existing benchmarks and prevent distortions. For example, in the case of cement, the existing practice of providing free allocation for clinker production (rather than cement) could have a distortionary effect. This is because is it fairly easy to substitute clinker with other materials, such as calcined clays, etc. Under high carbon prices, free allocation based on clinker production would provide companies with an incentive not to adopt this option. Subsuming cement under a border carbon adjustment or a product carbon requirement and phasing out free allocation would avoid the problem.

Short, medium and long-term policy tools for carbon leakage protection

Figure 9



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handful of sectors and, even then, will require a cautious and gradual introduction. Instead, a transitional arrangement will be needed that relies on existing state aid and free allocation systems that incorporate longer-term solutions like border carbon adjustments or carbon product requirements. Figure 9 summarizes the broader anti-leakage policy package needed in, in the short, medium and longer term.

In the short-term, the following specific reforms will be needed:

→ Free allocation must be continued at the full technology benchmark for sectors not subject to a border carbon adjustment, but **adjusted ex-post** based on true output ("output-based allocation"). Currently, free allocation is determined ex-ante based on past output.
→ **Reforms to state aid guidelines** are needed that limit support to electricity-intense sectors. Maximum aid levels should be linked explicitly to the carbon price and allowed to rise to 100% of the full technology benchmark for prices above 30€/tCO_2.
→ Border carbon adjustments and carbon product requirements must be gradually implemented for the relevant candidate sectors. This requires monitoring and reporting infrastructures, mechanisms to account for foreign carbon policies, mechanisms to provide export rebates, diplomatic efforts to reduce opposition and retaliation, etc.

Depending on the specific policy package design proposal, the EU may need to undertake additional reforms. These include:

→ reforms to eliminate the need for a cross-sectoral correction factor (depending on whether the EU expands the ETS);
→ changes to certain product benchmarks to avoid disincentives for clinker substitution (if free allocation is continued in the cement sector); and
→ rule changes that allow member states to provide cash payments instead of free allocation to sites receiving CCfDs without losing their allocated ETS allowances (provided that free allocation continues in sectors subject to CCfDs).[11]

11 In a free allocation system, the question is whether a free allocation should continue for ultra-low carbon sites receiving CCfDs, or whether a cash payment would be simpler, allowing allocations to be sold to raise the necessary revenues for the member state or the EU fund.

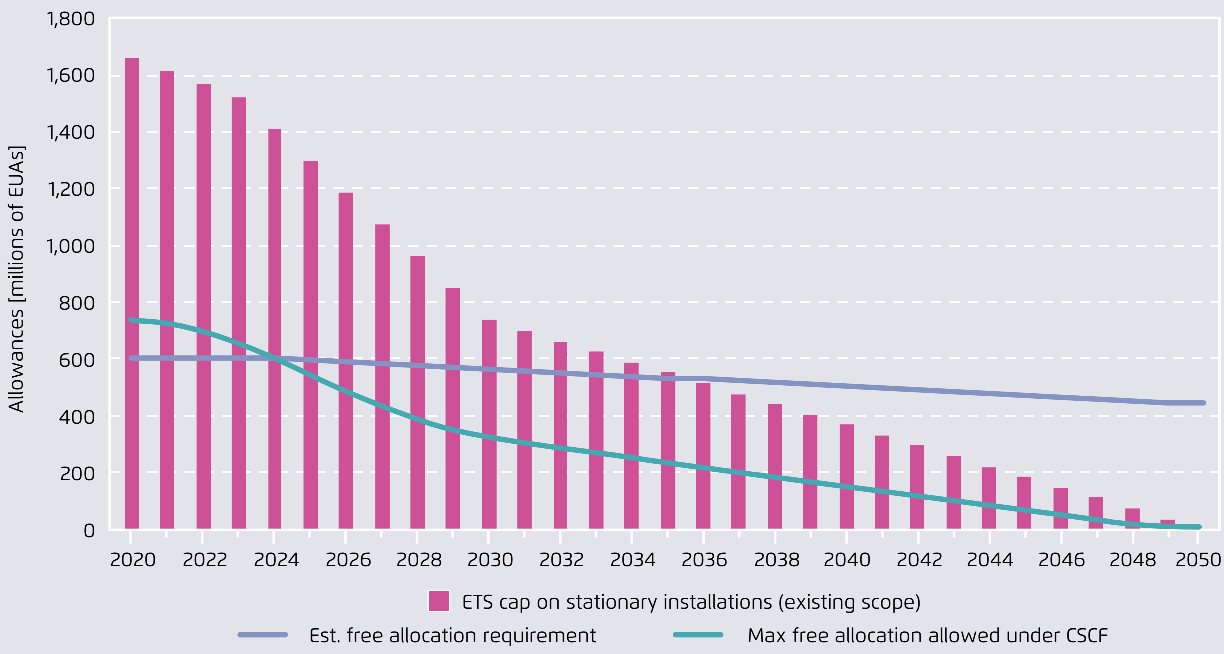
Box 2. The limits of the existing anti-carbon leakage system

