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Review paper

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LEGAL ANALYSIS OF EU REGULATIONS ON CIRCULAR ECONOMY AND SUSTAINABILITY PRINCIPLES IN PLASTIC FOOD PACKAGING

ABSTRACT

The pervasive use of plastic food packaging (PFP) presents a significant environmental challenge due to its contribution to pollution, resource depletion, and potential health risks, generating persistent negative externalities. This article undertakes a legal analysis of existing European Union (EU) regulatory instruments addressing these challenges through the lens of circular economy (CE) and sustainability principles. It critically examines how these regulations intend to mitigate the environmental damage associated with PFP within the EU. The study conducts a comprehensive review of key EU policy documents and legal frameworks governing PFP, examining how these instruments establish a legal framework for a closed-loop system and incentivize sustainable practices within the industry. It evaluates the alignment (or misalignment) between stated CE principles and demonstrable progress toward sustainability goals. Findings reveal a disconnect between the aspirations of CE initiatives in the EU and the reality of persistent environmental damage from PFP. The article argues for more robust, coherent, and targeted regulatory frameworks and innovative solutions to incentivize a transition towards a sustainable and circular economy within the PFP sector.

Keywords: EU law, plastic food packaging, circular economy, sustainable circular economy, negative externalities.

1. INTRODUCTION

Plastic, once celebrated as a revolutionary material, now poses a significant environmental challenge. Although it has driven economic growth,¹ improved convenience,² and revolutionized industries, its extensive use has led to a

¹ Economics, *Mapping the Plastics Value Chain: A framework to understand the socio-economic impacts of a production cap on virgin plastics*, 2024, p.2.

² for both consumers (e.g., ready-made meals, single-serve portions) and industry (e.g., proper food handling and transportation). See for example Vanapalli and others, *Challenges and strategies for effective plastic waste management during and post COVID-19*

staggering accumulation of plastic waste, resulting in widespread pollution that threatens ecosystems, wildlife, and human health.³ The visible manifestations of plastic pollution such as marine debris and its detrimental effects on fauna - are frequently highlighted, however, there are less visible but equally significant negative externalities⁴ associated with plastic production, consumption, and disposal. These externalities represent the full range of unaccounted social and environmental costs associated with plastic production and consumption, encompassing impacts on ecosystems, public health, and future generations.⁵ This burden increases pressure on several planetary boundaries⁶ because the pervasive nature of plastic pollution contributes to multiple environmental challenges, including pollution, biodiversity loss, resource depletion, and greenhouse gas (GHG) emissions.⁷

pandemic, 2021, 750 *Science of The Total Environment* 141514, p.3; or Porta, *Anthropocene, the plastic age and future perspectives*, 2021, 11 *FEBS Open Bio* 948, p.949
³ Andrady, *Plastics and environmental sustainability*, John Wiley & Sons, 2015; Porta, *op. cit.* note 2, p.950-951; Plastic-reimagined, "The Invention of Plastic: Tracing the Timeline of a Material Revolution" (March 13, 2023 updated: September 24, 2024). Available online: <https://www.plasticreimagined.org/articles/the-history-of-plastic-the-invention-and-its-future>; Singh and Walker, *Plastic recycling: A panacea or environmental pollution problem*, (2024) 2 *npj Materials Sustainability* 1

⁴ The concept of externality encompasses situations where the actions of one or more economic agents affect the well-being of others without an exchange or transaction, with negative externalities arising when the social cost of an activity exceeds its private cost. (Centemeri, *Environmental Damage as Negative Externality: Uncertainty, Moral Complexity and the Limits of the Market*, 2009, e-cadernos CES p.23.)

⁵ Akullian and others, *Plastic bag externalities and policy in Rhode Island*, *Brown Policy Review*, 2006; Centemeri, *op. cit.* note 4, p.23.; Rochman and others, *The ecological impacts of marine debris: unraveling the demonstrated evidence from what is perceived*, 97 *Ecology* 302, 2016; Reis and others, *Life in plastic, it's not fantastic: the economics of plastic pollution*, *Science for Sustainability (S4S) Journal*, 2017 1

⁶ Richardson and others, *Earth beyond six of nine planetary boundaries*, 9 *Science Advances* eadh 2458, 2023.

⁷ Reis and others, *op. cit.* note 5, p.3-4.; Farrelly and others, *Plastic legacies: Pollution, persistence, and politics*, Athabasca University Press, 2021. p.10; Persson and others, *Outside the Safe Operating Space of the Planetary Boundary for Novel Entities*, 56 *Environmental Science & Technology* 1510, 2022, 1511-1512.; Richon and others, *Legacy oceanic plastic pollution must be addressed to mitigate possible long-term ecological impacts*, 3 *Microplastics and Nanoplastics* 25, 2023, p.2-3.; Nyberg and others, *Leaving a plastic legacy: Current and future scenarios for mismanaged plastic waste in rivers*, 869 *Science of The Total Environment* 161821, 2023, p.2.; Villarrubia-Gómez and others, *Plastics pollution exacerbates the impacts of all planetary boundaries*, *One Earth*, 2024, 2122-2123.

The largest consumer of plastic materials is the packaging industry both globally⁸ and in the EU.⁹ Derived primarily from fossil fuels, approximately 60 % of all plastic packaging is dedicated to food and beverages.¹⁰ Plastic has become the predominant material for food packaging in Europe.¹¹ Packaged food consumption in Europe has dramatically increased in recent decades, driven by changing consumption patterns and a growing preference for convenience.¹² The PFP industry is under growing pressure to adopt sustainable practices that mitigate negative environmental impacts, enhance resource efficiency, and safeguard public health.¹³ The focus of this study is PFP, a critical area within the broader plastics landscape due to its substantial environmental footprint and complex regulatory demands.

The traditional linear models of plastic production and consumption, characterized by a "take-make-dispose" approach, are increasingly recognized as unsustainable.¹⁴ These models contribute to significant environmental degradation and economic inefficiencies, underscoring the urgent need for a transition to a circular economy (CE) for plastics. Core CE principles include eliminating waste and pollution through design and innovation, circulating products and materials in closed-loop systems, and regenerating natural systems.¹⁵ Despite growing interest

⁸ Packaging's share of global plastic consumption is 31% (<https://www.statista.com/topics/10136/plastic-packaging-industry-worldwide/#topicOverview>).

⁹ According to Plastics Europe End-users' plastic packaging consumption was 34.7% of the total European plastic consumption and the European plastics conversion was 39% based on application in 2022. /Europe, *The Circular Economy for Plastics: A European Analysis*, 2024. p.49 and p.63/

¹⁰ Groh and others, *Overview of known plastic packaging-associated chemicals and their hazards*, 651 Science of The Total Environment 3253., 2019, p. 3254

¹¹ Ncube and others, *Environmental Impact of Food Packaging Materials: A Review of Contemporary Development from Conventional Plastics to Polylactic Acid Based Materials*, 13 Materials (Basel), 2020, p.2.

¹² ING, *Plastic packaging in the food sector - Six ways to tackle the plastic puzzle*, 2019. p.7

¹³ <https://www.packaging-gateway.com/features/sustainable-packaging-food-industry/>.

¹⁴ EEA, *Plastics, the circular economy and Europe's environment — A priority for action*, 2021. p.7; Shi and others, *Perspectives on sustainable plastic treatment: A shift from linear to circular economy*, 173 TrAC Trends in Analytical Chemistry 117631, 2024.

¹⁵ EU, Communication from the Commission: A European Strategy for Plastics in a Circular Economy – Strategy, SWD(2018) 16 final (European Commission 2018); Guillard and others, *The Next Generation of Sustainable Food Packaging to Preserve Our Environment in a Circular Economy Context*, 5 Frontiers in Nutrition, 2018.; Barnes, *Understanding plastics pollution: The role of economic development and technological research*, 249 Environmental Pollution 812, 2019.; Velenturf and Purnell, *Principles for a sustainable circular economy*, 27 Sustainable Production and Consumption 1437, 2021; 5. Neves and Marques, *Drivers and barriers in the transition from a linear economy to a circular economy*, 341 Journal of Cleaner Production 130865, 2022.

in CE solutions for plastic packaging,¹⁶ research is still needed to assess their effectiveness in mitigating the negative externalities of PFP and achieving specific sustainability goals, such as reducing marine pollution or minimizing resource depletion.¹⁷ Geissdoerfer et al. suggest further investigation into the interconnectedness of CE and sustainability, as well as their impact on supply chains and innovation systems.¹⁸ Existing research has not yet synthesized the concepts of CE and sustainability with the specific negative externalities associated with PFP within the EU regulatory context. For example, while the benefits of closed-loop systems for plastic packaging are often promoted,¹⁹ there is a gap in understanding how these systems address microplastic pollution – a significant negative externality impacting both environmental and human health – throughout a product's lifecycle.²⁰ This article aims to address this gap by examining how key EU policy and regulatory instruments promote both circularity and sustainability for PFP. The analysis covers overarching key EU policy documents (such as the European Strategy for Plastics in a Circular Economy,²¹

¹⁶ Van Eygen and others, *Circular economy of plastic packaging: Current practice and perspectives in Austria*, 72 *Waste Management* 55, 2018.; Schmidt and others, *Challenges and Solutions for Plastic Packaging in a Circular Economy*, 93 *Chemie Ingenieur Technik* 1751, 2021.; Karayilan and others, *Prospective evaluation of circular economy practices within plastic packaging value chain through optimization of life cycle impacts and circularity*, 173 *Resources, Conservation and Recycling* 105691, 2021.; Zhu and others, *Packaging design for the circular economy: A systematic review*, 32 *Sustainable Production and Consumption* 817, 2022.;

¹⁷ For instance Guillard and others, *op. cit.*; Foschi and Bonoli, *The commitment of packaging industry in the framework of the European strategy for plastics in a circular economy*, 9 *Administrative Sciences* 18, 2019.; Pauer and others, *Assessing the environmental sustainability of food packaging: An extended life cycle assessment including packaging-related food losses and waste and circularity assessment*, 11 *Sustainability* 925, 2019.; Meherishi and others, *Sustainable packaging for supply chain management in the circular economy: A review*, 237 *Journal of Cleaner Production* 117582, 2019.

¹⁸ Geissdoerfer and others, *The Circular Economy – A new sustainability paradigm?*, 143 *ibid.* 757., 2017, p.767; Monciardini and others, '13 Circular Economy regulation: an emerging research agenda' in Allen, Stefano and Fiona (eds), *Handbook of the Circular Economy*, De Gruyter, 2023

¹⁹ See note 15

²⁰ For example: Steensgaard and others, *From macro- to microplastics - Analysis of EU regulation along the life cycle of plastic bags*, 224 *Environ Pollut* 289, 2017; Elsamahy and others, *Strategies for efficient management of microplastics to achieve life cycle assessment and circular economy*, 195 *Environmental Monitoring and Assessment* 1361, 2023; Gabisa and others, *Recycling of Plastics as a Strategy to Reduce Life Cycle GHG Emission, Microplastics and Resource Depletion*, 15 *Sustainability* 11529, 2023.

²¹ SWD(2018) 16 final (hereinafter: EU Plastics Strategy)

the European Green Deal,²² and the New Circular Economy Action Plan²³) as well as specific regulatory instruments (such as the Waste Framework Directive,²⁴ the Packaging and Packaging Waste Directive,²⁵ the Packaging and Packaging Waste Regulation,²⁶ the Single-use Plastic Directive,²⁷ and food packaging-specific laws). By investigating how these measures aim to internalize the negative externalities of PFP, the article argues that an SCE framework provides a viable mechanism for internalizing the negative externalities of PFP through stricter, more coherent, and targeted regulatory frameworks within the EU.

