JUNE 2025
A ROADMAP TO NET ZERO BY 2050

Decarbonising the European Containerboard Industry

CONTAINERBOARD EUROPE

WITH THE SUPPORT OF
CLIMACT

Table of Contents

Executive Summary

As the world confronts the urgent challenge of climate change, the European containerboard industry (EU 27, UK, CH, NO) is at the forefront of the transition to a circular, low-carbon economy. For decades, this industry has been a pioneer and leader in sustainability, championing recycling, resource efficiency, and renewable energy. Now, it is taking the next bold step: achieving Net Zero emissions by 2050.

This long-term focus reflects the investment cycles of industry players and offers a shared direction while respecting each member's specific context. We nevertheless recognise that the coming years will likely be marked by political and economic uncertainty, which makes it all the more important to define short-term milestones that maintain momentum and ensure continued progress. While this roadmap set out to assess the industry's full potential to reach Net Zero by 2050, as a follow-up to this roadmap, containerboard producers should define concrete near-term targets to stay on track and safeguard the industry's long-term competitiveness.

Net Zero means first reducing greenhouse gas (GHG) emissions and balancing hard to abate emissions with permanent removals, ensuring no additional GHG are emitted to the atmosphere. For the containerboard sector, this is more than an environmental goal, it is a strategic imperative. Decarbonisation will future-proof operations, strengthen competitiveness, and align with regulatory frameworks such as the Paris Agreement, while reinforcing Europe's leadership in sustainable packaging solutions.

The containerboard sector is essential to the success of the EU's climate and industrial transition.

A key enabler of the circular economy.

As a key enabler of the circular economy and a significant contributor to the bioeconomy, the industry plays a strategic role in driving both sustainability and competitiveness. This is reflected in resource-efficient production processes that valorise waste and excess heat and in the fact that many mills supply low-carbon energy back to the grid, demonstrating how circularity and decarbonisation are closely intertwined in practice.

The industry strongly supports the European Commission's Clean Industrial Deal (CID) as a critical framework to accelerate industrial decarbonisation, ensure global competitiveness, and mobilise the right tools for sectors undergoing deep transition.

As highlighted in the Future of European Competitiveness report (Draghi, 2024), the paper industry in general should be treated as a strategic sector and actively involved in shaping supportive policy measures.

The sector is already deeply aligned with key EU climate and environmental legislation, including the Renewable Energy Directive (RED), the EU Deforestation Regulation (EUDR), and the Packaging and Packaging Waste Regulation (PPWR). It may also become subject to the Carbon Border Adjustment Mechanism (CBAM), further underlining the need for coherent, enabling policy to support its transition.

This roadmap presents a practical, flexible, forward-looking strategy to support European containerboard producers in reaching Net Zero by 2050. It acknowledges that no single solution exists, offering a tailored set of measures based on mill's specific needs, technological capabilities, and cost considerations. All based on today's knowledge and expectations. It highlights three critical enablers: strong collaboration across the value chain; a strategic commitment to Net Zero as both a climate and economic imperative; and the availability of affordable low-carbon energy, supportive infrastructure, and targeted regulatory and financial frameworks.

Achieving Net Zero requires a whole-systems approach, addressing emissions across Scopes 1, 2, and 3.
This can only succeed through coordinated action, strong partnerships, and sustained investment. **Now is the time for the industry, policymakers, and stakeholders to align efforts and accelerate the transition towards a fully decarbonised containerboard sector.**

Together, we can drive Europe's Green Transition and secure a sustainable, competitive future for generations to come.

INDUSTRY ACTION: WHAT IS EXPECTED FROM EUROPEAN CONTAINERBOARD PRODUCERS?

Containerboard producers should proactively continue to implement decarbonisation measures, including:

- → **Upgrading machinery for higher efficiency**
- → **Electrification of processes,** where feasible (e.g., heat pumps, e-boilers, power-to-heat systems).
- → **Transitioning to low-carbon alternatives** (e.g., sustainable biomass, biofuels, low-carbon hydrogen).
- → **Shifting from grey electricity to low-carbon electricity,** including renewables or nuclear energy to ensure true emissions reduction.
- → **Invest in carbon capture technologies,** at mill exhausts for hard-to-abate emissions.
- → **Monitoring progress,** through efficient, data-driven reporting, avoiding unnecessary bureaucracy by leveraging our LCI database and report, which are, every two years, being updated by RISE in collaboration with FEFCO.

This initiative builds on the industry's ongoing efforts, which over the past 25 years have led to a 33% reduction in fuel consumption and a significant shift towards a more sustainable, low-carbon fuel mix.

SUPPLY CHAIN COMMITMENT: WHAT IS EXPECTED FROM VALUE CHAIN PARTNERS?

Achieving Net Zero by 2050 requires a fully aligned and committed value chain. As scope 3 fossil emissions account for 45% (11 $MtCO_2e$) of all fossil emissions (24 $MtCO_2e$), containerboard producers should actively engage and challenge both upstream and downstream partners to drive innovation, secure support, and accelerate decarbonisation:

- → **Upstream partners** should commit to cutting fossil emissions in raw material production, processing, and transportation.
- → **Downstream partners,** such as corrugators, should continue phasing out fossil fuels in their operations while ensuring a sustainable supply chain and robust recycling systems to maintain a steady supply of recycled fibres.

POLICY SUPPORT: WHAT IS EXPECTED FROM POLICYMAKERS?

The containerboard industry supports a competitive EU industrial strategy that fosters sustainable growth, quality employment, and climate ambition. In this context, the industry welcomes the Clean Industrial Deal and calls on policymakers to:

- → **Expand grid capacity and ensure access to affordable low-carbon electricity**, enabling the electrification of processes and the integration of renewable energy at scale.
- → **Invest in critical infrastructure,** including green energy hubs, and carbon capture, transport, and storage networks, to support deep decarbonisation pathways.
- → **Boost Europe's clean tech sector** through targeted support, to strengthen innovation, secure future-oriented jobs, and enhance global competitiveness.
- → **Ensure regulatory consistency** to provide planning security, enabling companies to commit to long-term investments with confidence.
- → **Align public funding,** subsidies, and incentives with industrial decarbonisation goals to drive competitiveness and accelerate the Green Transition.
- → **Develop a European Industrial Carbon Management Strategy,** aligned with national strategies, to coordinate efforts across borders and sectors.

Financing the Transition

Investment is essential to ensure the European containerboard industry remains competitive while delivering on its Net Zero commitments. A qualitative financial assessment has identified key areas requiring funding, including upfront capital expenditures (CAPEX) for technology upgrades and decarbonisation initiatives, as well as ongoing operational costs related to low-carbon fuels, renewable energy sourcing, process improvements, and more efficient logistics. **Public and private financial support will be critical, and both policymakers and investors must work in close partnership with the industry to secure the necessary funding and enable a cost-effective, globally competitive transition to Net Zero.**

Abbreviations and List of Figures

BECCS	Bioenergy with Carbon Capture and Storage
BIP	Biomethane Industrial Partnership
CAPEX	Capital Expenditures
CCS	Carbon Capture and Storage
CCU	Carbon Capture and Utilisation
CFD	Contracts For Difference
CFP	Carbon Footprint
CHP	Combined Heat and Power
CID	Clean Industrial Deal
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalent
CRC	Carbon Removal Certification
EAC	Energy Attribute Certificate
EUDR	EU Deforestation Regulation
ESR	Effort Sharing Regulation
ETS	Emissions Trading System
EU	European Union
FEFCO	European Federation of Corrugated Cardboard Manufacturers
FSC	Forest Stewardship Council
GHG	Greenhouse Gas
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory
LNG	Liquefied Natural Gas
OPEX	Operating Expenses
PCF	Product Carbon Footprint
PEFC	Programme for the Endorsement of Forest Certification
PPA	Power Purchase Agreement
PPWR	Packaging and Packaging Waste Regulation
RDF	Refuse Derived Fuel
RED	Renewable Energy Directive
RFNBO	Renewable Fuels of Non-Biological Origin
SBTi	Science-Based Targets initiative
TRL	Technology Readiness Level
WTE	Waste-to-Energy

01

THE CONTAINERBOARD INDUSTRY

Playing a vital role in Europe's Economy, Society and Green Transition

At the heart of Europe's circular economy, the containerboard industry is a driving force behind sustainable packaging, job creation, and the transition to Net Zero. Rooted in local communities and powered by skilled expertise, the industry is committed to delivering innovative, low-carbon solutions while continuously enhancing the environmental performance of its products.