Under current ETS anti-leakage rules, free allocation is provided based on past activity levels multiplied by CO_2 performance benchmarks based on the average of the best 10% of installations producing a given product in the EU. But the free allocations can be revised downwards if the total level of free allocation exceeds 46% of the total EU ETS allocation (including both free and auctioned allowances), whereupon a "cross-sectoral correction factor" (CSCF) kicks in. Furthermore, electricity-intensive sectors, such as producers of non-ferrous metals, are eligible to receive cash compensation for up to 75% of additional electricity costs arising from the ETS.[12]

While the system has avoided leakage fairly well so far, more ambitious climate policies would sharply decrease the total number of ETS allowances over the next 10 years. Consequently, even if the CSCF were reformed to allow for a share of free allocation higher than ~46% of the cap, the share of free allocation would still grow very quickly – potentially consuming up to 75% of the total number of allowances by 2030 and 100% by 2037. This indicates that free allocation is not a sustainable solution to carbon leakage in the

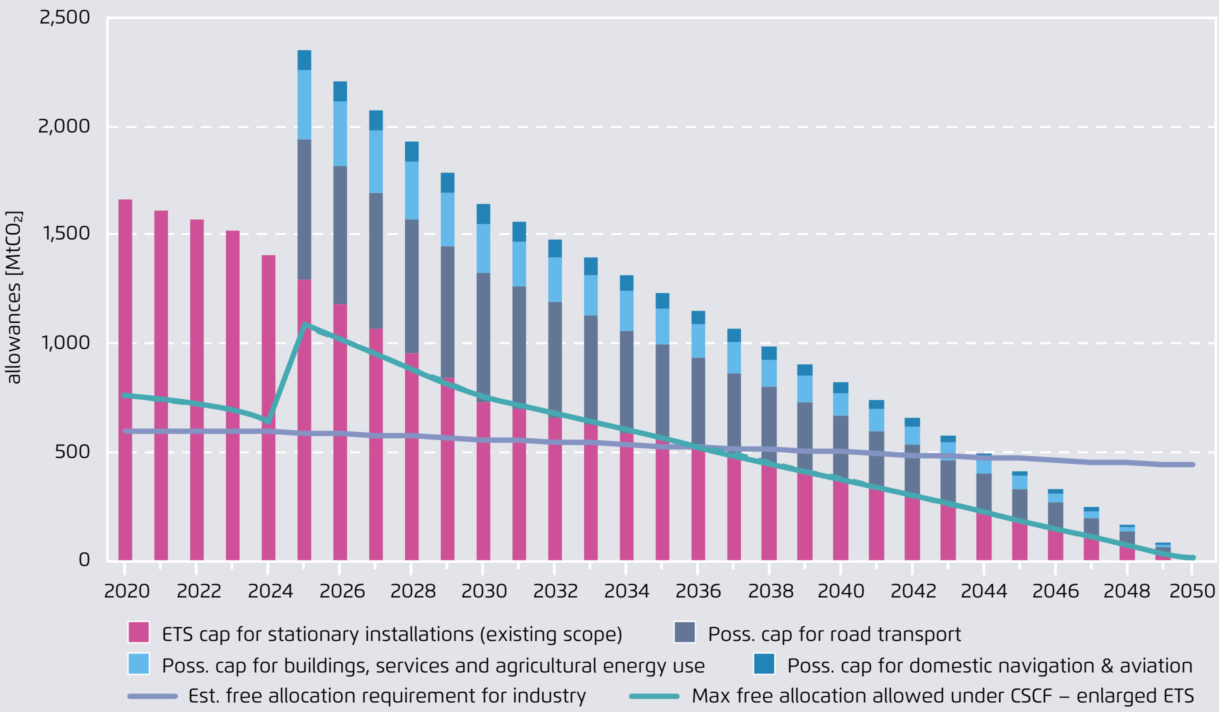
12 See European Commission (2012): Guidelines on certain state aid measures in the context of the greenhouse gas emission allowance trading scheme post 2012. Adopted on 22.05.2012. Official Journal C154, 05.06.2012, p. 4