Section 2 explores the environmental and social impacts of PFP, examining its inherent dichotomy: essential functions coupled with unsustainable practices. This section analyzes the negative externalities generated throughout the PFP lifecycle and introduces the principles of a circular plastics economy, culminating in a discussion of an SCE model for PFP. Section 3 delves into the EU's legal and policy framework for transitioning to a SCE in the PFP sector. It provides an overview of relevant CE policies in the EU, and the existing regulatory landscape governing PFP throughout its entire lifecycle from design to disposal. Section 4 analyzes the challenges and opportunities in internalizing the negative externalities of PFP, focusing on the EU's regulatory approach and identifying remaining gaps and future directions. Finally, Section 5 synthesizes the key findings of this research, highlighting the progress made, ongoing challenges, and potential legal developments needed to foster sustainability and circularity within the PFP industry. This concluding section emphasizes the need for targeted policies that incentivize sustainable design, promote closed-loop systems, and establish producer responsibility throughout the packaging lifecycle to effectively address the root causes of plastic waste and pollution.

²² EU, Communication from the Commission - The European Green Deal COM(2019) 640 final (2019), (hereinafter: European Green Deal)

²³ EU, A new Circular Economy Action Plan - For a cleaner and more competitive Europe (European Commission 2020), COM(2020) 98 final, (hereinafter: New Circular Economy Action Plan)

²⁴ Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives, OJ L 312 of 22/11/2008 (hereinafter: Directive 2008/98/EC)

²⁵ European Parliament and Council Directive 94/62/EC of 20 December 1994 on packaging and packaging waste, OJ L 365 of 31/12/1994 (hereinafter: Directive 94/62/EC)

²⁶ EU, Regulation (EU) 2025/40 of the European Parliament and of the Council of 19 December 2024 on packaging and packaging waste, amending Regulation (EU) 2019/1020 and Directive (EU) 2019/904, and repealing Directive 94/62/EC (EU 2025), OJ L 2025/40 of 22/01/2025 (hereinafter: Regulation (EU) 2025/40)

²⁷ Directive (EU) 2019/904 of the European Parliament and of the Council of 5 June 2019 on the reduction of the impact of certain plastic products on the environment, OJ L 155 of 12/6/2019, (hereinafter: Directive (EU) 2019/904)

2. ENVIRONMENTAL AND SOCIAL IMPACTS OF PLASTIC FOOD PACKAGING AND THE TRANSITION TO A SUSTAINABLE CIRCULAR ECONOMY

2.1. The Dichotomy of Plastic Food Packaging: Essential Functions and Unsustainable Practices

Food packaging serves multiple essential functions across a product's lifecycle, including protection, preservation, communication, and marketing.²⁸ Traditionally, packaging was designed to shield products from external factors, ensure safe handling, and provide consumers with necessary information.²⁹ However, contemporary industry practices often prioritize cost-efficiency, resulting in the use of complex, non-recyclable multilayer materials.³⁰ While these materials may reduce production costs, they pose challenges for recycling and sustainability, highlighting the tension between economic priorities and environmental responsibility. The increasing volume of PFP production has led to a surge in plastic packaging waste. This exacerbates issues related to littering, waste management, and recycling, especially given that packaging typically has the shortest lifespan among plastic products.³¹

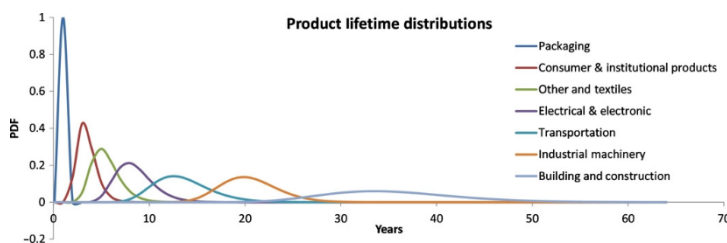


Figure 1: Product lifetime distributions for the eight industrial use sectors plotted as log-normal probability distribution functions. Source: Geyer et al. 2017³²

²⁸ Marsh and Bugusu, *Food Packaging—Roles, Materials, and Environmental Issues*, 72 *Journal of Food Science* R39., 2007, p.39; White and Lockyer, *Removing plastic packaging from fresh produce – what's the impact?*, 45 *Nutrition Bulletin* 35., 2020, p.37; Arfelli and others, *Environmental impacts of food packaging: Is it all a matter of raw materials?*, 49 *Sustainable Production and Consumption* 318, 2024, p. 319

²⁹ Yam and others, *Intelligent Packaging: Concepts and Applications*, 70 *Journal of Food Science* R1., 2005, p.1.; Ahmed and Rahman, *Handbook of Food Process Design* (John Wiley & Sons, Incorporated 2012, p.1237

³⁰ Soares and others, *Recycling of multi-material multilayer plastic packaging: Current trends and future scenarios*, 176 *Resources, Conservation and Recycling* 105905., 2022, p.8.

³¹ Yadav and others, *Life cycle assessment of reusable plastic food packaging*, 448 *Journal of Cleaner Production* 141529, 2024, p. 1.

³² Geyer and others, *Production, use, and fate of all plastics ever made*, 3 *Science Advances* e1700782, 2017, p.2.

In 2021, the EU generated 15.96 million tonnes of plastic packaging waste, with a recycling rate of only 39.7 percent.³³ Globally, a mere 2 percent of plastic packaging is recycled back into packaging, leaving the remaining waste to be incinerated, landfilled, recovered, or otherwise released into the environment.³⁴ Plastic, the most common food packaging material in Europe, is a major contributor to global waste, significantly impacting the environment and potentially threatening human health due to chemical migration from food contact materials (FCMs).³⁵ The lack of circularity in the current packaging waste management industry is evident, as most food packaging is designed for single use and quickly discarded. This linear model creates environmental challenges that hinder the sustainability of packaged food.³⁶ The following section will explore the externalities of the current linear system, emphasizing the urgent need for a transition towards circularity in the PFP industry.

2.2. The Negative Externalities of Plastic Food Packaging Throughout Its Lifecycle

The current life cycle of PFP in the EU, often linear and resulting in significant waste, contrasts sharply with CE principles. This system, from resource-intensive production to disposal, generates substantial environmental and socioeconomic damage, necessitating a systemic shift towards a closed-loop model.³⁷ This analysis will demonstrate the misalignment by examining key problem areas.

First, plastic production itself is problematic. Its strong reliance on fossil fuels contributes to habitat destruction, water and air pollution, and GHG emissions.³⁸ The extraction and refining of petroleum deplete finite resources, release harmful pollutants, and exacerbate climate change, posing health risks to surrounding communities.³⁹ Moreover, the numerous chemicals used in plastic manufacturing

³³ EU packaging waste generation with record increase - Eurostat (europa.eu).

³⁴ Defruyt, *Towards a New Plastics Economy*, (2019) Field Actions Science Reports 78., p.79

³⁵ Food packaging waste | SAFE – Safe Food Advocacy Europe, June 2024, accessed on 25.02.2025, link: <https://www.safefoodadvocacy.eu/actions/food-packaging-waste/>

³⁶ Kan and Miller, *Environmental impacts of plastic packaging of food products*, (2022) 180 Resources, Conservation and Recycling 106156., p.1

³⁷ WWF, *Plastics: The Cost to Society, the Environment and the Economy*, 2021., p.4.

³⁸ Shamoon and others, *Environmental impact of energy production and extraction of materials - a review*, 57 Materials Today: Proceedings 936., 2022, p.937.

³⁹ Sojinu and Ejeromedoghene, *Environmental challenges associated with processing of heavy crude oils*, 241 Processing of Heavy Crude Oils, 2019, p.244.; Kumar and others, *Impacts of Plastic Pollution on Ecosystem Services, Sustainable Development Goals, and Need to Focus on Circular Economy and Policy Interventions*, 13 Sustainability 9963., 2021, p.20-21.

– many of which are toxic – further compound these environmental and health concerns.⁴⁰

Second, the logistical demands of transporting plastic packaging add to its environmental burden. Transportation, often reliant on fossil fuels, increases the carbon footprint and contributes to climate change, particularly within the European food supply chain, characterized by long transport distances and numerous intermediaries.⁴¹

Third, current consumption patterns and packaging practices exacerbate waste generation. The increasing prevalence of ready-to-eat meals, on-the-go consumption, online food sales, and single-use packaging has fostered a culture of disposability, leading to increased plastic waste accumulation with severe consequences for ecosystems.⁴² Marketing strategies encouraging over-purchasing, such as bulk discounts and multi-pack deals, further contribute to this problem.⁴³ Moreover, certain packaging practices, while intended to protect food and extend shelf life, can inadvertently contribute to food waste. For instance, plastic packaging can trap moisture, accelerating spoilage, and bulk packaging can encourage over-purchasing beyond immediate needs.⁴⁴

Fourth, the persistence of plastics in the environment poses long-term ecological threats. Plastics can persist for hundreds of years, leaching harmful chemicals into soil and waterways, adversely affecting wildlife and human health.⁴⁵ The accumulation of plastic in the oceans is particularly devastating, threatening biodiversity, disrupting food chains, and causing long-term ecological

⁴⁰ Proshad and others, *Toxic effects of plastic on human health and environment: A consequences of health risk assessment in Bangladesh*, 6 International Journal of Health 1, 2018.; WWF, *op. cit.*, p.20

⁴¹ Chapman, *Transport and climate change: a review*, 15 Journal of Transport Geography 354, 2007.; J.-P. Schweitzer, *Unwrapped: How throwaway plastic is failing to solve Europe's food waste problem (and what we need to do instead)* 2018., p. 7. and 10.

⁴² ING, *op. cit.* note 12, p.7

⁴³ Aschemann-Witzel and others, *Consumer-Related Food Waste: Role of Food Marketing and Retailers and Potential for Action*, 28 Journal of International Food & Agribusiness Marketing 271, 2016, p.276

⁴⁴ WRAP, *Reducing household food waste and plastic packaging*, 2022., p.5; Normi and Baidurah, 'Transforming Food Waste into Nutrient-Rich Fertilizer: A Sustainable Path Towards Carbon Neutrality and Circular Economy' in Kapoor and others (eds), *Biomass Valorization: A Sustainable Approach towards Carbon Neutrality and Circular Economy* (Springer Nature Singapore 2024.), p.265

⁴⁵ Obuzor and Onyedikachi, 'Chemical Leaching into Food and the Environment Poses Health Hazards' in Nwaichi (ed), *Modernity in Health and Disease Diagnosis: The Account from STEM Women* (Springer Nature Switzerland 2023)

imbalances.⁴⁶ The low recyclability and persistence of materials like expanded polystyrene exemplify these challenges, contributing significantly to landfill waste and marine pollution.⁴⁷ Furthermore, the fragmentation of plastic into microplastics poses a further threat to aquatic life through ingestion and chemical toxicity.⁴⁸

Finally, the negative externalities of PFP extend beyond environmental concerns to social inequities. Marginalized communities, often located near production facilities or landfills, bear a disproportionate burden of plastic pollution, experiencing heightened exposure to toxic pollutants, resulting in health disparities.⁴⁹ The economic costs associated with plastic waste management, including collection, recycling, processing, and landfill management, place increasing financial pressure on governments and municipalities, ultimately impacting taxpayers.⁵⁰

This analysis demonstrates that the current linear system for plastic food packaging in the EU is unsustainable. It necessitates a systemic shift from the disposable model towards a closed-loop system aligned with CE and sustainability principles, as will be demonstrated below.

