UNIVERSITY OF CAMBRIDGE
INSTITUTE FOR SUSTAINABILITY LEADERSHIP

CLG Europe

Policy briefing

# Forging a carbon-neutral heavy industry by 2050:

## How Europe can seize the opportunity

October 2019

funded by

WE MEAN BUSINESS

## Corporate Leaders Group Europe

CLG Europe is a select group of leading European businesses, with a membership representative of Europe in both geography and sector. CLG Europe members have come together to work with policymakers and business peers to support stronger ambition and effective, accelerated action on climate change within the EU and globally. The group's work is aligned with the Paris Agreement and in support of the Sustainable Development Goals (SDGs).

CLG Europe is the sister group of UK-focused The Prince of Wales's Corporate Leaders Group, which has frequently defined the British business response to climate change.

The guiding mission of CLG Europe is to develop credible, ambitious positions amongst its membership and deploy effective strategic communications, thinking and action to engage with the highest levels of policy audiences and the wider business community. It acts to strengthen climate change policy and drive it into practice, both in Europe and, working with others, around the world.

CLG Europe is convened by the University of Cambridge Institute for Sustainability Leadership (CISL).

## The Cambridge Institute for Sustainability Leadership

The University of Cambridge Institute for Sustainability Leadership (CISL) is a globally influential Institute developing leadership and solutions for a sustainable economy. We believe the economy can be 'rewired', through focused collaboration between business, government and finance institutions, to deliver positive outcomes for people and environment. For over three decades we have built the leadership capacity and capabilities of individuals and organisations, and created industry-leading collaborations, to catalyse change and accelerate the path to a sustainable economy. Our interdisciplinary research engagement builds the evidence base for practical action.

## We Mean Business

We Mean Business is a global non-profit coalition working with the world's most influential businesses to take action on climate change. The coalition brings together international non-profit organisations: BSR, CDP, Ceres, The B Team, The Climate Group, CLG, WBCSD. We Mean Business provided financial support for the publication of this report.

## Author and acknowledgements

This policy briefing was authored by Dr Sanna Markkanen, with input and support from Romain Pardo, Martin Porter, Annabelle Roblin, Eliot Whittington, and Ursula Woodburn.

We would like to thank Ian Ellison, Associate Director, CISL; Professor Steve Evans, Director of Research, Centre for Industrial Sustainability at the Institute for Manufacturing, University of Cambridge; Professor Tim Minshall, Head of the Institute of Manufacturing, University of Cambridge; Wido Witecka, Analyst, Agora Energiewende; and CLG members and partners in the We Mean Business coalition for their helpful and constructive comments.

### Members

acciona
Coca-Cola European Partners
DSM Bright Science. Brighter Living.
EDF
Iberdrola
Interface
Signify
Storaenso
Unilever

### Affiliate members

Love every drop. Anglian Water
gsk
Heathrow Making every journey better
INGKA IKEA IKEA Retail business
sky
TESCO
Thames Water

Policy briefing

# Forging a carbon-neutral heavy industry by 2050: How Europe can seize the opportunity

**As momentum gathers behind a long-term vision for a climate-neutral economy by 2050, increasing attention is being directed to sectors of the economy that are difficult to decarbonise. This includes heavy industry – ie energy-intensive sectors associated with materials and machinery production such as oil, mining, shipping, steel, cement and chemicals. While heavy industry is not in itself one of the biggest contributors to GDP and employment, it provides inputs to value chains for most other sectors. Heavy industry plays a central role in the European economy, and its decarbonisation is essential if Europe's climate goals are to be achieved.**

This briefing synthesises some of the latest thinking around the challenges and opportunities involved in decarbonising European heavy industry. It brings together the key findings from recent reports on industrial transformation, such as those by Material Economics[1] and the Energy Transitions Commission,[2] on what is technologically possible and financially feasible. It also synthesises the associated policy-focused reports on how policymakers at national and European level can support businesses in this transition, in particular through the forthcoming industrial strategy for Europe and Europe's long-term strategy on climate.[3,4,5,6] Throughout the report, case studies are used to highlight how leading companies are innovating in segments of material-intensive value chains to move them and their businesses towards carbon neutrality.

**This briefing sets out four key approaches to reduce industrial emissions to net-zero by 2050:**

1. **Efficient use of carbon-intensive materials**
2. **High-quality materials recirculation using renewable energy**
3. **New production processes**
4. **Carbon capture and use/storage (CCUS)**

Businesses should embrace this future and seek to adopt these approaches. To support them policymakers should:

- create strategic clarity and direction including on areas like the deployment of CCUS, biomass and hydrogen
- support innovation and the deployment of new solutions
- work to unlock investment and provide financial support for these approaches
- provide the incentives to create market demand – including through carbon pricing
- embed circularity within industrial and wider policies
- align energy and other infrastructure plans to support this transition.

**This briefing has been issued by CLG Europe – an influential and diverse group of European businesses collaborating to define and lead the business response at the European level to the climate crisis, who also works with EU policymakers to support and accelerate economy-wide action. In response to the growing climate crisis, leading businesses are stepping up their ambition – setting emissions reduction targets aligned with the latest science, aiming to reach net-zero emissions by 2050, and calling for clear ambitious government policies in support of a prosperous future in which global warming is limited to 1.5 degrees. Clear and consistent government policies to drive the decarbonisation of the economy are critical to unlock investments in the zero carbon economies of the future.**

## The case for action

**In 2015, industry was responsible for 19 per cent of Europe's total greenhouse gas (GHG) emissions**, equivalent to 857 Mt $CO_2$.[7] The majority of industrial emissions come from a small number of basic commodity sectors, which account for approximately 2 per cent of Europe's 'value added' GDP and 1 per cent of jobs.[8] However, the indirect impact on the European economy and labour market is much greater, as these sectors form an essential part of value chains, which deliver services and societal functions that are essential for wellbeing and development, including infrastructure, agriculture, food production and packaging, mobility and appliances.