Free allocation and the EU ETS emissions cap with an EU-wide -55% in 2030 and climate neutrality in 2050 target — Figure 10



Agora Energiewende, 2020. Own estimates based on data from EEA, European commission.

Free allocation and the EU ETS emissions cap assuming ETS extension to buildings and transport — Figure 11



Agora Energiewende, 2020. Own estimates based on data from EEA, European commission.

medium term.[13] Even in the short term, strong growth in the free allocation share would tend to put pressure on the residual auctioning share of allowances, which currently supports several dedicated funds and provisions in the broader EU ETS policy framework.

Another option would be to include in the EU ETS fossil use sales for the transport and buildings sectors. This would increase the total allowances available each year (Figure 11). If the EU significantly enlarges the ETS, the existing free allocation mechanism could be retained for much longer than possible in the current system. Nevertheless, the EU would still need to transition to an alternative systems at some point down the line.

Another problem with the existing EU ETS anti-leakage system is that free allocation is given prior to firms' production decisions and unless production varies very significantly (more than +15% or −15%) from past activity levels, there is no ex-post adjustment to align free allocation to actual production levels at the end of the year. Under very high carbon prices, this could create an incentive for a certain percentage of installations to reduce their production by a given percentage, import a share of the production no longer produced in

13 This is true even if energy-intensive sectors reduce their emissions to zero, since the producers would still need to be protected from the additional cost of climate-neutral products relative to conventional ones. Under a free allocation system, low-carbon technologies would probably require free allocations at the full conventional benchmark, although cash payments might also be an alternative. In the absence of a dedicated funding source, however, this too would likely be an unsustainable solution in the long term.

Europe, and sell the surplus allocations on the market. This phenomenon is known as "operational carbon leakage." Incentives for operational leakage can be eliminated by introducing ex-post adjustments to the level of free allocation given each year based on the actual production from the preceding year (more on this below).

A third problem with the existing carbon leakage system is that, under current state aid guidelines, which expire in 2020, a maximum of 75% of indirect ETS costs can be offered to compensate electricity-intensive sectors. At future carbon prices of 45-60€/tCO_2, the absence of 100% compensation can have a major impact on the competitiveness of electricity-intensive products because these they compete in international commodity markets with strong competition from non-EU countries. For example, in 2018, the EU imported basic unwrought and semi-finished aluminium products equivalent to 42% of total EU aluminium production for that year (Eurostat, n.d.).

3.3 Downstream policies

The preceding sections identified four key requirements for the downstream segment of the value chain:

- → funding costs of decarbonization internalized in final product prices
- → standards and demand for climate-neutral basic material
- → stronger incentives to increase the quantity and quality of recycling
- → incentives for increased material CO_2-efficiency in final product design, manufacturing and construction

We identified the following policy priorities at the EU level to meet these requirements.