2.3. Principles of Circular Plastics Economy

The CE offers a transformative approach to resource management, contrasting sharply with the traditional linear "take-make-dispose" model.⁵¹ The CE, as a

⁴⁶ Dar and others, 'Ecotoxic Effects of the Plastic Waste on Marine Fauna: An Overview' in Shahnawaz and others (eds), *Impact of Plastic Waste on the Marine Biota* (Springer Nature Singapore 2022)

⁴⁷ Hidalgo-Crespo and others, *Circular economy of expanded polystyrene container production: Environmental benefits of household waste recycling considering renewable energies*, 8 Energy Reports 306, 2022.

⁴⁸ Turner, *Foamed Polystyrene in the Marine Environment: Sources, Additives, Transport, Behavior, and Impacts*, 54 Environmental Science & Technology 10411, 2020.; Hollerová and others, *Microplastics as a potential risk for aquatic environment organisms - a review*, 90 Acta Veterinaria Brno 99, 2021.; Issac and Kandasubramanian, *Effect of microplastics in water and aquatic systems*, 28 Environ Sci Pollut Res Int 19544, 2021.

⁴⁹ WWF, *Plastics: The costs to society, the environment and the economy*, 2021. p.22; Dauvergne, *The necessity of justice for a fair, legitimate, and effective treaty on plastic pollution*, 155 Marine Policy 105785, 2023, p. 2-3

⁵⁰ UNEP, *Global Waste Management Outlook 2024 - Beyond an age of waste: Turning Rubbish into a Resource*, 2024. p. 40; Kaza and others, *What a waste 2.0: a global snapshot of solid waste management to 2050* (World Bank Publications, 2018. p. 1. and 6.

⁵¹ The literature offers numerous interpretations for CE, see for example: EMF, *Towards the circular economy*, 2013; Commission, *Closing the loop - An EU action plan for the Circular Economy* (COM(2015) 614 final, 2015; Kirchherr and others, *Conceptualizing the*

regenerative system minimizes waste and resource consumption⁵² by closing product lifecycles through reuse, repair, remanufacturing, and recycling.⁵³ These strategies aim to decouple economic activity from finite resource consumption, guided by principles of *waste and pollution elimination, continuous material use, and natural system regeneration*.⁵⁴

The pervasive nature of plastic waste and its associated environmental harms make the plastics industry, particularly food packaging, a compelling case for CE implementation. Ideally, a circular plastics economy should apply the aforementioned CE principles to reduce the use of virgin, fossil-fuel-based feedstocks and minimize energy consumption throughout the plastic lifecycle.⁵⁵ This approach aims to reduce dependence on finite resources, mitigate pollution, and enhance resource efficiency, contributing to a more sustainable and resilient system. A circular plastics economy for food packaging should involve several key strategies. Prioritizing recycled and bio-based feedstocks is crucial for reducing reliance on virgin fossil fuels which requires investment in recycling infrastructure and the development of innovative, functional, and compostable bioplastics.⁵⁶ It necessitates responsible sourcing practices to minimize the environmental and social impacts of resource extraction, including ensuring fair labor practices, protecting biodiversity, and reducing GHG emissions.⁵⁷ Designing for circularity, using compatible materials, and standardized components, and minimizing complexity, enables reuse and recycling.⁵⁸ Investment in advanced recycling technologies, such as chemical recycling, is needed to handle complex plastic waste streams, recover high-value materials, and complement traditional

circular economy: An analysis of 114 definitions, 127 Resources, Conservation and Recycling 221, 2017; Prieto-Sandoval and others, *Towards a consensus on the circular economy*, 179 Journal of Cleaner Production 605, 2018.; Korhonen and others, *Circular Economy: The Concept and its Limitations*, 143 Ecol Econ 37, 2018.

⁵² Stahel, *The circular economy*, 531 Nature 435, 2016, p.435.

⁵³ Stahel, *op. cit.* note 52, p.435.; Suárez-Eiroa and others, *Operational principles of circular economy for sustainable development: Linking theory and practice*, 214 Journal of Cleaner Production 952, 2019, p.957.

⁵⁴ Sariatli, *Linear economy versus circular economy: a comparative and analyzer study for optimization of economy for sustainability*, 6 Visegrad Journal on Bioeconomy and Sustainable Development 31, 2017; Geissdoerfer and others, *op. cit.* note 18.; Korhonen and others, *op. cit.* note 52; Suárez-Eiroa and others, *op. cit.* note 54; Velenturf and Purnell, *op. cit.* note 15.

⁵⁵ Bucknall, *Plastics as a materials system in a circular economy*, 378 Philos Trans A Math Phys Eng Sci 20190268, 2020, p.4.; EEA, *op. cit.* note 14, p.9

⁵⁶ Ferreira-Filipe and others, *Are Biobased Plastics Green Alternatives?—A Critical Review*, 18 International Journal of Environmental Research and Public Health 7729, 2021, p.11-12.

⁵⁷ von Rosing and others, 'Chapter 13 - Sustainable sourcing practices' in von Rosing (ed), *The Sustainability Handbook, Volume 1* (Elsevier 2025). p. 197.

⁵⁸ Mesa, *Design for circularity and durability: an integrated approach from DFX guidelines*, 34 Research in Engineering Design 443, 2023, p. 446.

mechanical recycling.⁵⁹ Developing closed-loop systems, where plastic waste is collected, processed, and reintroduced into production, minimizes environmental leakage and fosters circularity.⁶⁰ Finally, raising consumer awareness about responsible plastic consumption, proper waste disposal, and the benefits of recycled products is crucial.⁶¹ Also, clear labeling and educational campaigns can empower consumers to make informed choices.

On the other hand, implementing a CE for PFP faces several economic, technical, and social challenges. Economic barriers include the sometimes higher cost of recycled plastic compared to virgin plastic, along with the substantial investment needed for new infrastructure and technologies.⁶² Technical challenges arise from the limitations of current recycling technologies, particularly in handling mixed plastic waste and maintaining the quality of recycled materials.⁶³ Social barriers, such as consumer behavior and lack of awareness, can also hinder the adoption of circular practices.⁶⁴ Emphasizing environmental, economic, and social equity and applying CE principles to the plastics industry presents a critical opportunity to advance sustainable development and foster resilience.⁶⁵ The shift requires collaborative efforts from businesses, policymakers, researchers, and consumers to overcome existing barriers and accelerate the transition toward a true CE for PFP.

2.4. SCE for Plastic Food Packaging

While the European Commission's revised monitoring framework for the CE aims to foster a sustainable, competitive, and resilient economy aligned with the UN's sustainable development goals,⁶⁶ simply adopting CE practices (such as waste

⁵⁹ Mangold and von Vacano, *The Frontier of Plastics Recycling: Rethinking Waste as a Resource for High-Value Applications*, 223 *Macromolecular Chemistry and Physics* 2100488, 2022, p. 9 and 14.

⁶⁰ Shamsuddoha and Kashem, *Zero Plastic Drive: A Comprehensive Review on Unveiling Innovative Sustainable Solutions for a Circular Plastics Economy*, 16 *Sustainability* 10329, 2024, p.10 and 20.

⁶¹ de Sousa, *Consumer Awareness of Plastic: an Overview of Different Research Areas*, 3 *Circular Economy and Sustainability* 2083, 2023.

⁶² Shamsuddoha and Kashem, *op. cit.* note 61, p.10.

⁶³ Bening and others, *Towards a circular plastics economy: Interacting barriers and contested solutions for flexible packaging recycling*, 302 *Journal of Cleaner Production* 126966, 2021, p.6.

⁶⁴ Gonella and others, *A behavioral perspective on circular economy awareness: The moderating role of social influence and psychological barriers*, 441 *ibid.* 141062, 2024, p.3

⁶⁵ Kirchherr and others, *op. cit.* note 51, p.229

⁶⁶ Commission, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: on a revised monitoring framework for the circular economy, 2023, p.2.

minimization, extended material use, and resource efficiency) does not inherently guarantee sustainability.⁶⁷ A comprehensive assessment of CE's actual benefits requires a holistic, impact-based approach that considers the broader sustainability implications of these practices.⁶⁸

The notion of sustainable development, as introduced in the Brundtland Report⁶⁹ and inclusive of the goals articulated in the 2030 Agenda,⁷⁰ aims to establish a framework encompassing social, economic, and environmental sustainability. However, the concept of "balancing" these dimensions has faced criticism for its lack of practical success, often resulting in the prioritization of one aspect over others.⁷¹ Frameworks like the planetary boundaries⁷² focus exclusively on maintaining Earth's ecological limits within which human activity must operate, while Raworth's Doughnut Economy, which builds on this framework, redefines the parameters of sustainable development by incorporating a social foundation.⁷³ The Doughnut Economy defines a "safe and just space" for human activity, bounded by an ecological ceiling (planetary boundaries) and a social floor (minimum social standards).⁷⁴ This framework advocates for a shift from balancing competing priorities to ensuring that all economic activity and social progress operate within these defined ecological and social boundaries. Consequently, sustainable circular plastic production necessitates a multifaceted approach encompassing environmental, technological, economic, and social considerations.⁷⁵ Beyond reducing pollution (environmental), it requires

⁶⁷ Ivanescu and Sorlescu, *The green economy: EU vision for competitive and sustainable development*, 10 Progress in Industrial Ecology, an International Journal 45, 2016, p. 45; Schroeder and others, *The Relevance of Circular Economy Practices to the Sustainable Development Goals*, 23 Journal of Industrial Ecology 77, 2019, p.81 and 92.; Mantalovas¹ and others, *Are circular practices always environmentally sustainable?*, 2024, p.99.

⁶⁸ Komiya and Takeuchi, *Sustainability science: building a new discipline*, 1 Sustainability Science 1, 2006, p.3.; Geissdoerfer and others, *op. cit.* note 18. p.; Haupt and Hellweg, *Measuring the environmental sustainability of a circular economy*, 1-2 Environmental and Sustainability Indicators 100005, 2019, p.5.

⁶⁹ WCED, *Our Common Future* 1987

⁷⁰ UN, *Transforming our world: the 2030 Agenda for Sustainable Development*, 2015, defined 17 Sustainable Development Goals (SDGs)

⁷¹ Heidi Rapp, *The hierarchy of resource use for a sustainable circular economy*, 47 International Journal of Social Economics 27, 2020.; Velenturf and Purnell, *op. cit.* note 15; Sjøfjell and Cornell, *What the actual? Tensions in the science-business-policy interface for global sustainability*, European Law Open 1, 2024.

⁷² Rockström and others, *A safe operating space for humanity*, 461 Nature 472, 2009.

⁷³ Raworth, *A safe and just space for humanity: can we live within the doughnut?*, 2012; Raworth, *A Doughnut for the Anthropocene: humanity's compass in the 21st century*, 1 The Lancet Planetary Health e48, 2017.