In particular, cement, steel, plastics and ammonia account for approximately 14 per cent (500 million tonnes) of the EU's annual $CO_2$ emissions[1] and, while decarbonising these industries is essential for Europe to achieve net-zero $CO_2$ emissions by 2050, these sectors face significant specific challenges in doing so, primarily because of emissions arising from chemical processes and the need for high-intensity heat. Any route to decarbonisation must be clear on how emissions can be abated without driving industries to relocate outside Europe. The changes required to decarbonise the materials sectors while preserving competitiveness will stretch across all sectors of the economy where carbon-intensive materials are used in the production, packaging, transport or delivery of goods and services.[2,5]

**Recent studies[1,2] show that reducing $CO_2$ emissions from these industries to net-zero by 2050 is technically feasible and financially possible, and can have multiple social and economic benefits.** The estimated additional investment associated with decarbonising these sectors is around 40–50 billion EUR per year by 2050 – or 0.2 per cent of projected EU GDP. However, the actual cost could be less if the cost of renewable energy drops faster than expected, or the cost of new technologies substantially declines in response to growing demand. The cost of industrial decarbonisation should also be considered in the context of numerous wider benefits of reducing industrial emissions and the long-term and increasing cost of climate damages associated with unabated climate change.

For businesses, the transition to net-zero industrial production will present challenges and opportunities. Companies across the economy will need to alter their production processes and potentially change their business models. Capital-intensive industries will face difficult investment decisions and potentially increasing production costs, especially in the short/medium term until new production technologies become cost-competitive with incumbent, fossil-fuel reliant production.

**However, the transition to zero carbon industry can yield substantial, long-term economic benefits by positioning European industry at the forefront of a global trend.** The extent to which European industry can take advantage of this opportunity depends on the strength of the political commitment and introduction of a regulatory framework that enables European industries to remain internationally competitive as they pursue deep cuts to emissions.[1] To this end, **the EU will need to lay the foundations for a new, clear industrial strategy that centres on clean technologies and the decarbonisation of industry.**

**Europe is in a strong position to become a world leader in low carbon industrial production:** European companies are innovative, relatively energy efficient, have access to a highly skilled workforce and are already taking a strong position on climate. Nearly half of all companies that are currently signed up to the Science Based Targets initiative (SBTi) are based in Europe, and businesses from Europe make up over 40 per cent of the RE100 organisations, which are committed to go 100 per cent renewable.[9] Some of the innovative practices and technologies that are already used or are being developed by European businesses to achieve ambitious targets are showcased in this report.

Although we have 30 years until the proposed 2050 deadline for carbon-neutral industry, the nature of investment cycles and the time required to reconfigure value chains means that **progress towards this goal must start now**. Much of the existing capital stock in the chemicals, steel and cement sectors will need to be replaced in the coming decade. The long lifetimes of plants in the energy-intensive sectors means that investment choices taken now and in the near future will determine whether European industry enters a net-zero emissions pathway without creating stranded assets.

**There is a pressing need for a clear and comprehensive, long-term policy framework to incentivise investment in the innovation, development and purchase of low carbon solutions by businesses.** This framework, including an industrial strategy that sets clear targets and priorities and aligns with the renewable energy strategy for Europe, will be essential to avoid lock-in of wasteful high carbon infrastructure and relocation of industries to regions with laxer regulatory frameworks.[1,5]

**Advanced planning and early action can substantially lower the cost of the low carbon transition and improve the competitiveness of European industry** as the demand for low carbon goods and production process technologies grows, positioning these industries at the forefront of new markets.[10,11] New technologies developed in Europe can play a key role in accelerating decarbonisation of industry worldwide.[6] EU industry has long gravitated towards increased specialisation, in particular around high value-added products and services.[6] Becoming a pioneer in low carbon industrial solutions and the circular economy would continue an established trend, strengthening the position of European industry globally.[1,6]

# The social and environmental benefits of action

Decarbonisation of the carbon-intensive materials industry will have multiple environmental and societal benefits. Improved material efficiency, greater circularity and decarbonisation of industrial production processes will make Europe's economy less reliant on imported fossil fuels, feedstock and raw materials,[1,6,12,13] while also creating new jobs in Europe.[1,6,13]

## Employment

Decarbonisation of the materials industry will require a mixture of approaches, ranging from measures to reduce demand for carbon-intensive materials to technological solutions to decarbonise the production processes. Although these transitions will create new employment opportunities, the exact number of new jobs emerging and old jobs lost is difficult to estimate, partly because the industrial transformation will coincide with greater automation and digitalisation, which in itself is likely to reduce jobs in certain sectors of the economy. The nature and location of employment impacts will be shaped by policy decisions regarding which of the approaches to industrial decarbonisation will be prioritised. However, the distribution of employment opportunities can be expected to change, as some sectors of the economy will contract while others expand.

For example, improved material efficiency and greater circularity is likely to result in some job losses in electronics manufacturing and sectors that produce and process raw materials, but these losses will be outnumbered by new jobs in recycling and repair services, leading to a positive net employment impact of approximately 700,000 more jobs.[14] Similarly, while employment in the construction sector is expected to fall from productivity gains as a result of new building techniques,[14] a greater number of new jobs in energy efficiency improvements to existing properties will compensate for this.[15]

As low carbon energy replaces fossil fuels, new jobs will be created in the low carbon energy sector, predominantly in renewables. Decarbonisation of European industry and heavy-duty transport is projected to more than quadruple electricity demand by 2050.[1,2,10] If this increase in demand is to be met predominantly from renewable electricity and green hydrogen, which currently account for 17.5 per cent of Europe's energy mix,[16] the annual growth rate in renewable electricity generation capacity in Europe must double from the annual average of 5.1 per cent in 2007–2017.[16,17] Even if much of the technology were imported and automation were to reduce the jobs required in installation and maintenance work, the number of jobs in renewable electricity and green hydrogen can be expected to grow considerably, simply as a result of the scale of growth in demand.