A cornerstone of circularity, containerboard is a fully recyclable and renewable semi-finished paper product, primarily used to produce corrugated cardboard packaging. As a key enabler of Europe's Green Transition, it optimises resource use, minimises waste, and supports a thriving recycling system.

Operating within a unique circular system, the European containerboard industry ensures that vital resources, such as water, fibres, and chemicals, are continuously recovered, treated, and reused. This circular approach not only minimises waste and carbon emissions but also enhances efficiency, creating a more sustainable and responsible production process.

Both primary and recycled fibres play complementary and equally essential roles in the containerboard production process. Their balanced use is key to maintaining circularity while ensuring superior product performance, delivering strength, durability, printability, and recyclability.

In 2024, the European containerboard industry produced nearly 35 million tonnes of containerboard across approximately 180 mills strategically spread across Europe. Today, the sector directly employs over 40,000 people and supports thousands more through its extensive supply chain.

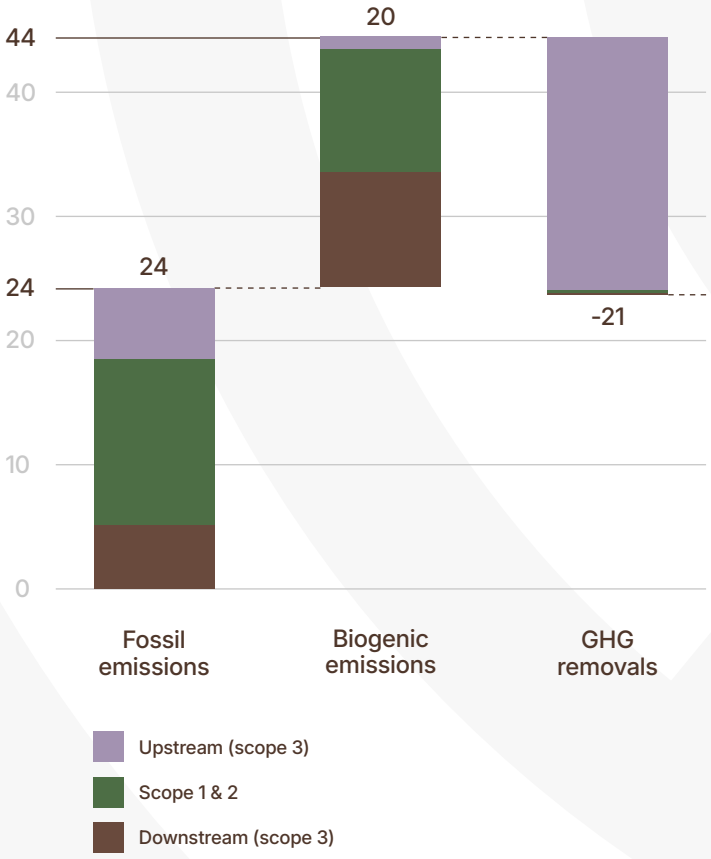
By combining circularity, innovation, and sustainability, the European containerboard industry continues to strengthen industrial resilience, drive economic growth, and pave the way for a climate-neutral future.

CURRENT STATE OF CARBON EMISSIONS

In 2020, the European containerboard industry emitted 24 Mt of fossil CO_2e and 20 Mt biogenic CO_2e, to produce 34 Mt of containerboard (see Figure 1).

The 24 Mt of fossil CO_2e were emitted by multiple actors of the value chain, distributed across all three scopes.

Figure 1:
Distribution of the industry's total emissions by type and scope (2020) [$MtCO_2eq$]



→ Direct emissions **(scope 1)** account for 46% of all fossil emissions from the industry. The majority originates from the combustion of natural gas (65%), coal (9%), and 18% refuse-derived fuels (RDF) in waste-to-energy (WtE) plants[1].

→ **Scope 2** fossil emissions (9% of the total fossil footprint) primarily result from the production of purchased electricity (77%) and bought steam (23%). Emissions from electricity generation have been estimated using a location-based approach[2], weighted according to the volume of containerboard produced in each country. Bought steam is mainly produced from the combustion of natural gas and to a limited extent from the combustion of waste. CO_2e emissions have been estimated using the emission factor for natural gas.

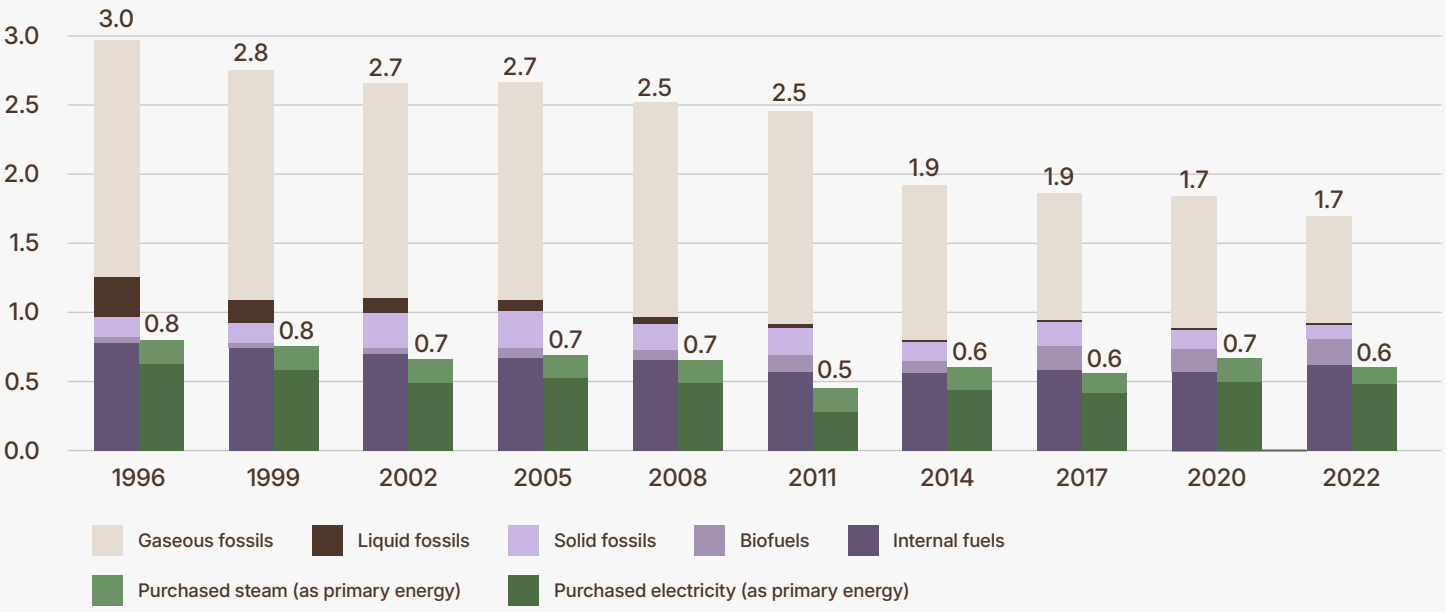
→ **Scope 3** indirect fossil emissions (45% of the total fossil footprint) are more evenly distributed across various sources, from which 53% is attributed to upstream emissions and 47% to downstream emissions. Upstream fossil emissions include the production of purchased goods (21%), the production of fuels (16%), and transportation (15%). Downstream, fossil emissions include processing of sold products (25%), downstream transportation of sold goods (20%), and end-of-life processing of sold goods (2%).