⁷⁴ Raworth, *op. cit.* note 74, p.e48

⁷⁵ Ghisellini and others, *A review on circular economy: The expected transition to a balanced interplay of environmental and economic systems*, 114 Journal of Cleaner Production 11, 2016, p.27.; Velenturf and Purnell, *op. cit.* note 15

integrating advanced recycling technologies (technological), ensuring cost-effective production (economic), and fostering consumer awareness and acceptance of recycled plastics (social).⁷⁶ Progress towards a sustainable circular economy (SCE) should be measured not solely by recycling rates, but also by broader sustainability goals encompassing environmental protection, economic resilience, and social equity. Integrating a robust sustainability lens into plastic production is crucial for enhancing the CE's long-term efficacy. A true SCE builds upon CE foundations by prioritizing environmental sustainability, human health, and social impacts. It addresses not only waste reduction and resource reuse but also broader impacts on ecosystems and communities.⁷⁷ However, potential adverse effects of certain CE practices must be considered as well.⁷⁸ For instance, recycling, while central to CE, can be energy-intensive and potentially less environmentally sound than using virgin materials in some cases.⁷⁹ Therefore, achieving a truly SCE necessitates a holistic framework that transcends a narrow focus on waste reduction, encompassing resource conservation, comprehensive lifecycle assessments of materials and products, as well as the social and ethical dimensions of circularity.⁸⁰ Applying a holistic lifecycle perspective across the entire value chain – from sourcing and production to recycling and end-of-life management – can significantly enhance the sustainability of products, particularly in the food packaging sector.⁸¹ This entails careful consideration of material selection, packaging design, and the systems that support reuse and recycling.

Several key strategies are essential for achieving a SCE for PFP. First of all, integrating eco-friendly materials into a circular PFP system, designing packaging for recyclability or compostability, and establishing the necessary infrastructure to support these processes are crucial for minimizing waste generation and resource depletion.⁸² Additionally, further waste minimization can be achieved through PFP optimization, including reducing over-packaging and exploring innovative designs

⁷⁶ Kumar and others, *op. cit.* note 40, p.26.

⁷⁷ Velenturf and Purnell, *op. cit.* note 15, p.1453

⁷⁸ Castro and others, *The rebound effect of circular economy: Definitions, mechanisms and a research agenda*, 345 *Journal of Cleaner Production* 131136, 2022, p.2

⁷⁹ Velenturf and Purnell, *op. cit.* note 15, p.1448 and Haupt and Hellweg, *op. cit.* note 69, p.1

⁸⁰ Ayaz and Tatoglu, *Unveiling the power of social value: Catalyzing circular economy in emerging market SMEs*, 453 *Journal of Cleaner Production* 142245, 2024, p.4.

⁸¹ Vidal and others, *Designing a circular carbon and plastics economy for a sustainable future*, 626 *Nature* 45, 2024, p.50.

⁸² El-Sayed and Youssef, *Eco-friendly biodegradable nanocomposite materials and their recent use in food packaging applications: a review*, 1 *Sustainable Food Technology* 215, 2023; UNEP, *op. cit.* note 50, p.24

and material alternatives to transition away from single-use plastics.⁸³ Sustainable sourcing of both ingredients and packaging materials is equally critical to minimizing environmental and social harm.⁸⁴ Finally, energy-efficient production methods across the entire supply chain, from food processing to packaging manufacturing, are essential for reducing the overall environmental footprint, requiring the adoption of energy-efficient technologies and process optimization.⁸⁵

The case of polyethylene terephthalate (PET), commonly used in beverage bottles, exemplifies the interconnectedness of *environmental*, *technological*, *economic*, and *social* factors in achieving sustainability. *Environmentally*, increasing the use of recycled PET (rPET) minimizes pollution from plastic production and disposal, aligning with the EU's 2030 target⁸⁶ for reusable or recyclable plastic packaging.⁸⁷ *Technologically*, advancements in recycling, particularly chemical recycling, are pivotal for a SCE for PET.⁸⁸ These technologies enable the breakdown of PET into its base components, allowing for the production of high-quality, food-grade rPET.⁸⁹ *Economically*, investing in efficient sorting and recycling infrastructure can create a cost-effective system for collecting and processing PET waste, making rPET a viable alternative to virgin PET.⁹⁰ *Socially*, public awareness campaigns promoting recycling and the use of rPET products can drive consumer demand for recycled content.⁹¹ PET recycling can also create local jobs in collection, sorting, and processing, fostering community engagement and economic inclusion.⁹²

⁸³ UNEP, *op. cit.* note 83, p.58; EMF, *The Global Commitment 2023 Progress Report*, 2023, p.5 and 16.

⁸⁴ Marsh and Bugusu, *op. cit.* note 28, p.R54; KerXin and others, *A study on the benefits of eco-friendly packaging on sustainable supply chain management in fast moving consumer goods industry*, 136 E3S Web Conf 04092, 2019.; Arfelli and others, *op. cit.* note 28, p.319.

⁸⁵ Marsh and Bugusu, *op. cit.* note 28, p.R53. ; Arfelli and others, *op. cit.* note 28., p.325.

⁸⁶ By 2030, all plastic packaging placed on the EU market should be either reusable or recyclable in a cost-effective manner. (Commission, *A European Strategy for Plastics in a Circular Economy - Brochure*, 2022. p.9)

⁸⁷ Babaei and others, *Chemical recycling of Polyethylene terephthalate: A mini-review*, 12 Journal of Environmental Chemical Engineering 112507, 2024; Wolberg, *The Performance of Recycled Plastics vs Virgin Plastics* (<https://oceanworks.co/blogs/ocean-plastic-news/the-performance-of-recycled-vs-virgin-plastics>).

⁸⁸ Muringayil Joseph and others, *Polyethylene terephthalate (PET) recycling: A review*, 9 Case Studies in Chemical and Environmental Engineering 100673, 2024, p.6

⁸⁹ *Loc. cit.*

⁹⁰ *Ibid.* p.5

⁹¹ Goldsberry, *New Survey Shows Consumers Want Products Made from Recycled Materials*, 2021, online available: <https://www.plasticstoday.com/packaging/new-survey-shows-consumers-want-products-made-from-recycled-materials>; Muringayil Joseph and others, *op. cit.* p.11.

⁹² Barford and Ahmad, *A Call for a Socially Restorative Circular Economy: Waste Pickers in the Recycled Plastics Supply Chain*, 1 Circular Economy and Sustainability 761, 2021.; Karasik and others, *Inequitable distribution of plastic benefits and burdens on economies and public health*, 9 Frontiers in Marine Science 1017247, 2023, p.04.

Furthermore, promoting recycling cultivates a culture of environmental responsibility and encourages behavioral changes that contribute to broader sustainability goals.⁹³ Ensuring equitable access to recycling infrastructure is also crucial for addressing social inequalities and allowing all communities to participate in and benefit from the CE.⁹⁴ Accordingly, achieving a SCE for PET requires a comprehensive strategy integrating advancements in recycling technologies, improved sorting infrastructure, optimized collection systems, and increased public awareness regarding the benefits of rPET. This integrated approach, considering technological, economic, and social factors, is essential to mitigate PET's environmental impact while fostering economic development and social responsibility—critical pillars of a sustainable future.

In conclusion, a SCE for plastics demands a comprehensive, holistic approach that integrates environmental soundness, social justice, and responsibility throughout the entire lifecycle of PFP, from raw material extraction to end-of-life management. This approach acknowledges the interconnectedness of environmental, technological, economic, and social factors, as highlighted by Geissdoerfer et al. and Velenturf et al.⁹⁵ By embracing this comprehensive perspective, a more resilient, inclusive, and ultimately sustainable PFP industry can be fostered, benefitting both the environment and society as a whole. This transition necessitates a comprehensive reevaluation of practices and policies, including those governing EU food packaging, prioritizing resource efficiency, waste reduction, and the equitable distribution of environmental benefits. Such a shift requires not only technological innovation but also fundamental changes in consumption patterns and a renewed commitment to sustainable development. The subsequent section will delve into the analysis of EU regulations relevant to PFP, identifying current shortcomings, and assessing their effectiveness in promoting a sustainable and safe food packaging system. This analysis will provide a comprehensive understanding of the regulatory landscape and its impact on achieving sustainability and circularity in the PFP industry.

⁹³ de Sousa, *op. cit.* note 62, p. 2090-2091.

⁹⁴ Solaja and others, *Examining Socio-Demographics and Understanding Business Factors among Plastic Bottle Waste Collectors in Ogun State, Nigeria*, Recycling and Sustainable Development, 2024, p.15-16.; Stoett and others, *Global plastic pollution, sustainable development, and plastic justice*, 184 World Development 106756, 2024, p.7.

⁹⁵ Geissdoerfer and others, *op. cit.* note 18, p.765; Velenturf and Purnell, *op. cit.* note 15, p.1441

3. THE EU'S TRANSITION TO A SUSTAINABLE CE IN PLASTIC FOOD PACKAGING: ADDRESSING CHALLENGES THROUGH LAW

3.1. The EU CE Policy Framework Towards Sustainable Plastic Food Packaging

The EU is actively transitioning from a linear to a CE model, recognizing the crucial role of packaging and packaging waste in this transformation.⁹⁶ This shift is driven by the necessity of transitioning towards sustainability, as articulated in key EU policy documents and legislative initiatives. Several interconnected strategies and regulations form the core of the EU's approach to sustainable PFP within the CE framework. The European Strategy for Plastics in a Circular Economy (Plastics Strategy) lays the foundation for this transition by emphasizing sustainability in the design, use, and recycling of plastics throughout the EU.⁹⁷ A key objective is to ensure that all plastic packaging placed on the EU market is either reusable or recyclable in a cost-effective manner by 2030.⁹⁸ The Plastics Strategy also prioritizes maintaining high food safety standards for PFP, particularly for recycled plastics intended for food-contact applications, while simultaneously promoting investment and innovation in CE solutions.⁹⁹ The European Green Deal (EGD), serving as Europe's roadmap towards climate neutrality, complements the Plastics Strategy. The EGD introduces proposals concerning sustainable products, including measures to provide consumers with transparent information on the environmental impact of products.¹⁰⁰ These initiatives aim to combat greenwashing and ensure the availability of sustainable alternatives for consumers.¹⁰¹ The Circular Economy Action Plan (CEAP), an integral part of the EGD, further reinforces the EU's commitment to advancing sustainable packaging. The CEAP initially prompted revisions to the Packaging and Packaging Waste Directive (PPWD) and the Single-Use Plastics (SUP) Directive,¹⁰² setting ambitious targets for improved recyclability and increased recycled content in plastic packaging, including a minimum of 30 % recycled content by 2030. This process culminated in the adoption of the Regulation on

⁹⁶Karamfilova, *Revision of Directive 94/62/EC on packaging and packaging waste* (Implementation Appraisal, 2022)

⁹⁷ EU Plastics Strategy

⁹⁸ EU Plastics Strategy

⁹⁹ EU Plastics Strategy

¹⁰⁰ COM(2019) 640 final

¹⁰¹ New proposals to make sustainable products the norm (europa.eu).

¹⁰² EC, Proposal for a Regulation of the European Parliament and of the Council on packaging and packaging waste, amending Regulation (EU) 2019/1020 and Directive (EU) 2019/904, and repealing Directive 94/62/EC (European Commission 2022),

Packaging and Packaging Waste (PPWR),¹⁰³ which replaces the PPWD. Labeling provisions for material composition and reusability, coupled with targets for reuse and refill systems, are also central components of the CEAP.¹⁰⁴ These measures aim to empower consumers to make informed choices, support the development of reusable packaging systems, and reduce reliance on single-use packaging. Finally, a policy framework for biobased, biodegradable, and compostable plastics aims to provide a comprehensive understanding of the associated challenges and benefits.¹⁰⁵ Grounded in the principles of the Plastics Strategy, the EGD, and the CEAP, this framework establishes conditions to ensure a positive overall environmental impact from the production and consumption of these materials.¹⁰⁶ It addresses policy gaps, guides future EU policy and legislation, and provides a common market approach – harmonizing standards and practices – to prevent unsustainable developments and foster a shared understanding across the EU. While this policy framework is not legally binding, the newly adopted PPWR introduces mandatory applications for some of these materials.