The extent to which the new jobs can be filled with European workers depends on the ability of the European governments to upskill and reskill workers whose current jobs may be at risk, and to effectively use their educational systems to teach children the skills that will prepare them for jobs in a zero carbon economy.[6] Successful implementation of industrial policy that facilitates a high level of innovation and new product development in Europe will also play a key role in ensuring that sectors such as research and technology remain strong, and in Europe.

## Environmental and human health

Based on current consumption patterns, the demand for new 'virgin' raw materials is expected to double between 2015 and 2050.[18] The more efficient use of energy-intensive materials and greater circularity would reduce waste and the extraction of primary resources.[18,19] Measures to decarbonise industry that cut the demand for 'virgin' raw materials will decrease the adverse environmental impacts of industry and resource extraction. This will result in healthier soil, water and ecosystems, reducing pollution, biodiversity loss, ocean acidification and overexploitation of freshwater resources.[13,20]

Environmental problems such as air, water and soil pollution are intimately linked to human health and wellbeing.[21, 22] A cleaner environment has multiple health benefits,[21, 22] and associated economic benefits.[20] In 2015, air pollution alone was responsible for 790,000 premature deaths in Europe, reducing the mean life expectancy in the continent by about 2.2 years.[23] The aggregate costs to the economy of air pollution caused by European industrial facilities in 2008–2012 was at least 139 billion EUR, and could be as high as 1,053 billion EUR,[24] suggesting that the health co-benefits of reducing GHG emissions and other pollutants (such as fine particulate matter and ozone) substantially outweigh the costs required to achieve carbon emission reduction targets.[25]

# Approaches to decarbonising industry

The Material Economics[1] report identifies four approaches to reduce industrial emissions to net zero by 2050. These range from a focus on reducing the demand for carbon-intensive materials, to increasing the recycling and reuse of the materials that are already in circulation, to decarbonising the production processes. None of the outlined approaches will achieve full decarbonisation on their own, meaning that several of the approaches must be implemented simultaneously. However, there are choices in to what degree, as long as the overall strategy is sufficiently ambitious – i.e. it delivers net-zero emissions across the industry. The approaches identified are:

## 1. Efficient use of carbon-intensive materials

Efficient use of carbon-intensive materials entails reducing the use of materials such as steel, cement and plastics to the minimum that is required to achieve a certain functionality or benefit (improving material efficiency). This will reduce the demand for these materials and, as a result, the need for new production.

To support more efficient use of carbon-intensive materials, businesses across all sectors of the economy will need to avoid using more carbon-intensive materials such as steel and cement than is needed to make a building or a manufactured product structurally sound. This can be achieved through:

- production mechanisms and technologies that minimise material waste in the manufacturing process[26]
- only using the amount of packaging materials that is required to perform an essential function (such as maintaining food hygiene standards for example)
- substituting carbon-intensive materials with low carbon alternatives, for example by replacing carbon-intensive materials such as plastics and cement with bio-based materials in construction and packaging where possible without compromising health and safety standards or functionality
- extending product lifespan by providing supporting services such as repairs, upgrades and product takeback to extend the life of products[13]
- maximising the utility benefits of products that contain carbon-intensive materials, such as cars, through a ‘sharing economy’ approach
- embracing business models that reduce the need for single-use packaging, such as enabling consumers to purchase a ‘refill’ using an existing container.

Potential reductions from increased material efficiency: 58–171 Mt $CO_2$ per annum by 2050 – i.e. approximately 12–34 per cent of the current sectoral emissions.

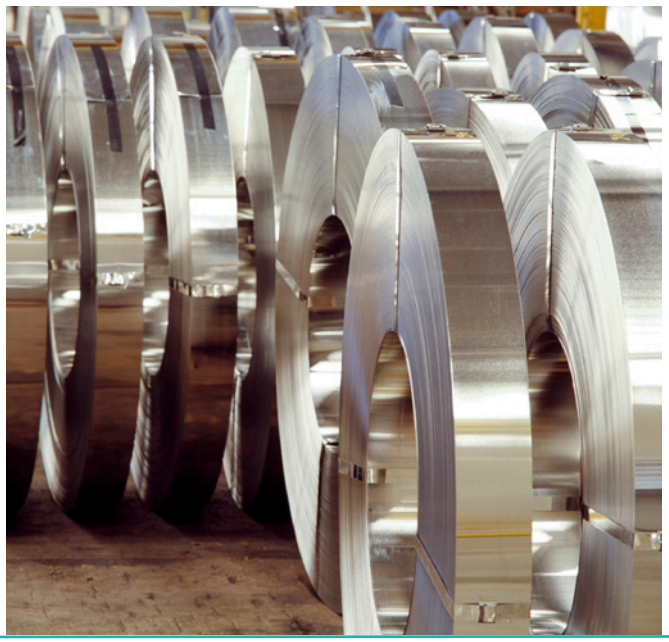
## Case study: Building with wood

Wood and wood fibre-based products are renewable and recyclable, contributing to a circular bioeconomy and reducing the demand for carbon-intensive materials such as steel, concrete and plastics. The $CO_2$ that is absorbed into a growing tree’s fibres remains embedded in wood-based materials through harvesting, product lifetime and recycling.

Stora Enso manufactures a range of wood- and fibre-based products ranging from drink cartons to building materials. In construction, wooden building materials provide a light-weight alternative that allows the amount of steel and cement in buildings to be significantly reduced. New innovations enable wood-based products to be used for a growing range of purposes, including tall, multi-storey buildings previously dominated by concrete and steel. Pre-fabricated wooden building materials such as cross-laminated timber (CLT) and laminated veneer lumber (LVL) can also cut construction time considerably.