The containerboard industry is circular in terms of biogenic carbon, with 20.2 Mt biogenic CO_2e being emitted for 20.7 $MtCO_2e$ being sequestered throughout the value chain. Main sources of sequestration are the production of raw materials (16 $MtCO_2e$), especially the trees, and the production of fuels, especially biofuels (4 $MtCO_2e$). On the other hand, this biogenic carbon sequestered into products ends up reemitted further down the value chain. Either through the combustion of biofuels and co-products from raw materials, such as black liquor (10 $MtCO_2e$) or through the incineration of containerboard products at end of life (9 $MtCO_2e$). The production of raw materials also contributes to the emissions of biogenic CO_2e, however, to a limited extent (1 $MtCO_2e$).

[1] Waste-to-energy emissions for 2020 have been estimated. Data on waste consumption with energy recovery was based on estimates made by industry experts for German mills and extrapolated to the EU using a factor of 1.3 (Expert assumption). Moving forward, Containerboard Europe plans to conduct a more detailed assessment of waste-to-energy consumption in EU mills in the biannual Life Cycle Assessment (LCA).

[2] A location-based approach reflects the average emissions intensity of the electricity grid where consumption occurs, while a market-based approach accounts for emissions based on contractual instruments (e.g. green certificates or power purchase agreements). The location-based method provides a clearer picture of the actual grid impact and is typically used to assess progress in physical decarbonisation at regional or national levels.

Figure 2:
Energy use and mix [MWh/ton nsp]



PAST SUCCESSFUL EFFORTS TO REDUCE EMISSIONS

Between 1996 and 2020, the European containerboard industry experienced an increase in absolute emissions, driven by an 89% growth in production volumes. However, during that span, **mills have actively implemented a wide range of efficiency measures, significantly enhancing production processes. As a result, fossil emissions per ton of containerboard produced have dropped by nearly 40% during this period**, underscoring the industry's unwavering commitment to continuous improvement and a more sustainable future.

Key initiatives that contributed to this achievement include:

→ **Improving Energy Efficiency:** Fuel consumption per ton of net saleable product (NSP) has reduced by 33%, thanks to process optimisations and improved product characteristics requiring less heat to dry, and less electricity in the processes (see Figure 2).

→ **Adjusting the Fuel Mix:**
The industry has diversified its energy sources, reducing the share of fossil fuels in its fuel mix, from 57% in 1996 to 44% in 2020. Electrification has increased, with purchased electricity making up 20% of the energy mix in 2020, compared to 17% in 1996. Additionally, the share of biofuels has grown, further decreasing reliance on fossil fuels (see Figure 2).

As shown in Figure 2, purchased steam and electricity represent a relatively small share of the total primary energy demand of the containerboard sector. The figure presents energy inputs in primary energy terms, meaning purchased electricity and steam have been converted using respective conversion yields to reflect the equivalent amount of primary energy required for their generation. This approach allows for a fair comparison between internally generated and purchased energy.

Over the years, purchased electricity and steam have consistently made up a modest portion of the total energy mix, illustrating the sector's high degree of energy self-sufficiency. Most of the heat and electricity used is produced on-site, giving the sector significant control over its energy sources. This autonomy is a strategic advantage in the context of decarbonisation, as it allows mills to directly influence the carbon intensity of their energy supply by switching to lower-carbon fuels or integrating more renewables.

While efficiency improvements remain valuable, they can obscure the full climate impact if they fail to account for the cumulative effect of increased production. **This roadmap** therefore **focusses on absolute emissions reductions**, aligning the industry's efforts with global climate goals, which prioritise total emissions reductions over relative efficiency gains.

This decision reflects the industry's dedication to genuine climate action and transparency. It signals a clear commitment to reducing its carbon footprint in a meaningful way rather than relying solely on incremental efficiency improvements. This approach also provides a more transparent and accountable framework for stakeholders (including policymakers, customers, and investors) to assess the industry's progress towards its Net Zero ambitions. By balancing projected production growth with its responsibility to contribute to a sustainable future, the industry is setting a clear pathway for long-term environmental stewardship.

02

OBJECTIVES AND METHODOLOGY

A. Objectives

With the right actions and continued commitment, the containerboard industry has a valuable opportunity to reduce emissions and lead the way towards a more sustainable future. However, assuming projected production growth and the industry continuing on its current trajectory (maintaining ongoing improvements in industrial processes and benefiting from broader decarbonisation efforts across the value chain, such as a cleaner electricity grid and more sustainable suppliers) emissions are expected to increase by approximately 20% under a Business-as-Usual (BAU) scenario.

This reinforces the need for the containerboard industry to proactively shape its own path and set an ambitious course towards Net Zero. The objective of this roadmap is to define that path, one built on three core pillars: (1) reducing fossil emissions as far as technically possible, (2) balancing biogenic emissions and removals at industry level, and (3) as a last resort, neutralising hard-to-abate fossil emissions through permanent removals possibly generated by the industry itself. Achieving this ambition will require close collaboration across the value chain, upstream and downstream partners alike, to reduce both fossil and biogenic emissions.

While the future feels far off and today's Economy and Society evolving almost daily, the window for action is narrow.

This underscores the urgency for policymakers and the industry to seize the best opportunities available to make critical decisions for the industry.

B. Methodology

Achieving Net Zero emissions requires a rigorous, methodical approach aligned with the latest recommendations and a conservative stance to ensure feasibility. A key principle is distinguishing between fossil and biogenic carbon, as their roles in the carbon cycle differ significantly.

Fossil emissions release long-stored carbon, increasing atmospheric greenhouse gases, while biogenic emissions cycle through natural absorption and release.
To enhance transparency and avoid misrepresenting emissions reductions, the GHG Protocol, SBTi, and the European Commission emphasize separate accounting. This distinction supports accurate reporting and the development of effective climate policies

THIS ROADMAP COVERS CRADLE-TO-GRAVE EMISSIONS, INCLUDING INDIRECT SCOPE 3 EMISSIONS, AND FOLLOWS A THREE-STEP APPROACH:

1

FOSSIL EMISSIONS
The primary objective is to reduce fossil emissions as much as possible, aiming for only unavoidable residual levels by 2050.

2

BIOGENIC EMISSIONS
Given the industry's reliance on biogenic carbon from wood, recovered paper, and biofuels, related biogenic emissions must be balanced by equivalent biogenic carbon removals through sustainable biomass sourcing.

3

PERMANENT REMOVALS
Residual fossil emissions can be offset through permanent carbon removals. The roadmap assesses the volume needed and the feasibility of BECCS (Bioenergy with Carbon Capture and Storage) in the containerboard industry.

⟶ **THIS STRUCTURED PATHWAY PROVIDES A CLEAR, STEPWISE APPROACH TO NET ZERO, REFLECTING THE INDUSTRY'S UNIQUE CHALLENGES AND EVOLVING CLIMATE DISCUSSIONS.**

03

VISION

A. Containerboard Europe's roadmap to Net Zero

The Containerboard Europe Net Zero scenario takes a comprehensive approach to emissions reduction across the value chain, emphasizing coordinated progress among containerboard producers, and their partners. Specific measures for both groups have been identified and incorporated into the roadmap to foster a unified and comprehensive approach to Net Zero.

The targets outlined serve as indicative averages to guide overall emissions reduction across the industry but are not a one-size-fits-all solution. Given differences in geography, infrastructure, and government support, containerboard producers should evaluate and implement solutions best suited to their specific context.

First, the roadmap outlines actions identified as technically and economically feasible solutions to reduce fossil emissions from mills. Second, it addresses biogenic emissions, focusing on how mills can work with their suppliers to ensure that their activities result in no net biogenic emissions. Finally, the roadmap considers residual fossil emissions and quantifies the volume of BECCS required to generate sufficient permanent removals to achieve Net Zero emissions at the industry level.