The EU's integrated approach to PFP, encompassing the Plastics Strategy, the EGD, and the CEAP aims to foster a sustainable and safe packaging ecosystem by promoting sustainable practices and addressing regulatory gaps.¹⁰⁷ This evolving regulatory landscape presents both opportunities and challenges for EU businesses, necessitating careful consideration of the legal and practical implications of the growing requirements.¹⁰⁸ A more detailed analysis of the mandatory instruments specifically targeting PFP is provided in the following subsection.

3.2. The regulatory landscape of Plastic Food Packaging Production and Use

EU regulations play a crucial role in shaping food packaging waste management.¹⁰⁹ The EU's regulatory framework for PFP addresses its entire lifecycle, from design and production to waste management and recycling,

¹⁰³ Regulation (EU) 2025/40

¹⁰⁴ [https://www.europarl.europa.eu/legislative-train/theme-a-european-green-deal/file-revision-of-packaging-and-packaging-waste-directive-\(refit\)](https://www.europarl.europa.eu/legislative-train/theme-a-european-green-deal/file-revision-of-packaging-and-packaging-waste-directive-(refit)).

¹⁰⁵ EC, *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions EU policy framework on biobased, biodegradable and compostable plastics*, 2022

¹⁰⁶ Ibid.

¹⁰⁷ New Circular Economy Action Plan

¹⁰⁸ J.-P. Schweitzer, *op. cit.* note 42, p.20.; Thapliyal and others, *Current Status of Sustainable Food Packaging Regulations: Global Perspective*, 16 Sustainability 5554, 2024.

¹⁰⁹ Schmidt and others, *op. cit.* note 16, p. 1751.

establishing specific requirements for the production, composition, reusability, and recoverability of all packaging destined for the EU market. Key legislative instruments include the PPWD and the new PPWR, the Food Contact Materials Regulation¹¹⁰ (FCM Regulation), the Regulation on plastic materials and articles intended to come into contact with food¹¹¹ (Plastic Regulation), and the Single-Use Plastics Directive (SUP Directive). For the end-of-life phase of PFP, this framework incorporates the PPWD (and PPWR), and the Waste Framework Directive (WFD), as well as the Regulation on recycled plastic materials and articles intended to come into contact with foods¹¹² (Plastics Recycling Regulation). This section focuses specifically on the design, production, and use phases of PFP, while the following section will address its end-of-life management.

The PPWD forms a cornerstone of the EU's regulatory framework for packaging, establishing general rules for all packaging¹¹³ destined for the EU market. Its primary objective is to minimize the environmental impact of packaging across various sectors by addressing its design, production, and end-of-life management, including plastic packaging used for food. Over time, revisions and amendments to the PPWD have incorporated provisions relevant to PFP. These include measures to reduce the consumption of lightweight plastic carrier bags,¹¹⁴ mandating Extended Producer Responsibility (EPR) schemes for all packaging, and increased recycling targets¹¹⁵ for packaging waste. Article 9 and Annex II of the PPWD outline Essential Requirements for packaging manufacturing and composition, promoting reusability and recoverability through material recycling,

¹¹⁰ EU, Regulation (EC) No 1935/2004 of the European Parliament and of the Council of 27 October 2004 on materials and articles intended to come into contact with food and repealing Directives 80/590/EEC and 89/109/EEC (2004), OJ L 338 of 13/11/2004 (hereinafter: Regulation 1935/2004)

¹¹¹ EU, Commission Regulation (EU) No 10/2011 of 14 January 2011 on plastic materials and articles intended to come into contact with food (2011), OJ L 12 of 15/1/2011 (hereinafter: Regulation 10/2011)

¹¹² EU, Commission Regulation (EU) 2022/1616 of 15 September 2022 on recycled plastic materials and articles intended to come into contact with foods, and repealing Regulation (EC) No 282/2008 (2022), OJ L 243 of 20/09/2022 (hereinafter: Regulation 2022/1616)

¹¹³ According to paragraph 1 in Article 3 packaging shall mean all products made of any materials of any nature to be used for the containment, protection, handling, delivery and presentation of goods, from raw materials to processed goods, from the producer to the user or the consumer. 'Non-returnable' items used for the same purposes shall also be considered to constitute packaging.

¹¹⁴ EU, Directive (EU) 2015/720 of the European Parliament and of the Council of 29 April 2015 amending Directive 94/62/EC as regards reducing the consumption of lightweight plastic carrier bags (European Parliament and the Council 2015), OJ L 115, 6/05/2015, (hereinafter: Directive 2015/720)

¹¹⁵ EU, Directive (EU) 2018/852 of the European Parliament and of the Council of 30 May 2018 amending Directive 94/62/EC on packaging and packaging waste (EU 2018), OJ L 150 of 14/06/2018 (hereinafter: Directive 2018/852)

energy recovery, or composting. Minimizing noxious and hazardous substances in packaging is also a key requirement, especially when it comes into direct contact with food.¹¹⁶ Nonetheless, while important, the PPWD's emphasis on end-of-life management has been criticized for insufficiently addressing upstream aspects of the packaging lifecycle, such as design and material choices.¹¹⁷ This focus potentially hinders a more holistic approach to circularity. Furthermore, the directive has faced challenges related to implementation delays and inconsistencies across Member States (MSs), and inadequate recycling targets, leading to regulatory uncertainty and burdens for producers.¹¹⁸ The persistent challenges of growing packaging waste, low recycling quality, and reliance on virgin plastics underscore the need for more robust and harmonized measures to achieve the EU's sustainability and CE objectives.¹¹⁹ To address these shortcomings, the Commission proposed a revision of the PPWD, culminating in the adoption of the PPWR on 16 December 2024, effective as of 11 February 2025.¹²⁰ Building upon the existing framework, the PPWR introduces significant changes, particularly for plastic packaging, with a stronger emphasis on sustainability, circularity, waste reduction, and minimized environmental impact. A key provision of the PPWR mandates that all packaging be recyclable by 2030,¹²¹ supported by clear assessment criteria to encourage design for circularity from the outset.¹²² Furthermore, businesses in specific sectors, such as takeaway and retail, shall offer reusable or refillable packaging options, incentivizing a shift away from single-use packaging.¹²³ To empower consumers, the PPWR mandates harmonized environmental labeling on all packaging, including PFP, providing clear information about recyclability and material composition to facilitate informed purchasing decisions.¹²⁴ The PPWR also introduces mandatory requirements for compostable packaging (mentioned above). Specifically, by 12 February 2028, tea bags, coffee pods, other soft single-serve beverage units, and sticky labels on fruit and vegetables must be industrially compostable, and

¹¹⁶ Annex II. of the Directive 94/62/EC

¹¹⁷ Tencati and others, *Prevention policies addressing packaging and packaging waste: Some emerging trends*, 56 Waste Management 35, 2016, p.36.; Bartl, *Withdrawal of the circular economy package: A wasted opportunity or a new challenge?*, 44 *ibid.* 1, 2015, p.2.

¹¹⁸ Karamfilova, *op. cit.* note 97.

¹¹⁹ *Ibid.*

¹²⁰ <https://www.consilium.europa.eu/en/press/press-releases/2024/12/16/sustainable-packaging-council-signs-off-on-new-rules-for-less-waste-and-more-re-use-in-the-eu/>.

¹²¹ In line with the European Green Deal and the new Circular Economy Action Plan

¹²² <https://foodpackagingforum.org/news/european-council-adopts-final-provisions-of-ppwr/>.

¹²³ Article 28 and 32 obligations related to refill and refill obligations for the takeaway sector; Article 29. reuse targets, Section 5 Article 51 Reuse and refill, Annex VI. Requirements specific to reuse systems and refill stations of Regulation (EU) 2025/40

¹²⁴ Article 12 of *Ibid.* and see also Commission, *Circular economy : new rules on packaging and packaging waste* (Publications Office of the European Union 2022)

potentially home-compostable where required by MS.¹²⁵ While the Regulation does not impose specific rules on biobased plastics currently, the Commission is required to review their technological and environmental performance within three years and may propose subsequent legislation with sustainability requirements and targets if deemed necessary.¹²⁶ Further strengthening the CE, the PPWR establishes concrete targets for minimum recycled plastic content in packaging, promoting the use of recycled materials and reducing reliance on virgin plastics.¹²⁷ Finally, to protect human health and the environment, the Regulation sets stricter limits on hazardous substances, including PFAS,¹²⁸ in packaging materials.¹²⁹ Both the PPWD and PPWR address the complex issue of chemicals in plastics, particularly FCMs. However, regulatory inconsistencies, such as the simultaneous presence of certain substances on both prohibited and approved lists, create ambiguity and complicate efforts to ensure the safety and quality of plastics.¹³⁰ This challenge is particularly pertinent given the widespread use of FCMs and the potential for component migration into food, posing risks to human health or altering the food itself.¹³¹

The EU has implemented two key regulations to address the potential risks of chemical migration from plastic FCMs into food, aiming to ensure both consumer safety and the effective functioning of the internal market. Regulation 1935/2004 (FCM Regulation) establishes general safety and quality principles for all FCMs,¹³² aiming to ensure a high level of consumer protection and safeguard

¹²⁵ Article 9 (1) of Regulation (EU) 2025/40

¹²⁶ Article 8 (1) of Regulation (EU) 2025/40

¹²⁷ Article 7 in Regulation (EU) 2025/40

¹²⁸ According to Recital 20 of Regulation (EU) 2025/40, Per- and polyfluoroalkyl substances (PFAS) are a group of thousands of synthetic chemicals that are used widely in the Union as well as in the rest of the world in a broad range of applications. Regarding PFAS tonnage, food contact material and packaging is one of the most relevant sectors. All PFAS in the scope of this Regulation are either very persistent themselves, or degrade into very persistent PFAS in the environment. When looking specifically at human health endpoints considered of most concern following long-term exposure of humans, i.e. carcinogenicity, mutagenicity, reproductive toxicity, including effects on or via lactation, and specific target organ toxicity, a large number of PFAS have a classification for at least one of these five endpoints. Based on the physical properties of PFAS, particularly persistence, along with identified health effects for some PFAS, PFAS represent an environmental and human health hazard.

¹²⁹ Article 5 in Regulation (EU) 2025/40

¹³⁰ Wiesinger and others, *Deep Dive into Plastic Monomers, Additives, and Processing Aids*, 55 Environmental Science & Technology 9339, 2021, p.9346

¹³¹ Karamfilova and Sacher, *Food Contact Materials Regulation (EC) 1935/2004 - European Implementation Assessment Study*, 2016, p. 98.