When a wooden building is taken apart, the building material can be recycled and reused, and the carbon content is only released into the atmosphere when the wood decomposes or is burnt for bioenergy. $CO_2$ is reabsorbed by the new generation of trees when the forests grow back. This loop can contribute to the circular economy thinking endorsed by the EU.

Stora Enso supplies some five million cubic metres of sawn timber and processed wood products every year to construction sites all over the world. The company applies a third party certified traceability system to ensure that all wood originates from sustainably managed forests.



## 2. High-quality materials reuse and recycling powered by renewable energy

High-quality materials recirculation refers to circular economy based strategies where carbon-intensive materials are recycled at the end of their lifespan and reused in 'second life' production processes. Some materials can be reused without needing to be processed.

Greater circularity will reduce waste and lower the demand for energy and virgin raw materials, especially in plastic and steel production, but also for other materials outside the scope of the Material Economics work, such as aluminium.

To facilitate material recirculation, producers of carbon-intensive materials will need to:

- produce high-quality materials that can be recycled multiple times
- develop new mechanisms to produce high-quality products using recycled materials
- develop mechanical and chemical recycling processes to enable end-of-life plastics to be reused as feedstock for new production
- improve the recyclability of steel through reduced contamination with other metals.

Recirculation of materials will require businesses that use carbon-intensive materials to:

- extend the lifetime of materials through design that makes it easier to disassemble products at the end of their lifespan, facilitating effective recycling of components and remanufacturing[13]
- engage in greater recovery and reuse of waste and by-products, often in collaboration with each other.

Potential reductions from increased materials recirculation: 82–183 Mt $CO_2$ per annum by 2050 or approximately 16–37 per cent of current emissions.

**Greater circularity will reduce waste and lower the demand for energy and virgin raw materials, especially in plastic and steel production**

### Case study: Circular building materials – the DSM-Niaga–ECOR collaboration

Particleboard and other panel materials are widely used in buildings and construction, furniture, interior decoration and displays. At present, the irreversible combination of materials and ingredients used in most products made with particleboard presents a major challenge for technically and economically feasible recycling.

Research collaboration between DSM-Niaga and ECOR has sought to address this challenge by developing fully recyclable alternatives for particleboard and other panel materials without compromising on material safety, quality and recyclability. The ECOR technology makes it possible for materials to be manufactured from natural fibres, with water, pressure and heat alone, while DSM-Niaga's reversible adhesive enables easy decoupling of different material layers for full recovery and high-value recycling. A combination of the ECOR and Niaga® technologies can be used to manufacture ECOR materials into products that are made from 100 per cent recycled content, and can be fully recycled after use.

Both companies seek to offer manufacturing processes to local companies, solving local waste problems and boosting local economies on a global scale.
For more information see www.ecorbenelux.com and www.dsm-niaga.com.

### Case study: Interface's mission to build a circular business model

Interface's Climate Take Back™ mission illustrates the company's commitment to run their business in a way that helps to restore and regenerate the environment. In addition to 88 per cent of the company's global energy demand being met from renewable energy sources, Interface has reduced the carbon footprint of its carpet tiles by over 60 per cent since 1996, and 58 per cent of the materials the company uses are recycled or bio-based. All flooring products sold by Interface are carbon neutral (Carbon Neutral Floors™) or are going beyond by becoming carbon negative (Proof Positive and CircuitBac Green).

Circular economy considerations at the end of life are also key to Interface's decarbonisation approach. The ReEntry take back service ensures that the company's products, and those of its competitors, will not go into landfill. Flooring tiles that are still in good condition are reused in collaboration with social enterprises. Flooring tiles in poor condition are converted to other products or can be recycled. When reusing, repurposing and recycling are not viable options, the products are recovered as energy in a waste to energy facility. Between 2016 and 2018, the ReEntry take back service prevented more than 3.5 million m2 of carpet going to landfill around the globe.

## 3. Innovating production processes

Materials production is likely to continue even as the demand for materials is successfully reduced through improved material efficiency and circularity, which means that decarbonisation of production is also required.

To reduce production process emissions, cement, steel, ammonia and plastics manufacturers will need to:

- develop production routes and mechanisms that enable fossil fuels to be replaced with alternatives such as electricity hydrogen sourced from renewables or other low carbon energy sources or sustainably sourced biomass, thus reducing the $CO_2$ emissions from energy-intensive production processes. The high heat requirements of industry in particular will require rapid deployment of innovative alternatives at commercial scale
- develop new methods to replace carbon-intensive raw materials and virgin raw materials with less carbon-intensive alternatives, such as biomass or end-of-life plastics in chemicals and steel production, or calcined clay in cement production.[27]

Potential reductions from new production processes: 143–241 Mt $CO_2$ per annum by 2050 – or approximately 29 –48 per cent of current industrial emissions.

**Innovative production processes are required given that materials production will continue.**

### Case study: The ∑IDERWIN project

The ∑IDERWIN project is a collaborative project between EDF and ArcelorMittal, together with 11 other partners across Europe, with support from the EU's Horizon 2020 programme (grant agreement: 768788). The aim of the initiative is to develop an energy-efficient process powered by renewable energy to produce steel plates from any iron oxide, including those inside the by-products from other metallurgies.

Compared to traditional steelmaking processes, this innovative technology can reduce direct $CO_2$ emissions by 87 per cent, while using 31 per cent less energy. It will also enable steel manufacturing to better use a broader range of recycled metals.

The ∑IDERWIN project, which commenced 12 years ago, is now at the stage where the prototype technology is being piloted to prove the industrial potential of the technology. The next stage of development will involve designing an industrial-scale set-up to validate the technology in a relevant environment.

