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A policy portfolio approach to plastics throughout their life cycle: Supranational and national regulation in the European Union

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Abstract

The environmental and health problems caused by plastics throughout their life cycle have attracted considerable public attention over the past decade, triggering policy responses in many constituencies. Similarly, interdisciplinary research on plastics has been burgeoning in the past few years, and political science contributions have covered the manifold root causes and consequences of this shift in public policy including media coverage, evolving discourses and policy agendas. In view of this policy relevance that drives scholarly inquiry, it is surprising that we lack a systematic assessment of the actual policy outputs. This article fills this lacuna by developing a policy portfolio approach to plastic regulation. To illustrate and substantiate our approach, we provide an exploratory analysis of EU plastics regulation over the last twenty years, complementing this with Denmark, Germany, and Poland as diverse cases of member state regulation. Overall, our research shows that the number of policy measures targeting plastics has massively increased both at the supranational and national level. This policy growth, however, varies across policy targets and instruments. Our findings highlight first, that the policy targets addressed are mainly located at the end of the plastics life cycle; and second, that the instrument choice is privileging the use of hierarchical forms of intervention over the use of market- or information-based instruments. We discuss these features of the policy portfolio approach in light of existing research on plastics and life-cycle-oriented policy approaches such as the Circular Economy.

KEYWORDS

European Union, life cycle, plastics, policy instruments, policy portfolio

1 | INTRODUCTION

Materials have the potential to shape social artifacts and technologies in such profound ways that they become characteristic of the societies which engage with them (Bensaude Vincent, 2013). The immense impact that plastic has had on our society today induced scholars to put the notion of the *Plastic Age* in the same line with other epochal

categories, such as the *Stone Age* and *Iron Age* (Kramm & Völker, 2023, p. 7). Plastics evolved into a symbol of mass consumption, a society of disposables, and large amounts of hardly manageable waste polluting the environment (Kramm & Völker, 2023). Heightened media coverage has encouraged greater public engagement with plastics (Bailey, 2022). The BBC series “Blue Planet,” for example, contributed to the upward momentum of media, public, and political attention to plastic pollution

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(Bailey, 2022; Males & Van Aelst, 2021). This has triggered policy responses in many constituencies across the globe (California State Legislature, 2014; China State Council, 2007; European Parliament & Council of the European Union, 2015). Similarly, interdisciplinary research on plastics has been burgeoning in the past few years (Belontz et al., 2019; Guron & Slentz, 2021; Kraftl et al., 2021; Seuront et al., 2022), and political science contributions have covered the various root causes and consequences of this shift in public policy including media coverage, evolving discourses and policy agendas (Clausen et al., 2022; Eckert, 2021; Palm et al., 2022). Scholars have documented the current enthusiasm and commitment of academics, businesses, nongovernmental organizations, and governments worldwide to engage with plastic pollution and circularity (Bailey, 2022; Leipold et al., 2022). Likewise, Barrowclough and Birkbeck (2022) proclaim a “new phase” of international policy discussions on plastic pollution, given the initiative of 100 governments in 2022 calling for a new global plastics agreement, with negotiations being underway.

Given this policy relevance, it comes as a surprise that in comparison to the overarching interest dedicated to the politics involved, we lack a systematic assessment of the actual policy outputs. Instead, existing social science research on the Circular Economy has focused on analyzing policy discourses and frames (Blomsma & Brennan, 2017; Calisto Friant et al., 2020; Eckert, 2021; Leipold, 2021). These studies engage with the process of formulating policy agendas and the politics behind them, but do not engage in a systematic analysis of the resulting policy outputs. The current body of research on plastic-related issues mirrors these limitations, predominantly concentrating on policy agendas or examining isolated policy measures. For example, Zaman and Newman (2021) discuss whether plastics are part of the zero-waste or toxic-waste agenda. Mah (2021) shows how corporations across the plastics value chain have joined forces to contain the Circular Economy policy agenda. Barrowclough and Birkbeck (2022) address the global governance of plastic pollution. While there are attempts to take stock of plastics regulation, these do typically not take into account the entire life cycle of plastics. Diana et al. (2022) started to create an inventory of the “global plastics policy landscape,” yet with a focus on plastic pollution. Furthermore, the inventory is characterized by an English-language bias, as made explicit by the authors. Similarly, Fitch-Roy et al. (2021) analyze Circular Economy regulatory policy packages in a sample of 60 countries, yet with a focus on waste management policies. In contrast to such comparative analysis, the bulk of existing research discusses case studies of specific legislation such as the EU Plastic Bags Directive 2015/720 (Nielsen et al., 2019; Steensgaard et al., 2017; Xanthos & Walker, 2017) or the EU Plastics Products Directive 2018/0172 (Charitou et al., 2021; Herberz et al., 2020).