¹³² Beyond adhering to the FCM Regulation, all FCMs must be produced in compliance with Good Manufacturing Practices stipulated in Regulation 2023/2006 of 22 December 2006 on good manufacturing practice for materials and articles intended to come into contact with food, OJ L 384 of 29/12/2006

human health.¹³³ The regulation acknowledges the diverse nature of FCMs and their potential impact on both food quality and human health,¹³⁴ addressing crucial aspects such as labeling, compliance documentation, traceability, and enforcement mechanisms.¹³⁵ However, the regulation also presents certain limitations regarding the design, production, and use of PFP. For instance, the handling of Non-Intentionally Added Substances (NIAS), such as impurities and by-products, poses challenges for manufacturers during production.¹³⁶ While the FCM Regulation holds them responsible for demonstrating NIAS safety,¹³⁷ the lack of specific migration limits creates practical difficulties.¹³⁸ This ambiguity makes compliance demonstration difficult and raises concerns about potential, albeit unknown, health risks. Although a de facto threshold of 10 µg/kg food, derived from the migration limit for unauthorized substances used behind a functional barrier, is often applied in practice, the absence of legally established limits for NIAS remains a significant regulatory gap.¹³⁹ This gap can stifle the development and use of novel materials and processing techniques. Further, the FCM Regulation's limited scope regarding environmental sustainability and CE objectives impacts design choices.¹⁴⁰ The regulation prioritizes preventing harmful chemical migration into food but lacks provisions actively promoting sustainable materials or recycled plastics.¹⁴¹ This omission can discourage the design and production of food packaging with improved environmental profiles, hindering the transition to a CE for plastics. This limited scope, including the lack of attention to reusable systems, highlights areas for regulatory improvement. To effectively address these limitations and align with broader EU initiatives such as the PPWR, the EGD, and the SUP Directive, the FCM Regulation needs a more integrated approach. This includes incorporating

¹³³ Paragraph 1 of Article 1 of Regulation 1935/2004

¹³⁴ SAFE, *Food Contact Materials (FCMs) - Feedback to the European Commission's Evaluation and Fitness Check Roadmap*, 2020, p.3.

¹³⁵ https://food.ec.europa.eu/food-safety/chemical-safety/food-contact-materials/legislation_en.

¹³⁶ Leeman and Krul, *Non-intentionally added substances in food contact materials: how to ensure consumer safety*, 6 Current Opinion in Food Science 33, 2015, p.34

¹³⁷ Article 3 of Regulation 1935/2004 and Article 19 of Regulation 10/2011

¹³⁸ <https://foodpackagingforum.org/resources/background-articles/non-intentionally-added-substances-nias>.

¹³⁹ Grob and others, *Food Contamination with Organic Materials in Perspective: Packaging Materials as the Largest and Least Controlled Source? A View Focusing on the European Situation*, 46 Critical Reviews in Food Science and Nutrition 529, 2006; Geueke and others, *Food contact substances and chemicals of concern: a comparison of inventories*, 31 Food Additives & Contaminants: Part A 1438, 2014; <https://foodpackagingforum.org/resources/background-articles/non-intentionally-added-substances-nias>

¹⁴⁰ ZWE, *Food packaging: safety first - Towards toxic-free and future-proof packaging*, 2023, p.2.

¹⁴¹ SANTE, *Study on sustainability in the context of food contact materials (FCM) in view of a possible revision of the FCM legislation*, 2024, p.6

environmental considerations into the design and production phases, fostering innovation, and incentivizing the adoption of sustainable plastic use.¹⁴² Such a holistic framework would better balance food safety with environmental concerns, promoting a CE for plastic food contact articles.¹⁴³

Given the limitations of the general FCM framework, Regulation 10/2011 (Plastic Regulation) provides supplementary, specific requirements for plastic FCMs. This regulation establishes requirements for the manufacturing and marketing of plastic materials and articles intended to come into contact with food.¹⁴⁴ It impacts manufacturers, importers, and retailers of plastic FCMs, influencing material choices, manufacturing processes, and product compliance. Specifically, the Plastics Regulation establishes a Union List of authorized substances that can be used in the manufacture of plastic FCMs,¹⁴⁵ and outlines compliance rules.¹⁴⁶ Furthermore, the regulation mandates that additives used in plastic FCMs must undergo a safety assessment by the European Food Safety Authority and be included in the Union List.¹⁴⁷ This requirement impacts both the design and production stages, as manufacturers must ensure compliance with permitted substances and their respective restrictions. Crucially, the Plastics Regulation establishes migration limits – determined by EFSA based on toxicological data – for substances transferring from plastic FCMs into food to ensure food safety during the use phase.¹⁴⁸ Compliance with these limits is a critical aspect of production quality control and impacts product safety for consumers. The regulation also outlines specific rules for compliance testing and documentation, influencing quality control procedures during production.¹⁴⁹ The Plastic Regulation undergoes regular revisions and amendments to reflect scientific advancements, address emerging concerns and adapt to evolving industry practices.¹⁵⁰

Beyond the overarching framework of the FCM and Plastic Regulation, the Single-Use Plastics Directive (SUP Directive) targets specific plastic products to mitigate their environmental impact, particularly on marine ecosystems and human

¹⁴² EC, *Commission staff working document evaluation of the legislation on food contact materials - Regulation (EC) No 1935/2004*, 2022, p.45

¹⁴³ SANTE, *op. cit.* note 142, p. 7.

¹⁴⁴ Paragraph 2 of Article 1 of Regulation 10/2011

¹⁴⁵ Article 5 and Annex I. of Regulation 10/2011

¹⁴⁶ Chapter V. of Regulation 10/2011

¹⁴⁷ <https://www.foodpackagingforum.org/food-packaging-health/food-packaging-materials/plastics>

¹⁴⁸ https://food.ec.europa.eu/safety/chemical-safety/food-contact-materials/legislation_en

¹⁴⁹ Chapter V. of Regulation 10/2011

¹⁵⁰ Paragraph 3 of Article 15 of Regulation 10/2011

health.¹⁵¹ This Directive complements the aforementioned regulations by addressing plastic pollution stemming from commonly littered items. The Directive implements a ban on ten single-use plastic products frequently found on European beaches. For the food packaging sector, this ban notably includes expanded polystyrene food and beverage containers and cups, directly impacting material choices during design and production.¹⁵² From December 31, 2024, producers of lightweight plastic carrier bags and specific types of packaging, including takeaway food containers, packets and wrappers, plastic drinks containers, and cups (including covers and lids), became subject to mandatory EPR schemes.¹⁵³ According to Article 8, MSs are obligated to establish these EPR schemes for all single-use plastic products listed in Part E of the Annex. These schemes require producers to cover the costs of waste management and litter cleanup associated with their products, collect and report data on these materials, and fund awareness-raising campaigns to promote responsible disposal and recycling.¹⁵⁴ The overarching goal of these EPR schemes is to incentivize producers to consider the environmental impact of their products throughout their lifecycle, influencing design and production choices towards more sustainable solutions.¹⁵⁵ The use phase might be also impacted, as consumers become more aware of proper disposal and recycling practices through the funded awareness campaigns. Furthermore, the SUP Directive establishes recycled content targets for plastic beverage bottles, mandating the incorporation of 25 % recycled plastic in PET beverage bottles by 2025, rising to 30 % for all plastic beverage bottles by 2030.¹⁵⁶ These targets directly impact production processes, requiring manufacturers to incorporate recycled materials into their production streams and can foster a CE for plastic beverage bottles.

Focusing on the design, production, and use phases of PFP, the current EU regulatory landscape presents a fragmented approach. While the FCM and the Plastic Regulation prioritize consumer safety, they lack comprehensive CE integration, particularly impacting the aforementioned stages. Although the SUP Directive and PPWR aim to bridge this gap, a more holistic framework is needed to effectively harmonize these regulations and incentivize sustainable innovation across the entire lifecycle of PFP.¹⁵⁷ The following section addresses the analysis of end-of-life management.

¹⁵¹ Recital 5 of Directive 2019/904

¹⁵² Article 5 and Part B of the Annex of Directive 2019/904

¹⁵³ Article 8 and Part E of the Annex in Directive 2019/904

¹⁵⁴ Paragraph 2 and 3 of Article 8 Directive 2019/904

¹⁵⁵ Maitre-Ekern, *Re-thinking producer responsibility for a sustainable circular economy from extended producer responsibility to pre-market producer responsibility*, 286 Journal of cleaner production 125454, 2021, p.2.

¹⁵⁶ Paragraph 1 of Article 9 of Directive 2019/904

¹⁵⁷ ZWE, *op. cit.* note 141, p.19.

3.3. The regulatory landscape of the end-of-life of plastic food packaging

Current end-of-life management practices for PFP present significant obstacles to achieving a SCE. While energy recovery is the predominant disposal method,¹⁵⁸ followed by recycling, a substantial portion (approximately 25 %) of plastic waste persists in landfills, underscoring systemic inefficiencies.¹⁵⁹ Several interconnected challenges hinder the effective end-of-life management of PFP waste. These include: the chemical complexity and heterogeneity of plastics, material contamination within the waste stream, technical and economic barriers to recycling certain plastic types, the presence of non-plastic components in packaging design, and inadequate recycling infrastructure.¹⁶⁰ Existing recycling technologies, such as mechanical and chemical recycling,¹⁶¹ face inherent limitations.¹⁶² Plastic degradation during recycling diminishes material quality and economic value, leading to downcycling.¹⁶³ Multi-material multilayer plastic packaging, commonly used in food packaging, poses a particular challenge due to separation difficulties, often resulting in downcycling or incineration.¹⁶⁴ Furthermore, insufficient collection infrastructure, cost inefficiencies,¹⁶⁵ and the production of low-quality recycled materials exacerbate the problem.¹⁶⁶ Critically, the presence of various, often overlooked, substances within plastics can compromise recycling processes and the safety and quality of recycled materials.¹⁶⁷

The EU has introduced key regulatory instruments to address these challenges. The WFD establishes a hierarchical framework for waste management, prioritizing waste prevention and reduction, followed by preparing for reuse, recycling, other recovery (e.g., energy recovery), and disposal as a last resort.¹⁶⁸

¹⁵⁸ Energy recovery means turning plastic waste into usable heat, electricity, or fuel through incineration or other processes. (<https://www.europarl.europa.eu/topics/en/article/20181212STO21610/plastic-waste-and-recycling-in-the-eu-facts-and-figures>)

¹⁵⁹ Plastic waste and recycling in the EU: facts and figures | Topics | European Parliament (europa.eu)

¹⁶⁰ Chanda, *Plastics Technology Handbook*, 2017, p.796

¹⁶¹ <https://plasticseurope.org/sustainability/circularity/recycling/recycling-technologies/>

¹⁶² Leal Filho and others, *An overview of the problems posed by plastic products and the role of extended producer responsibility in Europe*, 214 *Journal of Cleaner Production* 550, 2019, p.551

¹⁶³ Geyer and others, *op. cit.* note 32, p.2

¹⁶⁴ Kaiser and others, *Recycling of Polymer-Based Multilayer Packaging: A Review*, 3 *Recycling* 1, 2018, p.8

¹⁶⁵ Van Camp and others, *Exposing the pitfalls of plastics mechanical recycling through cost calculation*, 189 *Waste Management* 300, 2024.

¹⁶⁶ Soares and others, *op. cit.* note 30, p.7-8.

¹⁶⁷ Wiesinger and others, *op. cit.* note 131, p.9339.