### Case study: The HYBRIT Initiative - a value chain for fossil-free iron and steelmaking

In 2016, the Swedish companies SSAB, LKAB and Vattenfall joined forces under the HYBRIT Initiative (HYBRIT) to achieve a fossil-free energy-mining-iron-steel value chain. HYBRIT aims to replace coal, traditionally needed for ore-based steelmaking, with low carbon electricity and hydrogen. $CO_2$ will be replaced with $H_2O$ as emissions. A pilot phase is on-going until 2024, followed by a demonstration phase after 2025. The goal is to have the new technology ready for industrial scale by 2035.

HYBRIT's value chain, including large-scale H2 generation and storage, can support the transition towards a fossil-free energy-mining-iron-steel value chain while simultaneously playing an important role in the renewable energy system. The technology has a potential to drastically reduce the global $CO_2$ emissions and help achieve the Paris Agreement target. In the roadmap for the HYBRIT Initiative, a gradual conversion from blast furnace to electric arc furnace will happen from 2025. By 2045, the total emission reduction for Sweden will be 10 per cent and for Finland 7 per cent.

Read more: www.hybritdevelopment.com

## 4. Carbon capture and use/storage (CCUS)

CCUS is a blanket term for using technology to capture the $CO_2$ produced from electricity generation and industrial processes, and either transport to long-term sequestration (usually deep underground) or deploy as an input in other industrial processes.

CCUS will most likely be required to cut process emissions from cement production, as cement is currently less recyclable than other materials such as steel and plastics.[2] However, CCUS is viable only in specific circumstances where the captured carbon can be stored or used in a way that enables emissions to the atmosphere to be permanently avoided.[1]

Potential reductions from CCUS: 45–235 Mt $CO_2$ per annum by 2050 or approximately 9–47 per cent of industrial emissions.

**All businesses that use carbon-intensive materials will need to contribute.**

Decarbonisation of the energy-intensive materials industry will not happen in isolation. Businesses that produce energy-intensive materials will be responsible for decarbonising the extraction, processing, use and disposal of these materials. However, improved material efficiency and the transition to a circular economy will require a broader paradigm shift involving businesses across all sectors of the economy that use carbon-intensive materials in their value chains – from energy generation to retail – as well as governments and consumers.

To create a closed-loop system, societies will need to alter how they consume and dispose of energy-intensive materials and products containing such materials. The transition to a circular economy is likely to disrupt many established practices and will require some businesses to alter their business models to remain economically viable. However, digitalisation and the emergence of the 'sharing economy' will provide new opportunities for entrepreneurs with innovative ideas as well as established businesses that are at risk of becoming unviable as a result of changing demand patterns.[13]

# Enabling action: a policy approach for a net-zero carbon European industry

In the long term, the investment required to deliver the above actions has the potential to generate substantial benefits, including significant financial returns. However, much of this payback will take time to materialise and some of that return, such as the benefits associated with cleaner air and environment, will not accrue only or even mainly to those who made the initial investment. It is critical that supportive policies incentivise businesses to invest now, to open the door to these future benefits.

In the absence of a global carbon price or other global mechanisms for implementing carbon restrictions on industry,[6] Europe will need to consider how a policy framework to support industrial decarbonisation in Europe can enable and drive the approaches identified above. It will be essential for this policy framework to set out clear strategic priorities and long-term plans, alongside sufficient support mechanisms, to ensure that there is a viable and productive future for these industries.[1]

As policymakers work to decarbonise Europe's economy and improve its competitiveness they will face numerous challenges. Below we identify some of the priority areas for action in order to deliver a climate-neutral future for industry.

## Innovation support

At its heart, achieving industrial decarbonisation is a huge investment and innovation challenge. Establishing an enabling environment to encourage and facilitate innovation, research and development[4,6] will be key. Research and development will need to take place[5] to develop and commercialise:

- solutions to reduce the demand for carbon-intensive materials
- approaches to cut material waste in production processes
- product designs to improve the recyclability of carbon-intensive materials
- approaches to recycling and waste management and technological solutions to facilitate the transition to a circular economy
- manufacturing mechanisms and energy-saving solutions to reduce process emissions and enable decarbonisation of the energy supply used to power industrial processes.

Policymakers need to convene and support interdisciplinary partnerships and collaboration across governments, industry and research institutes,[6,10] such as the 'Industrial climate neutrality' grand challenge under Horizon Europe. Regulatory frameworks will need to be revised to create an enabling environment for innovation by setting standards for functionality without specifying which kind of solution needs to be used.[6] Approaches such as 'regulatory sandboxes', which exist outside the established regulatory framework, can be used to enable experimentation with novel technologies and business models, with a view to informing revision of existing regulation.[6]

New funding will be required for research and development, but also to support piloting, demonstration, deployment and commercialisation of new solutions and breakthrough technologies.[1,2,5,6] This support is particularly important in the near term (eg over the next decade), as timely action can drive technology maturation, lowering the cost of the transformation for businesses.[6,10] Targeted policy instruments will also be needed to enable new solutions to progress from pilot stage to reach full-scale industrial technological readiness level as quickly as possible to accelerate widespread and timely uptake.