Climact led the analytical work behind this roadmap, conducting expert interviews and in-depth consultations with industry representatives across different mills and containerboard grades. Their analysis formed the technical foundation of the work.

An expert from RISE (Research Institutes of Sweden) was tasked by Containerboard Europe to independently review the calculations and the development of the roadmap document. The aim of this independent review process was two-fold. Firstly, to ensure the method applied for calculating the industry emissions is scientifically sound. Secondly, to confirm that the subsequent roadmap developed delivers a credible framework and identifies appropriate actions for the European Containerboard Industry to apply in its efforts to achieve the goal of Net Zero by 2050. The critical review statement can be found in appendix 1.

The final document was then developed and formulated by Containerboard Europe to translate these insights into strategic, policy-oriented messages that reflect the sector's diversity, best practices, shared ambition and needs.

THE PROJECT WAS DIVIDED INTO FIVE MAIN STEPS:

1

COLLECT DATA & IDENTIFY BASELINE SCENARIO
Gather industry data and measure the carbon footprint to identify major emission sources and potential leverage points.

2

IDENTIFY DECARBONISATION SOLUTION
Group the most impactful decarbonisation measures into four ambition levels: no action, business as usual, ambitious, and transformational.

3

CREATE INDUSTRY SCENARIO
Model GHG emissions and energy demand across different ambition levels to produce contrasted scenarios. Elaborate one industry scenario by choosing a combination of lever levels aligned with Net Zero goals, reviewed by experts and the Steering Committee for feasibility

4

CONDUCT QUALITATIVE COST ANALYSIS
Assess the investment implications of the roadmap, prioritise early-action solutions, and explore financing mechanisms to support implementation.

5

DEVELOP THE SURROUNDING NARRATIVE AND ENABLING FRAMEWORK
Define the key implications and messages, policy recommendations, and industry commitments that support the Net Zero transition. Establish the necessary regulatory, financial, and infrastructural conditions to facilitate implementation and ensure alignment with broader climate and industrial strategies.

1. REDUCING FOSSIL EMISSIONS

A. Actions at mill level

Figure 3 presents a series of measures identified to reduce fossil emissions by 82% (11 $MtCO_2e$) by 2050 compared to 2020, as part of the Net Zero scenario. The measures are grouped by main category and highlighted in different colours:

→ Illustrated in shades of brown, dark blue and violet in Figure 3 are technological switches. How mills can adapt their processes and machines to reduce fossil emissions. Mills can first reduce the demand for fuels by investing in more energy-efficient machinery, either by investing in energy efficient machinery today, or through breakthrough (BT) energy efficient machinery as of 2040. The Net Zero scenario projects to reduce the average energy consumption across the industry by 1% per annum, and with an additional 10% between 2040 and 2050 through breakthrough technologies. Other measures include a bigger reliance on geothermal energy depending on the geothermal potential of different mills. Finally, the electrification of existing machines and processes can also contribute to significant reductions in emissions. Key strategies include hybridising heat sources, integrating electrified processes like electric boilers and high-temperature heat pumps, and improving energy flexibility through storage and digital systems.

→ Going in par with the electrification of certain processes, is the decarbonisation of the consumed electricity, whether produced on site or purchased from the grid (illustrated in purple in Figure 3). Mills can source renewable electricity through on-site generation (e.g. solar, wind) or off-site mechanisms like Power Purchase Agreements (PPA's) and Energy Attribute Certificates.

→ The shades of green in Figure 3 represent a series of measures that contribute to phasing out fossil fuels for low carbon alternatives for all processes that have not been electrified. They include the replacement of solid fossil fuels with solid, sustainably sourced, biomass, phasing out remaining solid and liquid fossil fuels with natural gas, subsequent phasing out natural gas with biomethane or low carbon hydrogen, and finally engaging with suppliers to decarbonise their excess heat that is being purchased by containerboard mills.

→ A final decarbonisation lever, in light grey below, refers to capturing part of the residual fossil emissions through Carbon Capture Utilisation and Storage (CCUS). However, its role in emissions reduction is minimal, as most fossil emissions are already mitigated through the previous measures. Nevertheless, Carbon Capture and Storage (CCS) will be crucial to capture biogenic CO_2e and neutralize the hard-to-abate fossil emissions (see section 3: Permanent Removals and CCUS).

Figure 3:
Scope 1 & 2 fossil GHG reduction potential of different measures by mills [$MtCO_2e$]

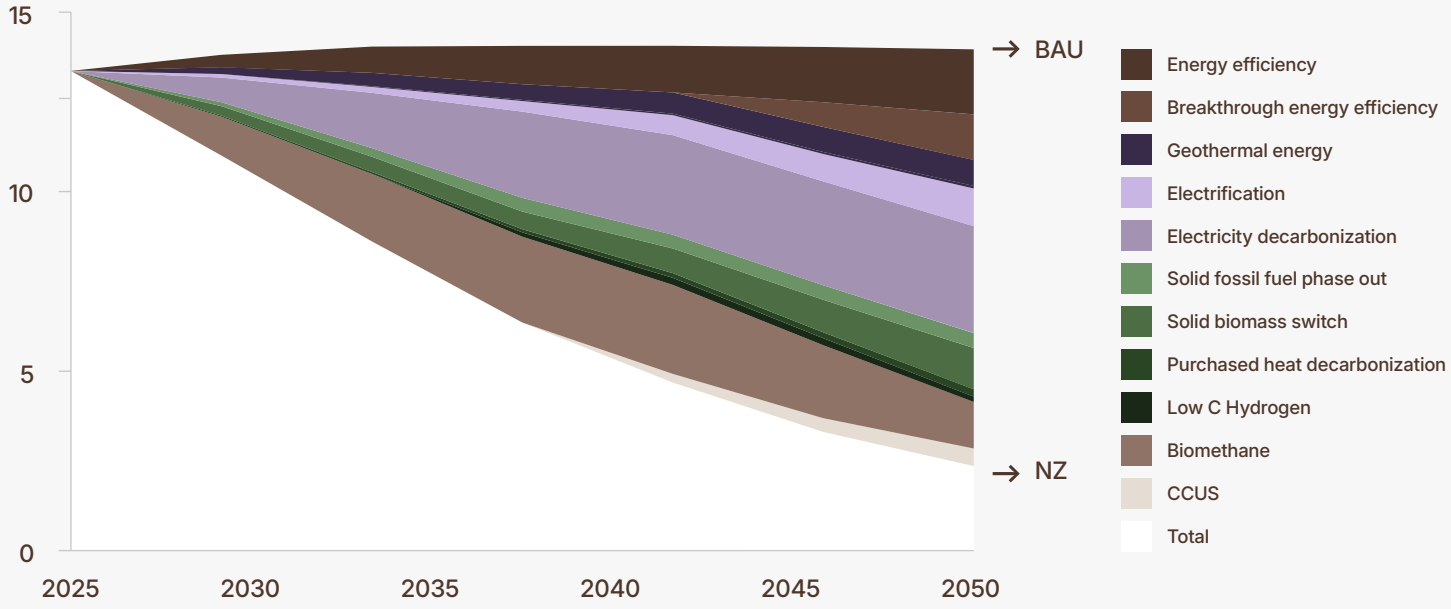
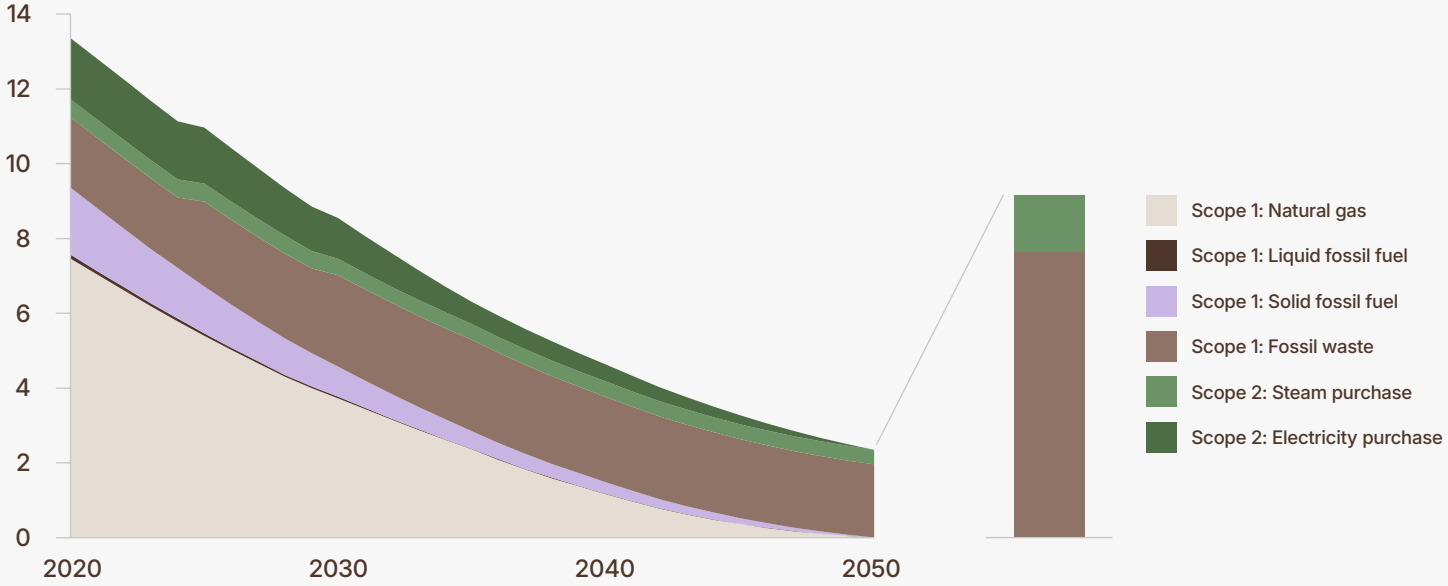