¹⁶⁸ Article 4 and Recital 30 of Directive 2008/98/EC

This hierarchy aims to promote the transition towards a CE by guiding actions towards minimizing waste and maximizing resource utilization. However, implementation faces obstacles. While prevention is paramount, the WFD lacks robust mechanisms and quantitative targets to effectively incentivize packaging waste reduction at the source.¹⁶⁹ The Directive promotes EPR schemes, holding producers accountable for end-of-life management and incentivizing design for recyclability and reuse.¹⁷⁰ Article 11 of the WFD mandates separate collection systems for recyclable waste, including plastics, to ensure high-quality recycling and reduce contamination. Furthermore, Article 11 and Annex V establish ambitious recycling targets, including a 55 % recycling rate for plastic packaging by 2030, and encourage improvements in recycling infrastructure and practices. Nonetheless, the WFD's general framework lacks specific provisions tailored to the complexities of PFP.

The PPWD, along with its amendments, and the new PPWR build upon the WFD by setting specific targets for packaging waste recovery and recycling, including plastic.¹⁷¹ The PPWR introduces more stringent targets, aiming for higher recycling rates and promoting recycled content in packaging (encompassing PFP).¹⁷² These targets incentivize the development of recycling infrastructure and technologies, and the establishment of re-use and refill systems.¹⁷³ While both instruments address EPR, the PPWD mandates EPR schemes only from 31 December 2024 and suffers from inconsistent implementation across MSs.¹⁷⁴ Producers are responsible for waste management costs, but variations in national implementation lead to inefficiencies, inconsistent financial contributions, and a diluted environmental impact.¹⁷⁵ The PPWR aims to strengthen and harmonize EPR requirements across the EU by introducing binding obligations for producers to finance and manage the collection, sorting, and recycling of packaging waste.¹⁷⁶ It mandates standardized EPR schemes, ensuring consistency across MSs, and introduces eco-modulation fees, where producers pay higher fees for non-

¹⁶⁹ Magrini and others, *Municipal solid waste prevention: A review of market-based instruments in six European Union countries*, 38 *Waste Management & Research* 3, 2020, p.4.

¹⁷⁰ Recital 27 and Article 8 of Directive 2008/98/EC

¹⁷¹ https://environment.ec.europa.eu/topics/waste-and-recycling/packaging-waste_en

¹⁷² For instance, in the new PPWR there are restrictions on certain single-use plastics, such as pre-packed fruits and vegetables weighing less than 1.5 kg, also all packaging on the EU market shall be recyclable in an economically viable way by 2030

¹⁷³ Recital 140 and 149 and Article 26 and 51 of the Regulation (EU) 2025/40

¹⁷⁴ Karamfilova, *op. cit.* note 97, p.5

¹⁷⁵ EUROPEN, *Factsheet on Extended Producer Responsibility (EPR) for used packaging*, 2015, p.4; Emma Watkins, *EPR in the EU Plastics Strategy and the Circular Economy: A focus on plastic packaging*, 2017. p. 9 and 19.

¹⁷⁶ Article 47 of Regulation (EU) 2025/40

recyclable or environmentally harmful packaging.¹⁷⁷ This harmonized approach aims to create a level playing field for businesses, reduce costs, and enhance the overall effectiveness of EPR in promoting a CE for packaging.¹⁷⁸

Beyond the provisions discussed in Section 3.2, the SUP Directive specifically addresses the end-of-life management of single-use plastics as well, including those used in food packaging. For instance, to facilitate the incorporation of recycled plastic into PET beverage bottles (introduced above), the Directive mandates a separate collection target of 77 % for plastic bottles by 2025, rising to 90 % by 2029.¹⁷⁹ Echoing the UN Sustainable Development Goal 12's¹⁸⁰ emphasis on sustainable consumption and production, the Directive prioritizes the adoption of sustainable and non-toxic reusable products and reuse systems over single-use alternatives to reduce waste generation at the source.¹⁸¹

Finally, the Plastics Recycling Regulation,¹⁸² aligned with the CEAP, aims to increase the recycled plastic content, particularly in food packaging while maintaining the same safety standards as those for plastics manufactured under the Plastic Regulation.¹⁸³ This regulation covers all recycled plastic types and recycling technologies, including the assessment of recycling processes.¹⁸⁴ A key element is the establishment of a Union register for technologies, recyclers, processes, systems, and decontamination facilities, providing comprehensive information on novel technologies, their properties, developers, and installations.¹⁸⁵ From July 2023, only plastics incorporating recycled plastic produced with a suitable recycling technology¹⁸⁶ (e.g., post-consumer mechanical PET recycling with individual EFSA authorization) or a new technology regulated under Chapter IV, may be placed on the market.¹⁸⁷ Stringent authorization

¹⁷⁷ Paragraph 7 of Article 7 of Regulation (EU) 2025/40

¹⁷⁸ Recital 28 and 36 and Article 1 of Regulation (EU) 2025/40

¹⁷⁹ Paragraph 1 of Article 9 of Directive 2019/904

¹⁸⁰ Ensure sustainable consumption and production patterns (<https://sdgs.un.org/goals/goal12>)

¹⁸¹ Recital 2 of Directive 2019/904

¹⁸² On October 10, 2022, the Regulation 2022/1616 replaced Regulation No. 282/2008, which previously governed authorization processes for recycling. However, the earlier regulation did not encompass all recycling technologies, excluding chemical depolymerization, the use of offcuts and scraps, and the use of barrier layers. (source: Recital 3 of the Regulation 2022/1616)

¹⁸³ Recital 1 and 16, and Article 4 of Regulation 2022/1616

¹⁸⁴ Recital 5 and Article 1 of Regulation 2022/1616

¹⁸⁵ Article 24 of Regulation 2022/1616

¹⁸⁶ Under Paragraph 1 of Article 3 of Regulation 2022/1616 'suitable recycling technology' is a recycling technology that is shown to be capable of recycling waste into recycled plastic materials and articles that comply with Article 3 of the Framework Regulation and is microbiologically safe.

¹⁸⁷ Paragraph 3 of Article 31 of Regulation 2022/1616

processes and reporting obligations¹⁸⁸ ensure the safety of recycled materials.¹⁸⁹ From October 2024, specific waste management operators involved in plastic collection and pre-processing must establish a third-party certified quality assurance system to control and ensure the quality and traceability of plastic input.¹⁹⁰ The Regulation's comprehensive approach, covering the entire recycling chain, aims to ensure the safety and quality of recycled plastic materials, facilitate enforcement, and support supply chain functionality.¹⁹¹ The Plastics Recycling Regulation, while aiming for comprehensive coverage of recycled plastics and technologies, faces challenges. Its uncertain applicability to emerging or novel methods could hinder innovation, predominantly for technologies outside the current framework.¹⁹² Furthermore, recycling complex multilayer food packaging structures is difficult, as these often fail to meet stringent food contact material safety standards, limiting the feasibility of certain recycling processes.¹⁹³ This regulation must balance promoting innovation with upholding strict safety standards to achieve its long-term goals of reducing raw material reliance and fostering a robust market for safe recycled plastics.¹⁹⁴

Given the dynamic nature of the EU's regulatory approach to PFP, with ongoing efforts to enhance environmental, health, and safety protections and promote sustainability and circularity, the effectiveness of these measures will ultimately depend on their rigorous implementation and enforcement.

¹⁸⁸ According to Paragraph 4 of Article 13 and Paragraph 1 of Article 14 of Regulation 2022/1616: Developers have reporting obligations every six months, providing the latest information from all installations using the novel technology, which forms the basis for EFSA's opinion on the technology's suitability

¹⁸⁹ Recital 5 and 15 of Regulation 2022/1616

¹⁹⁰ Recital 34 and Article 6 of Regulation 2022/1616

¹⁹¹ https://food.ec.europa.eu/food-safety/chemical-safety/food-contact-materials/plastic-recycling_en

¹⁹² <https://www.fgvw.de/en/news/archive-2022/food-law-new-eu-regulation-eu-2022-1616-recycled-plastic-materials-and-articles-intended-to-come-into-contact-with-foods>

¹⁹³ Europe, *Functional Barriers for the Use of Recycled Plastics in Multi-layer Food Packaging*, 2017, online available: <https://packagingeurope.com/functional-barriers-for-the-use-of-recycled-plastics-in-multi-layer-food-packaging/2083.article>; Kaiser and others, *op. cit.* note 165, p.3.; Soares and others, *op. cit.* note 30., p.5.

¹⁹⁴ COM(2020) 98 final

4. CHALLENGES AND OPPORTUNITIES IN INTERNALIZING THE NEGATIVE EXTERNALITIES OF PLASTIC FOOD PACKAGING

4.1. Remaining Gaps and Future Directions

Despite extensive legislative efforts in the EU, several gaps still remain in fully internalizing the negative externalities associated with PFP. The current legislation primarily leans on downstream solutions, such as waste management and recycling, but more emphasis is needed on upstream solutions, such as reducing plastic production or promoting alternative materials.¹⁹⁵ For instance, biobased, biodegradable, and compostable PFP offers a potential alternative to conventional options.¹⁹⁶ However, challenges persist, including high production costs, ensuring proper alignment with CE principles throughout their lifecycle (e.g., end-of-life management infrastructure), and the lower performance characteristics of some biodegradable plastics compared to conventional counterparts.¹⁹⁷ Further research and innovation are needed to overcome these limitations and fully realize the potential of these materials within a sustainable food packaging system.¹⁹⁸ This includes research to inform the development of harmonized EU standards and certifications, as well as innovation to meet regulatory requirements for end-of-life management and ensure compliance with existing frameworks such as the WFD.¹⁹⁹

¹⁹⁵ Reis and others, *op. cit.*, note 5, p.8. ; Greenwood and others, *Many Happy Returns: Combining insights from the environmental and behavioural sciences to understand what is required to make reusable packaging mainstream*, 27 Sustainable Production and Consumption 1688, 2021, p.1701.; Fletcher and others, *Turning off the Tap: How the world can end plastic pollution and create a circular economy* (United Nations Environment Programme 2023

¹⁹⁶ EC, *op. cit.* note 105; Asgher and others, *Bio-based active food packaging materials: Sustainable alternative to conventional petrochemical-based packaging materials*, 137 Food Research International 109625, 2020; Dirpan and others, *A Review on Biopolymer-Based Biodegradable Film for Food Packaging: Trends over the Last Decade and Future Research*, 15 Polymers 1, 2023.

¹⁹⁷ Matthews and others, *A review on European Union's strategy for plastics in a circular economy and its impact on food safety*, 283 Journal of Cleaner Production 125263, 2021; Moshood and others, *Sustainability of biodegradable plastics: New problem or solution to solve the global plastic pollution?*, 5 Current Research in Green and Sustainable Chemistry 100273, 2022; El-Sayed and Youssef, *op. cit.* note 83.; Dirpan and others, *op. cit.* note 197.