## Stimulating investment

Decarbonising heavy industry is capital intensive, especially where new production methods and machinery are required. New low carbon production processes will increase steel production costs by 20–30 per cent and cement and chemicals production costs by 20–80 per cent. Investment by carbon-intensive materials producers will need to increase from current levels to maintain current production levels while delivering decarbonisation.[4] Without clarity those investments risk being misallocated and stranded.[4,6]

To guide and unlock investment in a modern, decarbonised European industry, policymakers should:

- facilitate access to public and private sector funds aligned with delivering innovative, decarbonised industry [6]
- use carbon pricing, contracts for difference or other measures to close the gap between business as usual and new zero carbon solutions, and so incentivise investment. This may involve revisiting State Aid Guidelines [5]
- deliver new financial regulation and guidance, including the sustainable finance taxonomy that encourages long-term investment alignment with sustainable outcomes.[6]

## Putting greater circularity at the heart of industrial policy

The transition to a more circular economy will involve changes to production processes, consumption patterns and recycling infrastructure. Transforming whole value chains in this manner will require policy measures that target both material production (eg steel, cement, plastics) and the end product (eg cars, buildings, appliances).[5] A combination of standards, regulations and fiscal measures will be needed to reduce waste and incentivise investment in recycling and resource management infrastructure.[4]

Policymakers can support the transition to a circular economy by:

- developing a more ambitious strategic approach to a circular economy, for example by revising and strengthening the EU action plan for the circular economy [28]
- incentivising material efficiency through the tax system, for example by increasing taxes on resource extraction or material use or disposal[13]
- targeted use of regulation – such as mandatory standards for materials efficiency, recycled content and recycling[2]
- investing in the required infrastructure and other support services to enable circularity and recycling.

## Developing markets for low carbon materials and products

Demand for new low carbon materials and products is fundamental to the viability of decarbonised industry. Regulatory and financial measures that favour zero carbon or low carbon products, services and investments – including recycled materials and products that are more recyclable and reusable – will be needed to instigate and support change in consumption patterns.[5,13] Conversely, regulations and incentives that encourage unsustainable activities must be eliminated.[11]

New markets for low carbon options can be supported by:

- use of public sector procurement rules and regulatory incentives for green private sector procurement[5,13]
- standards that support greater transparency on the environmental impact of materials and products, such as life cycle GHG accounting that includes the end-of-life phase[5] and more standardised carbon reporting globally[5,6]
- clear incentives such as subsidies to reduce the costs of low carbon options, or carbon pricing or consumption charges to increase the cost of unsustainable activities.[6]

## Aligning energy plans to support the transition

Decarbonisation of the industrial sector has significant implications for the energy system – most notably through the potential for a significant (up to fourfold) increase in electricity demand to supply the increasingly electrified industrial sectors. Energy policy and industrial policy will need to be synchronised as energy demand and supply both evolve in the context of urgent decarbonisation.[6,10]

Across Europe, policymakers will need to:

- develop long-term plans and roadmaps for the power sector that take account of the potential for significantly increased demand
- invest in energy efficiency in other sectors of the economy to control the growth in demand for energy[6]
- support the transition from natural gas to decarbonised power sources such as renewable gas, low carbon power and hydrogen produced from low carbon power.

## Strategic clarity

Above all, **European policymakers will need to establish a strategic direction and consensus on policy priorities**. As illustrated in this report, there are multiple approaches to industry decarbonisation. A shared and widely understood strategy will help align public and private sector efforts for greatest impact.

As part of this, policymakers will need to consider and decide what role some of the more controversial options – such as use of biomass and CCUS – will play in the transition to net-zero carbon industry. They should consider how much biomass will be needed, how policy can ensure that this demand will be met from sustainable production and how biomass can be used to create the highest possible value (such as through uses that enable embodied carbon benefits to be maximised). Similarly, in which instances, and to what extent, should CCUS be used in the decarbonisation of industry? How will it be regulated and financed to safely and sustainably achieve the desired outcome? Policymakers will also need to take a clear position on hydrogen production, including deciding how, and to what extent, the production and use of hydrogen needs to be controlled.

There will be a role for hydrogen, CCUS and biomass, but there needs to be greater clarity and consensus in order to unlock investment decisions. A stable, long-term policy framework outlining a ‘hierarchy’ of various abatement options should be designed and implemented urgently, as the investment choices taken now and in the next decade will determine the costs and difficulty of the decarbonisation of European industry and the scale of stranded assets.

# Conclusions

A successful transition to zero carbon industry will involve changes in the production and consumption of goods and services, affecting all sectors of the economy. The process will be closely intertwined with the decarbonisation of the energy supply and transformation of the transport sector. It will also coincide with other societal, technological and economic changes driven by increasing automation and digitalisation.

The changes required to decarbonise heavy industry are essential for the broader effort to achieve a net-zero economy in Europe by 2050. The scale and complexity of the task is enormous, and heavy industry is at the very core of it. Meaningful progress towards net-zero will require a coherent, clear, bold and strategic policy framework linking together the multiple approaches across the economy. Such policy will also need to facilitate innovation and collaboration involving actors from academia to industry, within and across industries and the economy.

**The transition to net-zero carbon industry or economy should be viewed as an investment opportunity for European companies.** With the right policy framework, European industries can reap the benefits of improved productivity and competitiveness, while establishing themselves in a strong position internationally as a leader in low carbon innovative and sustainable products and services, energy efficiency and renewable energy.[6] New technologies and new sustainable industrial systems developed in Europe can accelerate decarbonisation of industry worldwide,[6] while improving material and energy security in Europe, creating new jobs, and contributing to a cleaner, healthier environment.

Although new technologies and low carbon solutions will be more costly than conventional, carbon-intensive options, this disadvantage applies only for a limited time. As the new technologies take off at scale, the financial benefits arising from mass deployment will vastly outweigh the initial investment costs.[8] Decisions such as whether to prioritise decarbonisation approaches that rely on reducing demand through material efficiency and circular economy or technological solutions such as CCUS will have widespread implications for investment and innovation. The wealth held in institutional investment funds in Europe vastly exceeds the amount of the investment needed to achieve a net-zero carbon economy by 2050.[8] However, without a clear policy framework that sets an unambiguous direction for travel, the degree of uncertainty and lack of confidence will deter long-term investment from these sources as well as from businesses that have a responsibility to their shareholders. The window of opportunity for European industry to become a world leader in low carbon solutions is now, but it is narrow.