Figure 4:

Hard to abate fossil scope 1 & 2 emissions under the Net Zero scenario [$MtCO_2e$]



If these different targets and measures from the Net Zero scenario are met, scope 1 and 2 fossil emissions can decrease by 82% in 2050 compared to 2020. About 2.3 Mt of fossil CO_2e are expected to still be emitted by the industry, as shown in Figure 4. They include emissions from the incineration of fossil waste as the main contributor to the industry's residual fossil emissions. Other hard-to-abate fossil emissions come from purchased heat, that other industries cannot or do not manage to fully decarbonize.

Fossil emissions from waste incineration are particularly hard to abate for the industry. Recycled containerboard producers rely on recovered paper as a fibre source, but raw material sorting facilities cannot fully separate plastic from paper waste. As a result, recycled containerboard producers inevitably get fossil-based waste along with recovered paper delivered. To meet energy demands for heat and electricity, mills have begun utilising this residual waste delivered on-site, harnessing its energy content.

Although mills do not generate plastic waste, the emissions from its incineration are attributed to them. Despite this, continuing **waste-to-energy valorisation remains a logical choice for mills due to its benefits: it reduces landfill waste, lowers fossil CO_2 emissions when replacing fossil fuels, and leverages mill Combined Heat and Power (CHP) incinerators, which are more efficient than municipal ones** due to their optimised power and heat utilisation in combination with the paper production process.

Given these advantages, the roadmap maintains waste-to-energy valorisation as necessary for the coming years, despite its resulting fossil emissions. However, mills can further attenuate the negative impact through three key actions: encouraging sorting facilities to better separate fossil-based and biogenic waste, maximizing waste reuse/recycling before incineration in line with the cascading principle, and integrating carbon capture technologies into waste-to-energy systems to further reduce fossil emissions.

B. How the value chain can reduce fossil emissions and support the industry's Net Zero objective

Achieving Net Zero requires strong collaboration across the supply chain. Key actions include engaging suppliers to cut direct fossil emissions, optimising logistics through improved load factors, transitioning to cleaner freight fuels, committing to sustainable sourcing, and minimising transport distances.

Downstream partnerships, particularly with corrugated cardboard producers, are also essential to the success of Containerboard Europe's Net Zero scenario. FEFCO, representing the European corrugated cardboard industry, has already developed a roadmap (FEFCO, 2021), aiming to eliminate direct fossil emissions while relying on supply chain partners, including containerboard producers, to decarbonise indirect emissions. Reaching climate neutrality in the corrugated industry relies heavily on the upstream decarbonisation of containerboard production.

The Containerboard Europe Net Zero roadmap aims to credibly align with the FEFCO roadmap by demonstrating how the containerboard industry foresees to reduce its fossil emissions by at least a similar target as expected in the FEFCO roadmap. However, it is not possible to seamlessly connect the two roadmaps due to some key differences: (1) The volume of containerboard produced in Europe does not match the volume processed by European producers of corrugated cardboard due to trade balances. (2) Geographic scope variations further impact containerboard volumes across both roadmaps. (3) Differences in emission factor databases, updated between the two roadmaps, result in variations in carbon footprints for the same activity level. Consequently, although both roadmaps share a common decarbonisation objective, absolute emission values should not be directly compared.

2. ENSURING NO NET BIOGENIC EMISSIONS

Due to the projected growth of production, biogenic emissions are expected to stabilise around 20 $MtCO_2e$. These remaining biogenic emissions are mainly due to the combustion of biofuels (11 $MtCO_2e$) and the incineration of containerboard that is not recycled (7 $MtCO_2e$). Other small sources of biogenic emissions are related to the production of raw materials, such as fibres and starch. This continuous emission of biogenic carbon is mainly driven by the expected increase of production volumes and the consequent increased consumption of biofuels on the one hand, and the increased energy efficiency and decreased incineration on the other hand. These biogenic emissions are extremely difficult to reduce as biogenic carbon is the main constituent of the fibres used in the industry, and biofuels will be relied upon increasingly as an alternative to fossil fuels.

The Net Zero roadmap therefore focuses on ensuring that biogenic emissions are balanced by an equivalent amount of carbon removals. Biogenic emissions, resulting from the combustion or decomposition of biomass, are considered carbon-neutral when the biomass is sourced sustainably. For biofuels, this principle is already embedded in EU regulations: under the Renewable Energy Directive (RED), only biofuels that meet strict sustainability criteria are counted towards renewable energy targets. The EU Emissions Trading System (ETS) also exempts compliant biomass from carbon pricing, and the EU Deforestation Regulation (EUDR) reinforces sustainable sourcing requirements.