¹⁹⁸ EMF, *The New Plastics Economy: Rethinking the future of plastics & catalysing action*, 2017; SWD(2018) 16 final

¹⁹⁹ Misko, *Plastic Packaging in a Circular Economy*, Food Safety Magazin, 2019, p.4; Lovett, *End-of-life options for bioplastics: Clarifying end-of-life options for bioplastics and the role of PLA in the circular economy*, 2020, p.19

The difficulty and low level of recycling multilayer PFP also present a significant hurdle.²⁰⁰ While these complex structures are essential for preserving food quality and safety, extending shelf life, and ultimately minimizing food waste, their current incompatibility with existing recycling infrastructure raises a critical environmental concern.²⁰¹ Eliminating them without viable alternatives could lead to increased packaging and food waste. Furthermore, the lack of clear labeling and consumer awareness regarding proper disposal methods for multilayer packaging exacerbates the problem, often leading to these materials ending up in landfills or incinerators.²⁰² Encouraging material innovation in recyclable or compostable alternatives for multi-material applications, or requiring product redesigns into mono-material formats, represents a potential regulatory approach for promoting sustainable packaging practices.²⁰³

Another major issue is the widespread use of potentially harmful chemicals in PFP production and recycling. While chemicals in PFP often serve functional purposes, their potential adverse impacts on human and environmental health, along with the complexities they introduce to recycling processes, raise concerns.²⁰⁴ These complexities are further amplified in recycled plastics, where the presence of hazardous substances, including NIAS, poses additional challenges.²⁰⁵ This issue is further compounded by the fragmented nature of current EU regulations on FCMs.²⁰⁶ The gap between the general FCM Regulation and specific substance regulations hinders comprehensive risk assessment and control of hazardous

²⁰⁰ Geueke and others, *Food packaging in the circular economy: Overview of chemical safety aspects for commonly used materials*, 193 *Journal of Cleaner Production* 491, 2018; Matthews and others, *op. cit.* note 198.; Schmidt and others, *Multilayer Packaging in a Circular Economy*, 14 *Polymers* 1825, 2022.

²⁰¹ Matthews and others, *op. cit.* note 198, p. 12

²⁰² Schmidt and others, *op. cit.* note 201, Ciawi and others, *Redefining Packaging Solutions: The of Split-layer Packaging for Waste Reduction and Climate Action*, 3 *J Mod Ind Manuf* 12, 2024.

²⁰³ EMF, *op. cit.* note 199.; Fletcher and others, *loc. cit.* note 196.

²⁰⁴ Geueke and others, *op. cit.* note 201, p.492; Geueke and others, *Prioritization approaches for hazardous chemicals associated with plastic packaging*, 2018; Ciawi and others, *op. cit.* note 203, p. 2-3

²⁰⁵ EU, *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on the implementation of the circular economy package: options to address the interface between chemical, product and waste legislation*, 2018, p.1; Geueke and others, *op. cit.* note 201, p. 492; Matthews and others, *op. cit.* note 198, p. 4; Undas and others, *Safety of recycled plastics and textiles: Review on the detection, identification and safety assessment of contaminants*, 312 *Chemosphere* 137175, 2023, p.2

²⁰⁶ Sundqvist-Andberg and Åkerman, *Sustainability governance and contested plastic food packaging – An integrative review*, 306 *Journal of Cleaner Production* 127111, 2021, p. 11; SANTE, *op. cit.*, note 142, p. 13

chemicals throughout the lifecycle of plastic packaging.²⁰⁷ Inconsistencies between EU and national regulations create additional complexities and legal uncertainties while tracing and controlling chemicals in recycled plastics for food contact applications presents significant legal and technical challenges.²⁰⁸ Although the Plastic Recycling Regulation promotes increased use of recycled plastics in FCMs, ensuring safety requires stringent controls and traceability mechanisms to address legacy chemicals and contamination risks.²⁰⁹

To foster a truly sustainable and circular PFP system within the EU, the current regulatory environment requires revisions. Promoting innovation through research and development of recyclable and compostable alternatives, particularly for complex multilayer applications, is crucial for minimizing negative externalities. Transitioning towards mono-material designs, which are inherently easier to recycle, should be incentivized through targeted regulatory measures.²¹⁰ Furthermore, integrating CE principles into the design phase of PFP, prioritizing material reduction, recyclability, and compostability, is essential. This necessitates implementing eco-design guidelines that internalize the environmental costs associated with PFP.²¹¹ Establishing a transparent and harmonized system with clear standards and labeling requirements will facilitate proper sorting and recycling while improving consumer awareness.²¹² Standardizing packaging requirements per product category can streamline material management and reduce complexity, further contributing to a CE.²¹³

Finally, incentivizing innovation through targeted regulatory measures and financial support will accelerate the development and adoption of sustainable PFP solutions, ultimately mitigating the negative externalities associated with current

²⁰⁷ Varalda and others, *Risk assessment of food contact materials*, 22 EFSA Journal e21107, 2024, p.3; SANTE, *op. cit.*, note 142, p. 5

²⁰⁸ Poças and do Céu Selbourne, *Drivers, advances, and significance of measures for effective circular food packaging*, 7 Frontiers in Sustainable Food Systems 1140295, 2023, p. 03

²⁰⁹ Recital 11 and 15 of the Plastics Recycling Regulation; EFSA Panel on Food Contact Materials and others, *Scientific Guidance on the criteria for the evaluation and on the preparation of applications for the safety assessment of post-consumer mechanical PET recycling processes intended to be used for manufacture of materials and articles in contact with food*, 22 EFSA Journal e8879, 2024.

²¹⁰ Schmidt and others, *op. cit.* note 201, p. 20

²¹¹ Sundqvist-Andberg and Åkerman, *op. cit.* note 207, p. 7-8; Schmidt and others, *op. cit.* note 201, p. 20

²¹² Mielinger and Weinrich, *A review on consumer sorting behaviour: Spotlight on food and Fast Moving Consumer Goods plastic packaging*, 47 Environmental Development 100890, 2023, p. 16 and 18.; Ciawi and others, *op. cit.* note 203, p. 8

²¹³ COM(2020) 98 final p. 9 and 13.; Schmidt and others, *op. cit.* note 201, p. 20; Mielinger and Weinrich, *op. cit.* note 213, p. 18

practices.²¹⁴ However, regulations alone are insufficient to fully address the complexities of PFP. Achieving sustainable food packaging within a CE, which is crucial for internalizing the negative externalities of PFP, necessitates a collaborative effort involving all stakeholders, including food and packaging manufacturers, recyclers, policymakers, civil society, and consumers.²¹⁵ Moreover, a fundamental shift in environmental policy design is necessary – moving beyond limited consumption-phase measures to fully acknowledge the diverse functionalities of PFP and effectively address related behavioral practices.²¹⁶ Encouraging changes in consumption patterns, such as reducing reliance on single-use packaging and promoting reusable alternatives, is essential and demands targeted consumer education, awareness campaigns, and incentives for sustainable choices.²¹⁷

4.2. The EU's Regulatory Approach: Addressing PFP Lifecycle Challenges

The environmental and social costs associated with PFP are largely driven by market failures. These failures particularly stem from the inability of markets to internalize the full environmental costs associated with PFP's lifecycle – from production and use to disposal.²¹⁸ This failure arises from negative externalities, where environmental harms – such as pollution, resource depletion, GHG emission, biodiversity loss, and health risks – are not reflected in the market price of PFP, leading to excessive production and consumption.²¹⁹ Additionally, regulatory gaps, consumer behavior, and structural economic factors, such as the low cost of virgin plastic, or the long transport distances exacerbate the issue.²²⁰ Furthermore, the costs of managing plastic waste (collection, sorting, and recycling) are often externalized, leading to inadequate waste management systems and increased plastic pollution.²²¹ Addressing these market failures requires intervention. The EU's regulatory approach involves a combination of strategies (analyzed above) targeting different stages of the PFP lifecycle, from production to disposal, with varying degrees of success. The EGD establishes

²¹⁴ Reis and others, *op. cit.* note 5, p. 8; COM(2020) 98 final p. 16-17; 3. Sundqvist-Andberg and Åkerman, *op. cit.* note 207, p. 8 and 11;

²¹⁵ Geueke and others, *op. cit.* note 201, p.502

²¹⁶ Sundqvist-Andberg and Åkerman, *op. cit.* note 207, p. 11

²¹⁷ Shamsuddoha and Kashem, *op. cit.* note 61, p. 4 and 18;

²¹⁸ Carton, 'Environmental economics', *Companion to Environmental Studies*, 2018; OECD, *Improving markets for recycled plastics: Trends, prospects and policy responses*, 2018.

²¹⁹ Reis and others, *op. cit.* note 5; EEA and others, *Plastics, the circular economy and Europe's environment – A priority for action* (Publications Office, 2021).

²²⁰ WWF, *op. cit.* note 50

²²¹ Reis and others, *op. cit.* note 5

ambitious targets for sustainability and resource efficiency, within and beyond which key legislative measures address the externalities associated with PFP. These measures aim to: reduce packaging waste,²²² promote reuse and recycling,²²³ harmonize packaging formats to discourage single-use plastics,²²⁴ restrict specific single-use plastic products,²²⁵ promote sustainable alternatives,²²⁶ introduce design requirements for PFP,²²⁷ and enhance the safety aspects of PFP.²²⁸ A crucial element of the internalization strategy is the implementation of EPR schemes. EPR schemes hold producers responsible for the post-consumer management of their packaging, covering costs associated with waste collection, data gathering, reporting, and litter cleanup.²²⁹ However, the effectiveness of EPR schemes varies across MSs due to differences in implementation and enforcement.²³⁰ Harmonization and stricter enforcement across the EU are essential for maximizing the impact of EPR and achieving a truly SCE for packaging.

5. CONCLUSION

PFP, despite its functionality, presents significant environmental and socioeconomic challenges due to its persistent negative externalities, from resource depletion and pollution to potential health risks. While the EU has implemented various regulatory instruments aimed at mitigating these impacts through CE principles, a gap remains between the aspirations of these initiatives and the reality of continued environmental damage. Current EU policies, including recycling targets and EPR schemes, represent steps towards circularity. However, they often lack a cohesive and comprehensive framework, resulting in fragmented efforts and potentially counterproductive outcomes. For example, an overemphasis on recycling may inadvertently disincentivize higher-value circular strategies such as refillable packaging systems or standardized reusable packaging models. Furthermore, existing legal frameworks struggle to fully internalize the external costs associated with PFP's lifecycle, from production to disposal. This

²²² See Directive 2008/98/EC, Directive 94/62/EC, Regulation (EU) 2025/40

²²³ See Directive 2008/98/EC, Directive 94/62/EC, Regulation (EU) 2025/40, Directive 2019/904, Regulation 2022/1616

²²⁴ See Directive 2019/904 and Regulation (EU) 2025/40

²²⁵ See Directive 2019/904 and Regulation (EU) 2025/40

²²⁶ See Directive 2019/904 and Regulation (EU) 2025/40

²²⁷ See Directive 2019/904, Regulation (EU) 2025/40 and Regulation 2022/1616

²²⁸ See Regulation 1935/2004, Regulation 10/2011, Regulation (EU) 2025/40, and Regulation 2022/1616

²²⁹ See Directive 2008/98/EC, Directive 94/62/EC, Directive 2019/904, Regulation (EU) 2025/40

²³⁰ Leal Filho and others, *op. cit.* note 163

underscores the need for more robust regulations that ensure equitable resource distribution and clear responsibility allocation, supported by standardized national implementations for consistent enforcement and a level playing field for businesses. Transitioning towards a truly sustainable CE model for PFP requires a multifaceted approach that goes beyond simply addressing end-of-life management. It demands a fundamental shift in environmental policy design, moving beyond limited consumption-phase measures to fully acknowledge the diverse functionalities of PFP and effectively address related behavioral practices. This includes fostering collaborative efforts among all stakeholders to drive changes in consumption patterns, reduce reliance on single-use packaging, and promote reusable alternatives through targeted education, awareness campaigns, and incentives. Ultimately, even a fully circular PFP model must consider broader sustainability concerns. The sustainability of a product extends beyond its packaging to encompass factors such as portion size and the potential harmfulness of chemical components. Addressing these complex challenges requires integrated legal and policy reforms, coupled with innovative solutions, to incentivize a genuine transition towards a sustainable and circular PFP sector. This holistic approach is essential for creating a truly sustainable and equitable PFP system.

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