As set out in this briefing there are four key approaches to reduce industrial emissions to net-zero by 2050:

1. Efficient use of carbon-intensive materials
2. High-quality materials recirculation using renewable energy
3. New production processes
4. Carbon capture and use/storage (CCUS)

Businesses should embrace this future and seek to adopt these approaches. To support them policymakers should:

- create strategic clarity and direction including on areas like the deployment of CCUS, biomass and hydrogen
- support innovation and the deployment of new solutions
- work to unlock investment and provide financial support for these approaches
- provide the incentives to create market demand – including through carbon pricing
- embed circularity within industrial and wider policies
- align energy and other infrastructure plans to support this transition.

European Commission President Von der Leyen's commitment to proposing a European Green Deal and to achieving a net-zero European economy by 2050 provides an ideal opportunity for European policymakers to set an industrial strategy that has climate neutrality at its core. A supportive and stable policy framework should be designed and implemented as a matter of urgency to maximise the benefits for the environment, businesses and European citizens. As the examples in this briefing illustrate, however, many European companies are taking the initiative, innovating and responding to this challenge.

**The transition to net-zero carbon industry or economy should be viewed as an investment opportunity for European companies.**

# References


1 Material Economics. (2019). Industrial Transformation 2050: Pathways to Net-Zero Emissions from EU Heavy Industry. Retrieved from: https://www.climate-kic.org/wp-content/uploads/2019/04/Material-Economics-Industrial-Transformation-2050.pdf

2 Energy Transitions Commission – ETC. (2018). Mission Possible: Reaching net-zero carbon emissions from harder-to-abate sectors by mid-century. Retrieved from: http://www.energy-transitions.org/sites/default/files/ETC_MissionPossible_FullReport.pdf

3 Pellegrin, J. et al. (2019). How to tackle challenges in a future-oriented EU industrial strategy? Study for the Committee on Industry, Research and Energy, Policy. Department for Economic, Scientific and Quality of Life Policies, European Parliament, Luxembourg. Retrieved from: http://www.europarl.europa.eu/RegData/etudes/STUD/2019/638409/IPOL_STU(2019)638409_EN.pdf

4 Wyns, T., Khandekar, G., Axelson, M., Sartor, O., & Neuhoff, K. (2019). Towards an Industrial strategy for a Climate Neutral Europe, IES. Retrieved from: https://europeanclimate.org/wp-content/uploads/2019/04/Towards-an-Industrial-Strategy-FULL-REPORT.pdf

5 Agora Energiewende. (2019). The "Clean Industry for Europe (CI4E)"-package: Towards a climate neutral industry by 2050.

6 European Commission. (2019). A vision for the European Industry until 2030: Final report of the Industry 2030 high-level industrial roundtable. Retrieved from: https://publications.europa.eu/en/publication-detail/-/publication/339d0a1b-bcab-11e9-9d01-01aa75ed71a1/language-en/format-PDF/source-104431216

7 Total greenhouse gas emission trends and projections. (2018). Retrieved September 19, 2019, from European Environment Agency (EEA) website, https://www.eea.europa.eu/data-and-maps/indicators/greenhouse-gas-emission-trends-6/assessment-2

8 Grubb, M. with Hourcade, J.-C. & Neuhoff, K. (2014). Planetary Economics: Energy, climate change and the three domains of sustainable development. London: Routledge.

9 CDP. (2018). Higher ambitions, higher expectations: CDP Europe report 2018. Retrieved from: https://6fefcbb86e61af1b2fc4-c70d8ead6ced550b4d987d7c03fcdd1d.ssl.cf3.rackcdn.com/cms/reports/documents/000/004/069/original/CDP_Europe_report_2018.pdf?1553594302

10 McKinsey & Company. (2018). Decarbonization of industrial sectors: the next frontier. Retrieved from: https://www.mckinsey.com/~/media/McKinsey/Business%20Functions/Sustainability/Our%20Insights/How%20industry%20can%20move%20toward%20a%20low%20carbon%20future/Decarbonization-of-industrial-sectors-The-next-frontier.ashx

11 New Climate Economy. (2018). Unlocking the inclusive growth story of the 21st century: Accelerating climate action in urgent times. Retrieved from: https://newclimateeconomy.report/2018/wp-content/uploads/sites/6/2019/04/NCE_2018Report_Full_FINAL.pdf

12 European Commission and IRENA. (2018). Renewable Energy Prospects for the European Union. Retrieved from: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2018/Feb/IRENA_REmap_EU_2018.pdf

13 Hoogzaad, J., & Bardout, M. (2018). Looking Beyond Borders: The Circular Economy Pathway for Pursuing 1.5° C. Innovative approaches to peace and security from the Stanley Foundation policy briefing. Stanley Foundation. Retrieved from: https://www.stanleyfoundation.org/publications/pab/CircleEconomyPAB318.pdf

14 European Commission. (2018). Impacts of circular economy policies on the labour market. Retrieved from: https://publications.europa.eu/en/publication-detail/-/publication/fc373862-704d-11e8-9483-01aa75ed71a1/language-en

15 European Commission. (2016). The Macroeconomic and Other Benefits of Energy Efficiency. Retrieved from: https://ec.europa.eu/energy/sites/ener/files/documents/final_report_v4_final.pdf

16 Renewable energy statistics. (2019). Retrieved September 19, 2019, from Eurostat website, https://ec.europa.eu/eurostat/statistics-explained/index.php/Renewable_energy_statistics

17 Findings Expressed in Chapter 3 of: IRENA. (2017). Perspectives for the Energy Transition: Investment Needs for a Low-Carbon Energy System. Organisation for Economic Co-operation and Development, International Energy Agency and International Renewable Energy Agency. Retrieved from: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2017/Mar/Perspectives_for_the_Energy_Transition_2017.pdf?la=en&hash=56436956B74DBD22A9C6309ED76E3924A879D0C7