Policy need 8. A climate surcharge on material-intensive final products

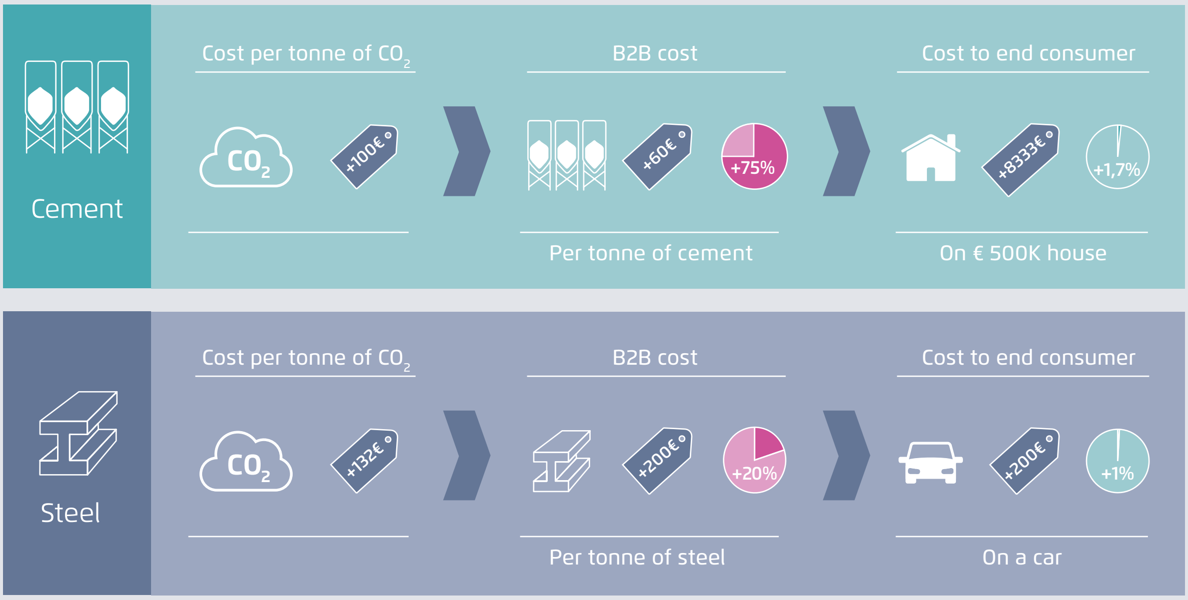
If scaled at the EU level, CCfDs and related policies will probably require a new dedicated funding source. In general, it is desirable that any new funding source is ultimately paid for by the final consumer of the products, so that the sector would be "self-funding." The ideal solution would therefore be a climate surcharge to be placed on final products that have very high levels of energy-intensive basic materials such as steel, cement or basic chemicals.

The list of such products could be long or short depending on how broad or narrow policymakers wish to make the tax base. But even a narrow tax base for a limited number of products such as new buildings, new motor vehicles and plastic packaging items would be able to both cover a large share of the consumption of steel, cement and plastic chemicals. For such products, the contribution rates would be very low, typically in the order of less than 1% of the final product cost,[14] thus reducing any risk of undermining market demand. Carbon leakage would not be possible either, since all products sold in the internal market, including imports, would be subject to the charge, while exports could be exempted (See Figure 12).

14 These are based on our own estimates.

How the cost of carbon in upstream basic materials translates into price increases in downstream products

Figure 12



Agora Energiewende (2020), adapted from illustration of Energy Transition Commission (2018)

Climate surcharges could be levied at the national or the European level. Indeed, the EU has already proposed a plastics tax to pay for part of the European recovery fund post-Covid19 – "Next Generation EU". The EU could expand this approach to a broader set of products containing large shares of carbon-intensive basic materials.

Policy need 9. Requirements to improve recycled basic material quality and material efficiency in manufacturing

One of the biggest barriers to boosting the circular economy for basic materials such as steel, non-ferrous metals and plastics is the degraded quality of secondary scrap and plastic. This limits the share of recycled materials that can be used to substitute new virgin materials. Since the products that are manufactured or built today will be the recycled scrap available 10, 20 or even 50 years from now, the issue is urgent.