In sum, there is a remaining gap regarding our understanding of plastics regulation from a comparative and longitudinal perspective. This article fills this lacuna by developing a novel policy portfolio approach to plastic regulation that allows us to systematically take stock of the policy targets addressed in regulation along the life cycle of plastics and the policy instruments used to that end. A comprehensive understanding of the policy outputs provided in this article is a

precondition to be able to assess the overall orientation of the policy framework, that is, its effectiveness and its deficiencies. We address the following research questions:

What are the policy targets addressed and the policy instruments used in plastics regulation?

To what extent do existing policy portfolios on plastics address the health and environmental problems posed throughout the life cycle of plastics?

To illustrate that our approach is a valuable tool to trace the evolution of policy portfolios over time, across policy targets and instruments, we provide an exploratory analysis of EU plastics regulation over the last twenty years, complementing this with Denmark, Germany, and Poland as diverse cases of member state regulation. By systematically analyzing policies on plastics at the EU and the member state level over two decades, we find that—despite an overall expansion of the policy portfolios—not all life cycle stages are equally addressed. Moreover, the analysis reveals that most measures fall into the realm of hierarchical governance, while market-based instruments such as taxes and levies are overall less applied.

Our analysis contributes to the interdisciplinary study of plastics regulation in at least three ways. First, we provide a conceptual framework that enables a systematic and comprehensive view of the policy measures taken. This framework will serve as a useful tool to compare plastics policies across jurisdictions and over time. Second, we make an empirical contribution by mapping and evaluating the policy output at both the EU and the member state level (Denmark, Germany, and Poland) from 2000 to 2021. Finally, in practical terms, our findings might stimulate a broader discussion on whether the EU and its member states are on the right track to meet their sustainability goals regarding plastics.

The paper is structured as follows: We first develop our conceptual framework that combines the life cycle logic with the policy portfolio approach and subsequently explain its operationalization. We then map and assess plastics regulation in the EU and in the selected member states and conclude by discussing our findings and their policy implications.

2 | A POLICY PORTFOLIO APPROACH TOWARD THE PLASTICS LIFE CYCLE

To be able to systematically take stock of plastics regulation in a comparative perspective, we need a conceptual approach that is able to capture the multiple policy targets across the life cycle of plastics, as well as the various policy instruments policymakers may choose to address the environmental and health issues involved. Moreover, we need an approach that is not specific to any jurisdiction but instead can easily travel to other political contexts. In short, we need to overcome the problems of the “traveling problem” and of “stretching” typically involved in concept formation and make sure there is functional equivalence in institutional terms in order to allow for valid and meaningful comparison (Sartori, 1970, pp. 1035–1036). Moreover, we are

including supranational as well as national settings, which allows us to assess whether in a multilevel governance setup such as the EU other political entities use the policy portfolio in different ways.

To meet these requirements, we use the established approach of policy portfolio analysis. According to Fernández-i-Marín et al. (2021), policy portfolios are composed of two dimensions: policy targets and policy instruments. Policy targets are all potential policy issues addressed by the regulator on a certain policy problem (*What is addressed?*). Policy targets represent the breadth of governmental involvement in a given area. The second dimension address all policy instruments that regulators have at their disposal to regulate the respective policy targets (*How it is addressed?*). Policy instruments thus capture the degree or depth of state intervention (Hinterleitner et al., 2023). The combined information on the policy targets covered, and the type and number of instruments used, allow us to examine *where and to what degree* policymakers intervene along the entire life cycle of plastics.

Previous research on policy portfolios has shown that countries can increase their policy effectiveness in environmental matters if they tailor specific policy instruments and instrument combinations to policy problems rather than reusing the ever-same policy instruments and instrument combinations (Fernández-i-Marín et al., 2021). Factors that support a higher policy design quality are low institutional constraints for policy-makers and a well-equipped bureaucracy (Fernández-i-Marín et al., 2021). While we frequently see trends of policy expansion and accumulation (Adam et al., 2018; Adam et al., 2019; Knill et al., 2012), there are also some instances of policy dismantling (Gravey & Jordan, 2020; Knill et al., 2020). A thorough, systematic analysis of policy outputs is the only way to accurately assess larger trends in regulation on a broader scale. This allows us to fully grasp policy changes and understand the evolution of regulation.

2.1 | Policy targets

The policy targets in our study are not derived from policymakers' own definitions of what constitute appropriate or desirable policy targets to address the problem of plastic environmental pollution and human health impact. Instead, we draw our policy targets from a comprehensive, conceptually-driven understanding of the plastic lifecycle informed by secondary literature. Grounded in recent research, our approach encompasses all stages of the plastic lifecycle (Moraga et al., 2019), thereby providing a holistic perspective on policy measures addressing the environmental and health impact of plastics. Several recent studies have defined policy-relevant stages of the material life cycle of plastics. Milios (2018), for instance, classifies life cycle policies under three such stages. These are production (including product design), use/consumption, and waste management (see Syberg et al., 2021 for a similar typology). Hartley et al. (2020) extend this classification to the four stages of production, product design, use phase and consumption, and end-of-life and waste. We contend that the material input phase should be regarded as separate from design or production from a life cycle policy perspective since the latter focus on final plastic products, and the former focuses on resource

extraction and primary polymer production. Moreover, as explained below, the problem pressure is particularly acute at the material input phase. Hence, we suggest differentiating between policy measures that address five stages of the lifecycle, namely material input, product design, production, consumption, as well as waste management and end-of-life (Figure 1, for the detailed coding scheme of policy targets see Table A1 in the Appendix).