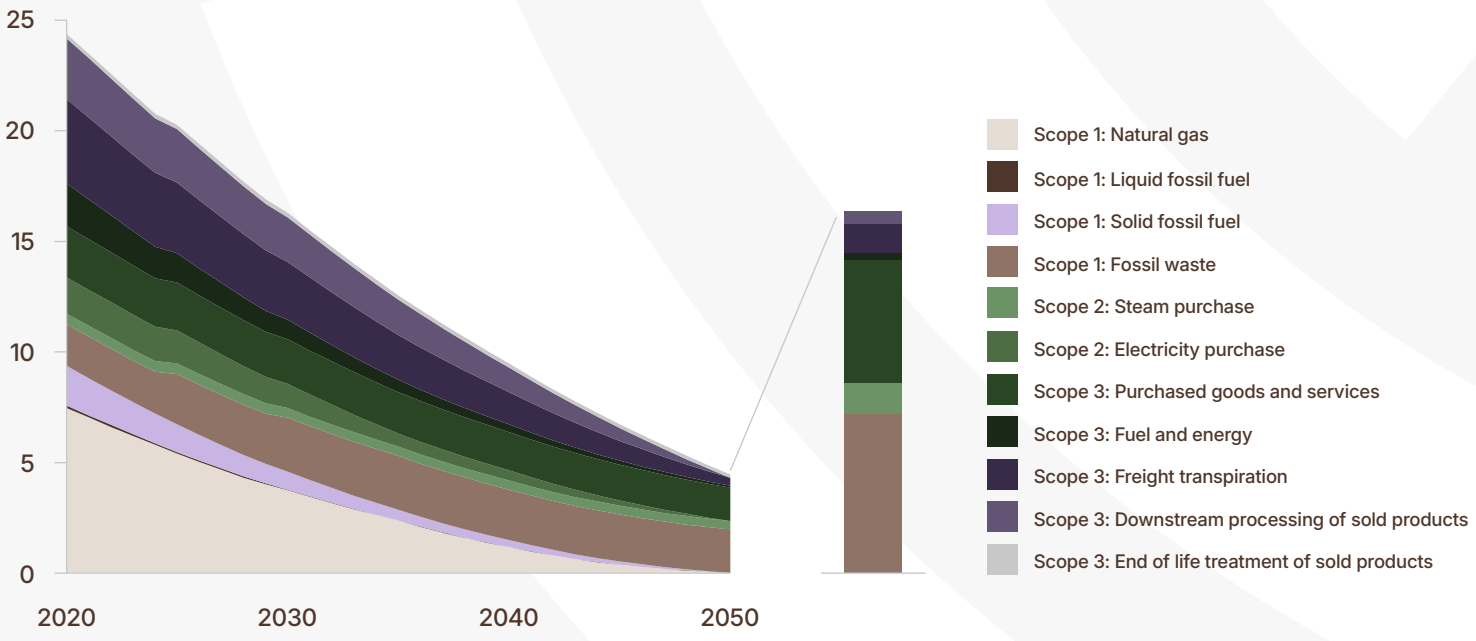
However, while such frameworks exist for biofuels, equivalent targets or sustainability criteria have not yet been established for biogenic raw materials, used in the manufacturing of products like containerboard. This is a critical gap, as biogenic feedstocks account for approximately 87% of the industry's reported carbon removals.

3. PERMANENT REMOVALS AND CCUS

If the different targets and measures from the Net Zero scenario are implemented industry wide, fossil emissions are expected to decrease by 82% by in 2050 compared to 2020. About 4.4 Mt of fossil CO_2e are expected to still be emitted by the industry across all three scopes, as shown in Figure 5.

To achieve Net Zero, the deployment of Carbon Capture and Storage (CCS) will be essential to address remaining fossil emissions. CCS captures CO_2 from mill flue gases, which include both fossil and biogenic carbon. As decarbonisation progresses, the share of fossil CO_2 in these emissions will decline, while the relative share of biogenic CO_2 will increase.

Figure 5:
Evolution of fossil emissions under the Net Zero scenario [$MtCO_2e$]



CCS contributes to Net Zero in two distinct ways, depending on the type of CO_2 captured:

- → Capturing fossil CO_2 helps reduce the industry's remaining fossil emissions as far as technically and economically possible, this contributes to direct emissions reduction.

- → Capturing biogenic CO_2 (BECCS) creates a net removal of CO_2 from the atmosphere. Since the carbon in biomass originates from atmospheric CO_2, storing it permanently prevents its return to the atmosphere. This qualifies as a carbon removal and can be used to neutralise the industry's residual fossil emissions, in line with existing guidelines for Net Zero.

The roadmap estimates that CCS may need to cover around 19% of total mill emissions by 2050 to break even. Total mill emissions include 23.3 $MtCO_2e$ of biogenic emissions and 4.9 $MtCO_2e$ of fossil emissions without CCS.
CCS would allow for an additional 0.5 $MtCO_2e$ reduction in fossil emissions, down to 4.4 $MtCO_2e$ hard to abate fossil emissions. And also, to permanently sequester up to 4.4 $MtCO_2e$ through BECCS (19% CCS of 23.3 Mt biogenic CO_2 in 2050), enough to balance the remaining hard-to-abate fossil emissions and close the final gap to Net Zero.

Despite its potential, CCS adoption in the industry faces challenges, including high costs, regulatory uncertainty, and infrastructure constraints. Given these factors, the containerboard sector will prioritise lower-cost, proven decarbonisation solutions first, using CCS only where necessary to close the final gap to Net Zero. Mills should determine whether CCS is viable based on their specific context, with deployment expected only where infrastructure and policy support make it feasible. If transport and storage pose significant challenges, mills may also explore Carbon Capture and Utilisation (CCU), converting captured CO_2 into renewable fuels or other products.

While CCU can support broader decarbonisation goals and create new value streams, it is not currently recognised as a permanent removal under existing Net Zero standards, unless the CO_2 is stored in long-lived materials such as carbonated construction products or mineralised aggregates. These pathways are still under evaluation, and their eligibility for carbon removal accounting may evolve as standards develop.

04

FINANCING THE TRANSITION

This roadmap outlines effective emissions reduction strategies for the European containerboard industry. Based on expert interviews and qualitative estimates, the cost and investment section provides a high-level view of expected trends, highlighting key drivers and the relative affordability of decarbonisation measures rather than a precise financial assessment.

This analysis offers an upper-bound industry-wide cost estimate, serving as a starting point for further discussion and refinement.

The transition to a Net Zero containerboard industry will require significant financial commitments. Production costs are expected to rise due to both upfront capital investments and increased operational expenses. The shift to new technologies (such as electric boilers, high-temperature heat pumps, and low-carbon energy infrastructure) demands substantial funding. Additionally, in the early stages of the transition, operational costs will increase as mills adopt low-carbon fuels, enhance recycling and reuse logistics, and invest in energy-efficient transportation. Moreover, the electrification of production processes will require major upgrades to the electricity grid and supporting infrastructure, costs that must be factored into the overall investment landscape for a successful and resilient decarbonisation pathway.

Despite these challenges, **mills can already implement cost-effective decarbonisation measures with high impact.** The feasibility of these measures depends on each mill's specific circumstances but typically include transitioning from coal to natural gas, upgrading machinery for greater energy efficiency, and working with supply chain partners to reduce emissions. Actions such as optimising waste management and improving biogas recovery can deliver immediate gains while laying the foundation for deeper decarbonisation.