We have identified three ways to incentivise the improvement of material quality:

→ The EU could reform recycling legislation for basic materials to include **stronger incentives for material quality conservation**. This could be done via reforms to sectoral legislation under the EU Waste Framework, such as the End-of-Life Vehicles Directive, the Waste Framework Directive and the Construction and Demolition Waste policy framework. Reforms could take different shapes, but options should include minimum recycled content requirements, additional material quality separation, collection and tracing requirements and incentives for Extended Producer Responsibility schemes to set quality goals alongside quantity objectives.
→ The EU could **ban or otherwise disincentivize products with low recyclability or poor material efficiency performance** – akin to existing practices for energy using products. This could include,

for instance, incentives to reduce the number of polymers that plastic products contain, ensuring that products such as vehicles, machines or buildings are designed with longevity and ease of disassembly in mind, banning or disincentivizing (via labelling) material-intensive construction and design.

- The EU could revise construction and vehicle waste legislation to **adopt minimum requirements for end-of-life de-construction, sorting and tracing**. This should include, as a minimum, tighter limits and regulations on the demolition of and sorting of waste from buildings and construction and tighter limits and regulations on the shredding of vehicles.

Policy need 10. "Climate neutrality-compatible" product labelling and eco-design requirements for embedded carbon

Assuming that carbon contracts for difference and climate-neutral compatibility requirements for the production of intermediate materials after 2030 are in place to drive investment upstream, there are two ways that the EU can support the creation of lead markets and demand for low-carbon basic materials:

- **Low-CO_2 product labelling for basic materials.** Common EU-wide labelling can help foster purchaser confidence in the environmental integrity and climate-neutrality compatibility of basic materials. The label can be used as a reference point for leading private-sector purchasers who wish to advertise their green credentials. Since production technologies for intermediate basic materials are updated only every 20-30 years, these labels should not use the A-F rating, like the one used by the EU's Energy products under Energy labelling. Rather, because non-marginal change is required, and the EU must be carefull not to incentivize "lock in" of half-way solutions to climate neturality, the relevant label should only indicate "climate-neutrality compatibility". This solution would thus be more akin to the current EU's "Eco-labelling" system, rather than its "Energy labelling". The resulting standards could potentially be used in a variety of legislative instruments, such as the environmental standards set under the Construction Product Regulation, Green Public Procurement Directive or the Industrial Emissions Directive.
- **Design requirements for final products** containing large amounts of basic materials. To create a more complete set of incentives, the EU should set **minimum requirements for embedded CO_2 in final products**, beginning with buildings and vehicles. One of the strengths of embedded carbon requirements is that they address material intensity, choice of materials, choice of recycled vs. primary materials, etc. They can also help tackle important sources of waste due to overestimation of materials needs in construction and inefficient manufacturing processes. These regulations could follow the example of leading member states such as France, Sweden, Finland, and Denmark and require that member states adopt policies that require all new buildings to have embedded carbon below a given tCO_2/m^2 threshold (adjusted for certain features of the building), with tightening standards over time. Indeed, the EU has begun trialling its own evaluation system for measuring building LCA emissions, known as LEVEL(s). This could be used a a technical basis for further requirements on member states to adopt mandatory requirements on new construction across the EU.

The change could be adopted via amendments to the Construction Products Regulation[15] and the creation of a new product regulation for construction products.

15 See https://ec.europa.eu/growth/industry/sustainability/ecodesign_en

Box 3. Examples of eco-design requirements for lifecycle carbon assessment (LCA) limits and new construction labels

Although many private and local government LCA initiatives exist (Bionova, 2018), national LCA labelling and eco-design policies have recently begun to emerge at the EU member-state level (Zero Waste Scotland, 2019).

For example, France's "E+C- labelling" scheme is a state-backed system that reports the full LCA emissions (and energy performance) of new buildings. Under the label, new buildings must report a) total energy consumption, and b) total lifecycle CO_2 emissions, including energy use and embedded emissions in construction materials.[16] Based on this label, from 2021, a reform of the existing thermal energy regulation on buildings[17] will impose maximum binding limits on each of the above measurements. The limits for embedded CO_2 emissions are expressed in $kgCO_2/m^2$, with an assumed 50-year building lifetime. Certain adjustments then factor in other relevant criteria (e.g. climatic zone, parking spaces, etc). While the limits are not extremely strict at the moment, the regulation defines limits below the minimum for buildings to receive a higher performance label. This is done to create a reference point for more ambitious clients and construction companies. It is expected that the binding limits will progressively be tightened over time.