18 Pardo, R., & Schweitzer, J. P. (2018). A long-term strategy for a European circular economy – setting the course for success. Policy Paper produced for the Think2030 project, Brussels, November 2018. Retrieved from: https://ieep.eu/uploads/articles/attachments/f99f1ac9-83a0-47e0-a0a2-74f3ce528ad8/Think%202030%20Circular%20Economy.pdf?v=63710011292

19 Blok, K., Hoogzaad, J., Ramkumar, S., Ridley, A., Srivastav, P., Tan, I., Terlouw, W., & de Wit, M. (2016). Implementing the circular economy globally makes Paris targets achievable. Circle Economy and Ecofys. Retrieved from: https://www.circle-economy.com/wp-content/uploads/2016/06/ircle-economy-ecofys-2016-implementing-circular-economy-globally-makes-paris-targets-achievable.pdf.pdf

20 Science for Environment Policy. (2018). What are the health costs of environmental pollution? Future Brief 21. Brief produced for the European Commission DG Environment by the Science Communication Unit, UWE, Bristol. Retrieved from: https://ec.europa.eu/environment/integration/research/newsalert/pdf/health_costs_environmental_pollution_FB21_en.pdf

21 WHO. (2018). Circular economy and health: Opportunities and risks. Retrieved from: http://www.euro.who.int/__data/assets/pdf_file/0004/374917/Circular-Economy_EN_WHO_web_august-2018.pdf?ua=1

22 European Environment Agency (EEA). (2013). Environment and human health. EA Report No 5/2013. Retrieved from: https://www.eea.europa.eu/publications/environment-and-human-health

23 Lelieveld, J., Klingmüller, K., Pozzer, A., Fnais, M., Daiber, A., & Münzel, T. (2019). Cardiovascular disease burden from ambient air pollution in Europe reassessed using novel hazard ratio functions. European Heart Journal, 40(20), 1590–1596. doi: https://doi.org/10.1093/eurheartj/ehz135

24 European Environment Agency (EEA). (2014). Costs of air pollution from European industrial facilities 2008–2012 – an updated assessment. EEA Technical Report No 20/2014. Retrieved from: https://www.eea.europa.eu/publications/costs-of-air-pollution-2008-2012

25 Markandya, A., Sampedro, J., Smith, S., Van Dingenen, R., Pizarro-Irizar, C., Arto, I., & González-Eguino, M. (2018). Health co-benefits from air pollution and mitigation costs of the Paris Agreement: a modelling study. Lancet Planetary Health, 2, 126–33. doi: https://doi.org/10.1016/S2542-5196(18)30029-9

26 For example, novel production technologies in car manufacturing can reduce the amount of sheet metal, improving material utilisation by 20 per cent. See Horton, P. M., Allwood, J. M., & Cleaver, C. (2019). Implementing material efficiency in practice: A case study to improve the material utilisation of automotive sheet metal components. Resources, Conservation and Recycling, 145, 49–66. doi: https://doi.org/10.1016/j.resconrec.2019.02.012

27 For example, substituting cement with calcined clay and limestone in concrete production can reduce cement demand by 27 per cent. See Shanks, W., Dunant, C. F., Drewniok, M. P., Lupton, R. C., Serrenho, A., & Allwood, J. M. (2019). How much cement can we do without? Lessons from cement material flows in the UK. Resources, Conservation and Recycling, 141, 441–454. doi: https://doi.org/10.1016/j.resconrec.2018.11.002)

28 European Commission. (2015). Closing the loop – An EU action plan for the Circular Economy. COM(2015) 614 final. Retrieved from: https://eur-lex.europa.eu/resource.html?uri=cellar:8a8ef5e8-99a0-11e5-b3b7-01aa75ed71a1.0012.02/DOC_1&format=PDF

## Cambridge insight, policy influence, business impact

The University of Cambridge Institute for Sustainability Leadership (CISL) brings together business, government and academia to find solutions to critical sustainability challenges.

Capitalising on the world-class, multidisciplinary strengths of the University of Cambridge, CISL deepens leaders' insight and understanding through its executive programmes; builds deep, strategic engagement with leadership companies; and creates opportunities for collaborative enquiry and action through its leadership groups.

Over the past 30 years we have built up a leadership network of over 8,000 senior leaders and practitioners from business, government and civil society, who have an impact in every sector and on every continent. Their experience and insights shape our work, which is further underpinned by multidisciplinary academic research.

HRH The Prince of Wales is the Royal Founding Patron of CISL and has inspired and supported many of our initiatives.

**Head Office**
1 Trumpington Street
Cambridge, CB2 1QA
United Kingdom
T: +44 (0)1223 768850
E: info@cisl.cam.ac.uk

**EU Office**
The Periclès Building
Rue de la Science 23
B-1040 Brussels, Belgium
T: +32 (0) 2 894 93 19
E: info.eu@cisl.cam.ac.uk

**South Africa**
PO Box 313
Cape Town 8000
South Africa
T: +27 (0)82 829 6852
E: info.sa@cisl.cam.ac.uk

**Publication details**


**Disclaimer**
The opinions expressed here are those of the authors and do not represent an official position of CLG, CISL, the wider University of Cambridge, or clients.

**Reference**
Please refer to this publication as University of Cambridge Institute for Sustainability Leadership (CISL). (2019). *Forging a carbon-neutral heavy industry by 2050: How Europe can seize the opportunity*, Cambridge, UK: The Prince of Wales's Corporate Leaders Group.

**Copies**
This full document can be downloaded from the Corporate Leaders Group's website: www.corporateleadersgroup.com

**Contact**
To obtain more information on the report, please contact
Adele Williams:
E: adele.williams@cisl.cam.ac.uk
T: +44(0)1223 768451

October 2019