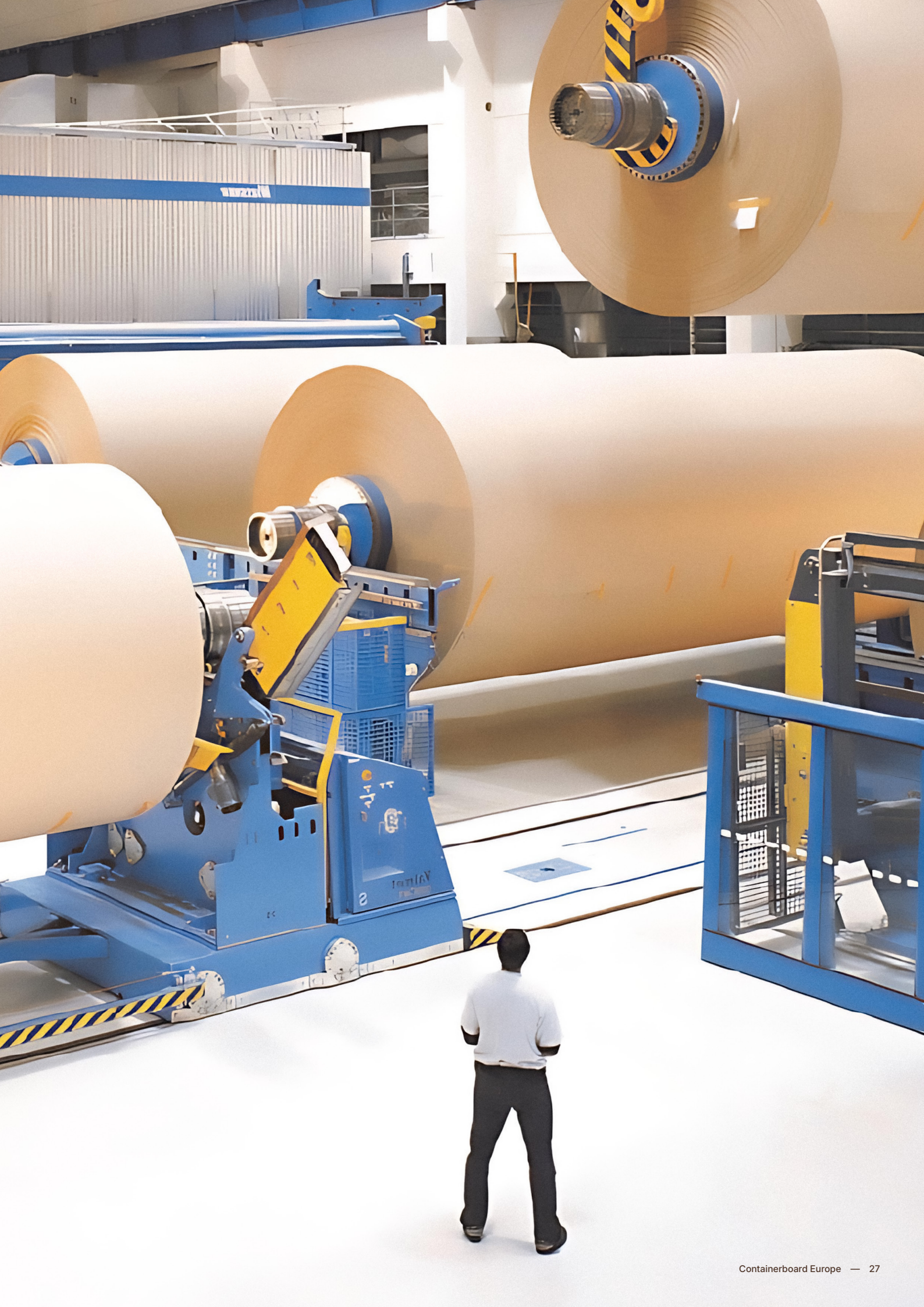
Achieving full decarbonisation, however, requires substantial financial support to address more costly and complex measures. These include full process electrification, research and development for next-generation energy-efficient machines, deployment of low-carbon hydrogen and biomethane, and investments in carbon capture and storage (CCS). **Without targeted financial support, the high costs of these technologies could put European containerboard production at a competitive disadvantage** compared to regions with less stringent environmental standards.

The total cost to fully decarbonise the containerboard value chain is not expected to exceed €45 billion, based on the most conservative modelling assumptions. This figure accounts for the entire value chain, not just direct emissions, and assumes today's decarbonisation technologies remain at current prices, with no gains from innovation, scale effects, efficiency improvements, and no spillover benefits from broader system-level changes. In practice, actual costs are expected to be significantly lower. Technological innovation, economies of scale, and process optimisation will all play a role in reducing capital needs. Moreover, decarbonisation efforts across industries are deeply interconnected: investments in clean electricity, renewable infrastructure, hydrogen, and carbon management will be shared across sectors, meaning the containerboard industry will benefit from advances and economies driven by others.
EU-wide investments in grids, innovation, and enabling infrastructure will support multiple industries. As such, this figure must be seen as a cautious upper limit, providing clarity and confidence that the industry's transformation is both achievable and likely to be far more cost-effective.

The EU's Clean Industrial Deal (CID) offers a major opportunity for the containerboard industry to accelerate its transition to Net Zero. As an energy-intensive sector embedded in the clean tech transition, the industry is well positioned to benefit from targeted support for electrification, renewable energy, and efficiency improvements. Crucially, the CID explicitly recognises circularity as a core driver of decarbonisation and competitiveness, an area where the containerboard industry already leads.

The CID aims to mobilise €100 billion in support, through tools such as the Industrial Decarbonisation Bank (EID), a new State Aid Framework, and EIB-backed investment programs. To fully seize this opportunity, the containerboard industry will require a balanced mix of public and private investment, backed by stable carbon pricing, regulatory clarity, and targeted instruments like green bonds, loan guarantees, and Contracts For Difference (CFDs).
These mechanisms are essential to reduce investment risk and scale up the deployment of clean technologies across the sector.

Without targeted financial support, the high costs of these technologies could put European containerboard production at a competitive disadvantage.



05

ENABLING THE NET ZERO TRANSITION: POLICY PRIORITIES FOR SUCCESS

The 2024 Draghi Report underscores the urgent need for a competitive and resilient European industrial base, warning that high energy costs, global competition, and regulatory complexity threaten Europe's industrial leadership. The 2025 Clean Industrial Deal directly responds to these challenges by accelerating decarbonisation, expanding clean tech investment, and strengthening industrial competitiveness.

To maintain global leadership in sustainable production while achieving Net Zero, policymakers must take urgent action to support the European containerboard industry.

1. EXPAND GRID CAPACITY AND LOW-CARBON ENERGY INFRASTRUCTURE

A successful transition to Net Zero requires secure, cost-competitive access to low-carbon energy, including low-carbon electricity, low-carbon hydrogen, and biomethane. Expanding renewables, nuclear energy, and other clean electricity sources is critical, yet grid congestion, high energy costs, and infrastructure gaps threaten to stall industrial decarbonisation.
Without urgent action, containerboard mills may struggle to electrify or adopt hydrogen-based processes.

To overcome these challenges, policymakers must:

- → Secure access to abundant, affordable fossil-free energy to maintain the sector's global competitiveness and support fuel-switching.
- → Prioritise large-scale grid expansion and cross-border energy integration.
- → Develop industrial decarbonisation hubs that consolidate energy resources and infrastructure.
- → Invest in energy storage, smart grids, and hydrogen corridors to balance supply and demand.
- → Ensure easy and timely access to the electricity grid and heat networks for industrial prosumers, including support for upgrading or securing connections where needed.
- → Facilitate long-term renewable energy contracts (Power Purchase Agreements) to ensure cost-competitive power for industry.
- → Expand carbon capture and storage (CCS) infrastructure to manage unavoidable process emissions.
- → Promote voluntary integration of industry with the energy system to enable systemic emissions reductions and enhance grid flexibility, building on the sector's leadership in renewable industrial heating and electricity generation.

The European Commission's Action Plan for Affordable Energy already highlights these priorities, emphasizing faster permitting, grid expansion, and cross-border energy integration. Now, urgent implementation is needed to unlock industrial transformation.

2. STRENGTHEN INVESTMENT IN CLEAN TECH AND R&D INNOVATION

For the containerboard industry, and broader EU manufacturing, to remain competitive while reaching Net Zero, scaling up clean technology investment is critical. However, current funding mechanisms are fragmented and insufficient. The Clean Industrial Deal must expand and streamline financial support to accelerate deep industrial transformation.

Policymakers therefore must:

- → Strengthen investment instruments such as the Industrial Decarbonisation Bank to de-risk large-scale projects.
- → Deploy financial tools (e.g., Contracts For Difference, carbon pricing mechanisms, and blended finance) to bridge the gap between R&D and full-scale commercialization.
- → Reduce reliance on foreign supply chains by prioritising investment in domestic clean tech manufacturing.
- → Support the development of bio-based materials, electrification systems, and energy-efficient production technologies.
- → Improve access to financing by operationalising instruments such as the Industrial Decarbonisation Facility and the Clean Industry State Aid Framework.
- → Maintain free allocation of emissions allowances and indirect carbon cost compensation under the EU ETS to preserve global competitiveness and avoid carbon leakage during the transition.
- → Ensure that the Carbon Border Adjustment Mechanism (CBAM) is designed and implemented to effectively prevent carbon leakage, including simplifying its structure, addressing fraud risks, and considering an export adjustment.
- → Support market access for EU bio-based products by removing trade barriers through bilateral agreements and reinforcing trade defence instruments against unfair competition.