In 2018, Sweden's National Board of Housing, Building and Planning (Boverket) introduced a new regulation for climate declarations of buildings, effective from 2022. It will include mandatory reporting requirements for most buildings and binding limits for climate impacts expressed in $kgCO_2 e/m^2$ BTA[18] (Boverket, 2020). Since 2015, Denmark has been offering a freely available lifecycle assessment tool for buildings. It will shortly be publishing a set of voluntary sustainability classes. These are intended to try out monitoring and evaluation tools before the introduction of mandatory requirements in the building regulations in 2023 (Zero Waste Scotland, 2020). Similarly, Finland launched a public consultation in 2018 on how to approach whole-life carbon footprinting. This will become mandatory for new buildings by 2025 (Zero Waste Scotland, 2020).

Meanwhile the EU itself has been trialling, since 2018, the new LEVELS framework, which attempts to develop a harmonised European methodology for evaluating the sustainability performance of buildings across several indicators, including embedded CO_2 emissions in materials. The EU could potentially build on this framework to introduce mandatory measures as has been done in the above-mentioned member states.

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16 See XPAIR (2020) and Batiment à Energie Positive & Reduction Carbone (RE2020), « Le label E+C- et la Réglementation Environnementale 2020 : Votre guide technique !, » https://blog.batimat.com/e-c-label/

17 See the Regulation on Thermal Energy use in Buildings ("Reglementation Thermique 2020").

18 BTA refers to "bruttoarea," which is broadly equivalent to "Gross Floor Area" (or GFA).

Policy need 11. Green public procurement requirements for basic materials

EU public procurement legislation from 2014 already permits [19] – but does not require – environmental criteria to be used in public procurement for the domestic market. Following the distinctions made by Chiappinelli and Zipperer (2017), two basic approaches for the EU could potentially be envisaged and implemented via a reform of the Public Procurement Regulation:

→ The EU could set **declining maximum CO_2 limits on specific materials** that are eligible for use in public projects. A similar approach has also been adopted by Buy Clean California[20] in the United States, which forbids certain CO_2-intensive materials in public projects when the scope 2 emissions are above a given threshold. This approach has the effect of supporting the phase-out of CO_2-inefficient products.

→ The EU could introduce **mandatory life-cycle CO_2 performance criteria** in assessing projects, based on harmonized European methodology. Under the Most Economically Advantageous Tender system, environmental criteria can be explicitly monetized, with the better environmental performers receiving a reduced, "fictive" bid price. The Dutch Public Infrastructure Authority already uses a lifecycle assessment tool ("Dubocalc") and a shadow price of 50€/tCO_2e to calculate fictive bids. The lifecycle assessment method is based on the Environmental Product Declaration Standards EN 15804 and EN 15978, with national adaptations (Zero Waste Scotland, 2020). To support this more generally across the EU for basic material products, the EU should certify compliant methodologies and databases and require member states to implement these systems.

19 See European Commission (2014): Directive 2014/24/EU on public procurement and repealing Directive 2004/18/EC; Directive 2014/25/EU on procurement by entities operating in the water, energy, transport and postal services sectors and repealing Directive 2004/17/EC.

20 See https://www.dgs.ca.gov/PD/Resources/Page-Content/Procurement-Division-Resources-List-Folder/Buy-Clean-California-Act