To position itself at the forefront of industrial decarbonisation, the entire European paper industry (represented by CEPI), not just the containerboard industry, should actively and collectively engage in the Clean Industrial Deal's innovation ecosystem. This collaboration is essential to achieving cost-effective emissions reductions while maintaining long-term global competitiveness. Containerboard Europe will, obviously, support any necessary advocacy efforts to advance these goals.

3. ENSURE REGULATORY CONSISTENCY AND STREAMLINE PERMITTING

A stable, predictable regulatory environment is essential to unlocking long-term industrial investment in decarbonisation. However, regulatory fragmentation, complex permitting, and shifting policies are major barriers, delaying industry-wide transformation.

To accelerate Net Zero progress, policymakers must:

- → Streamline permitting renewables, industrial electrification, hydrogen, and CCS.
- → Simplify State Aid rules to fast-track industrial decarbonisation investments.
- → Ensure regulatory alignment across EU member states, harmonising carbon pricing mechanisms and emissions trading schemes.
- → Strike a balance between compliance and competitiveness, reducing unnecessary administrative burdens while maintaining ambitious environmental standards. For that reason, the industry welcomes the European Commission's Omnibus Package proposal aimed at simplifying EU rules and making sustainability reporting more accessible and efficient.
- → Maintain and strengthen carbon leakage protection measures in parallel with the rollout of CBAM, ensuring any extension of its scope is preceded by impact assessments and consultation with industry stakeholders.
- → Adopt a risk-based regulatory approach that accelerates deployment of proven low-carbon technologies while preserving environmental integrity.

The IEA (2021) warns that permitting delays for clean energy projects remains a major bottleneck to industrial transformation. To remove these barriers, Europe must adopt a risk-based regulatory approach. One that reduces bureaucracy for proven low-carbon technologies while upholding environmental integrity.

By ensuring clear, stable, and efficient regulations, policymakers can provide the certainty needed for large-scale investment, securing Europe's leadership in sustainable manufacturing and green industrial growth.

06

CONCLUSION

The Containerboard Europe Net Zero Roadmap is more than a vision. It is a strategic guide for how the European containerboard industry can achieve Net Zero by 2050 while maintaining competitiveness and resilience. The pathway outlined presents practical, feasible solutions that balance the urgency of climate action with the economic realities of the industry.

THIS ROADMAP REINFORCES THREE KEY MESSAGES:

1 **THE EUROPEAN CONTAINERBOARD INDUSTRY IS EMBRACING NET ZERO AS BOTH AN ENVIRONMENTAL RESPONSIBILITY AND AN ECONOMIC NECESSITY.**
As global markets demand low-carbon products, maintaining technological leadership and ensuring cost-competitive decarbonisation will be critical to sustaining Europe's industrial strength in the face of international competition.

2 **DECARBONISATION IS ACHIEVABLE BUT REQUIRES A COLLECTIVE COMMITMENT.**
Success depends on close collaboration between the industry, supply chain partners, and policymakers. No single entity can achieve Net Zero alone.

3 **AVAILABILITY OF LOW CARBON ENERGY CARRIERS AND ADAPTED INFRASTRUCTURES, REGULATORY AND FINANCIAL SUPPORT WILL DETERMINE THE SUCCESS OF THIS TRANSITION.**
Without access to affordable low-carbon energy, targeted funding, and streamlined permitting, the industry's ability to decarbonise while remaining globally competitive will be at risk.

WHAT'S NEXT?

Looking ahead, we, as Containerboard Europe, will remain committed to tracking progress every two years through an update of our LCI database and report, carried out by RISE in collaboration with FEFCO. This data will serve as a critical tool for measuring advancements, identifying gaps, and refining strategies to ensure the roadmap stays on course.

By working together and taking responsibility for their respective roles, stakeholders can turn the decarbonisation of the containerboard industry into a credible, achievable reality. One that strengthens Europe's leadership in sustainable packaging.

About the Authors

Containerboard Europe is the official association of producers of containerboard (also called corrugated base papers) in Europe. Bringing together and representing the interests of more than 120 companies from 22 countries, it serves as a unified voice for the industry, supporting its members in addressing challenges and driving progress.

Currently, Containerboard Europe's membership consists of eleven national associations, along with individual members from countries without an official national association. The association is headquartered in Brussels.

Containerboard Europe is the trade name used by Cepi ContainerBoard, an international non-profit association registered with the CBE under number 0833.959.775, with its registered office at 250 Avenue Louise, 1050 Brussels. containerboardeurope.org

CLIMACT is a consulting company active in the energy transition and climate change since 2007. It is based in Brussels (BE) and has about 50 employees. CLIMACT empowers its clients to act on climate change. It uses its expertise and experience to identify and remove barriers, facilitating the implementation of adequate solutions.
climact.com

Bibliography

European Commission, (2024). Empowering Europe's economic future: The Draghi report on competitiveness. Publications Office of the European Union. https://commission.europa.eu/topics/eu-competitiveness/draghi-report_en

FEFCO, (2021). FEFCO Climate Neutrality Roadmap. https://www.fefco.org/eu-policy/climate-neutrality

IEA (2021), Net Zero by 2050, IEA, Paris https://www.iea.org/reports/net-zero-by-2050, Licence: CC BY 4.0

07

APPENDIX

Critical Review Statement by RISE.

Appendix 1:

Kontaktperson
Michael Sturges
RISE Bioeconomy & Health
+44 (0)7787 531141
michael.sturges@ri.se

Independent review Statement

Decarbonising the European Containerboard Industry: A Roadmap to Net Zero by 2050

Review background

This document forms the independent review statement for the strategic study and report "Decarbonising the European Containerboard Industry: A Roadmap to Net Zero by 2050". The report was prepared by CLIMACT and was commissioned and funded by ContainerBoard Europe.

The critical review has been performed by an independent expert:

• Michael Sturges (lead reviewer) - RISE Research Institutes of Sweden – a sustainability expert with specific focus on life cycle issues and carbon impacts with specific experience relating to the forest industries and pulp and paper sector.

Review process

The independent expert was involved throughout the project, specifically considering:

- Calculation of the industry GHG emissions – in particular, whether the life cycle data was interpreted correctly and whether the system boundaries, calculation methods, etc were scientifically sound;
- Interpretation of the numerical results – in particular, setting of scenarios and determination of levers;
- Preparation of the roadmap – reviewing and commenting on each iteration of the roadmap.

The reviewer participated in a number of TEAMS meetings with the CLIMACT team and project sponsors. During these meetings, issues were discussed, advice was provided and comments were given. In between the meetings, numerous email exchanges were also taken on specific points where advice or clarification was required .

Opinion of the reviewer

The reviewer finds the level of quality and attention to detail by the CLIMACT team to be appropriate considering the objective of the work. The approaches applied were scientifically sound and the latest available data was used in an appropriate way. Input from industry

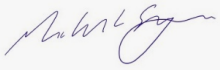
stakeholders and experts has ensured that the scenarios are realistic and the proposed pathway to Net Zero is achievable if the supporting conditions are also met.

Subsequently, the reviewer considers the results and conclusions to present a sound and credible roadmap for achieving Net Zero in the European Containerboard Industry, based on best available knowledge today. Of course, it is recognised that future iterations of the life cycle inventory study which provides the base data for the calculations may lead to opportunities to improve the analysis in the future. Furthermore, the emergence of new and breakthrough technologies may create new, as yet unforeseen opportunities. Subsequently, it may be necessary to revisit aspects of the roadmap in light of future of new data and/or technology breakthroughs.

As with all models and analysis based on modelling, there are limitations and uncertainties. However, the reviewer believes that the Roadmap represents an important reference document and starting point on the sector's Net Zero journey.

Critical review sign-off

The reviewer certifies that the statement provided is a fair reflection of his assessment and views of the study: "Decarbonising the European Containerboard Industry: A Roadmap to Net Zero by 2050".

Signed:  Dated: 20th March 2025

Michael Sturges, RISE Research Institutes of Sweden