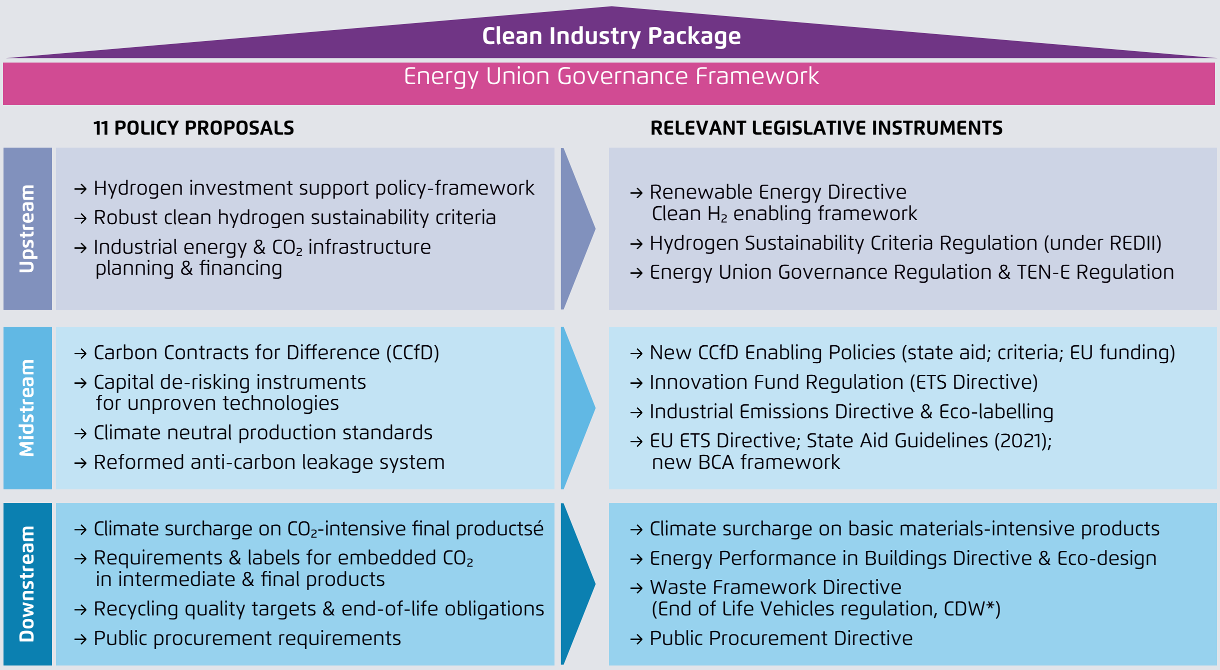
4 Summarizing the 11 proposals for a clean industry package

The previous section has laid out a detailed list of specific proposals for policies that together could constitute something approximating a clean industry package for Europe. They are not meant to be a shopping list but, rather, are an attempt to address specific conditions for putting Europe's energy-intensive industrial sector on a path to climate neutrality by 2050. The policies are intended to be, and, in many cases, depend fundamentally on being, part of a package in order to have maximum effectiveness.

We have shown in several instances that policy effectiveness will depend on national-level and sub-national-level interventions. Helping member states to activate these levers of policy – facilitating a broad and inclusive "one-speed" transition across the EU27 – will require a combination of both "harder" legislative instruments together with other "softer" policies that enable, harmonize and provide technical and capacity-building support.

What legal architecture should this combination of policies take? Should they be combined in, say, a "clean industry directive"? A dedicated clean-industry directive is probably not required. With the exception of the introduction of border carbon adjustments and the new CCfD policy, most of the necessary policies could be introduced by reforming

Policies and Legislative instruments to implement the Clean Industry Package — Figure 13



Agora Energiewende (2020)

Note: CDW stands for Construction and Demolition Waste existing regulatory instruments. Yet a risk of this approach is that the overarching vision of a comprehensive and coherent package gets lost in the detail. To keep its eye on the big picture, the EU will need to consider the role of **new governance tools** for industrial decarbonization, both as it prepares legislation and over the longer term.

Figure 13 summarizes the eleven policy recommendations and maps them onto existing EU-level legislative instruments. The figure shows that, save for CCfDs and eventual border carbon adjustment legislation, virtually all of the proposed instruments could be attained through reforms to existing legislative tools.

Furthermore, virtually all of these legislative files have been proposed for revision under the Green Deal and the 2030 Climate Target Plan. This represents a golden opportunity to implement the proposed policies. At the same time, however, important elements that are not part of the legislative files on the table – notably an enabling framework for carbon contracts for difference and the development of robust standards for climate-neutral materials – must not be forgotten.

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