The main sustainability objective for plastics at the (1) material input stage is to reduce the inputs of fossil-based feedstock. Existing research suggests that in view of the ever-growing amount of plastic production combined with low levels of recycling, the only viable path to depart from increased input of fossil-based feedstock would be one of de-growth, at least for the plastic industry, either through the substitution of plastics by alternative materials or an overall reduction of production (Bauer & Fontenit, 2021; Mah, 2021). Staying within the paradigm of plastics production, the two options of achieving reduced use of virgin materials are first, to produce more recycled plastic having virgin material properties, and second, to switch to the use of bio-based feedstock. Policy measures could thus seek to support change in this regard given that at present industry keeps producing fossil-based virgin plastics. The use of recyclates as a secondary material in plastic production, though viewed as pivotal for promoting circularity (OECD, 2022; Ellen MacArthur Foundation and UNEP, 2022), represents a mere 6% of the global production in 2019. Similarly, while considered to be conducive to circularity (Moshood et al., 2021; Rosenboom et al., 2022), the use of bio-based materials remains a rather theoretical option given the insignificant share of roughly around 1% in the markets (Maga et al., 2019). In the (2) product design phase, the main objective is to achieve products that incorporate recycled content and are themselves easily recyclable and reusable (Hopewell et al., 2009; Johansen et al., 2022). Moreover, product design requirements may drive the durability of products for longer-lasting lifespans (Barkhausen et al., 2022). In the context of (3) plastics production, the central aim is to reduce pollution and littering that negatively affects air, water, oceans, and soil (Meys et al., 2021). The use of harmful chemicals in plastics production is another concern both with regard to health and environment. Additives are used in the production of plastics to achieve certain product features such as durability (adding stabilizers) or flexibility and pliability (adding plasticizers). Yet, additives may leach out from the plastics, pollute the environment, and have severe impacts on human health (Koelmans et al., 2014; Lam et al., 2018). At the (4) consumption or use stage, the critical policy goal is to reduce fossil-based consumption and plastics consumption overall (Borg et al., 2022; Hartley et al., 2020; Nielsen et al., 2020). Single-use items constitute a major part of plastic consumption and production. It is estimated that about 42% of primary fossil-based plastics globally were used in packaging, and 54% of all plastics disposed were from single-use packaging (Geyer et al., 2017). Lastly, the primary goal of (5) waste and end-of-life management is to reduce the adverse impacts of plastic waste on the environment through improper waste treatment (including dumping) and to ensure the separation, recycling, and recovery of waste materials (Johansen et al., 2022). The most common method

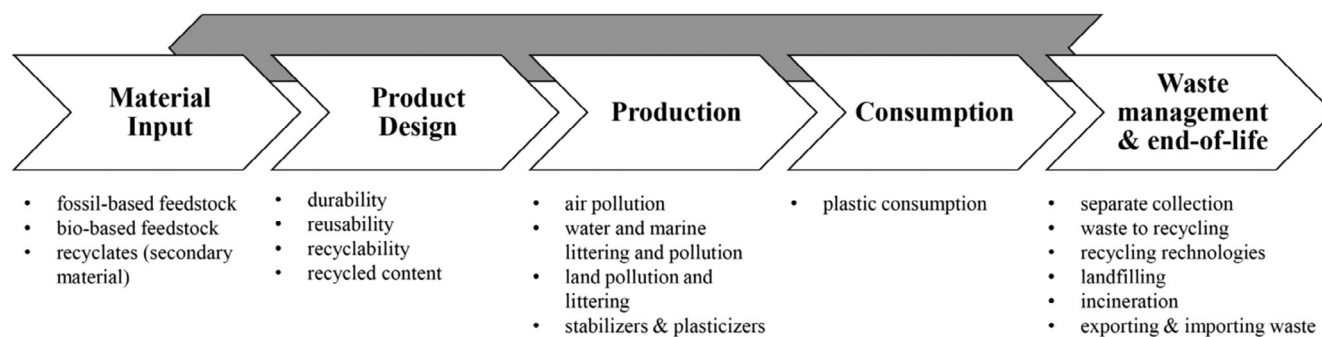


FIGURE 1 Policy targets throughout the life cycle of plastics. Source: Own illustration.

for the recycling of plastic waste is still mechanical recycling (Ragaert et al., 2017). Chemical recycling, in turn, is based on converting the plastic polymers into smaller molecules which can then be reformed into new molecules, such as plastics but also other chemicals (Vollmer et al., 2020). This type of recycling is suited for heterogeneous and contaminated plastic waste material (Ragaert et al., 2017; Vollmer et al., 2020), and thus would ideally complement mechanical recycling. The two technologies could also compete, however, where policy-makers would trust the option of chemical recycling and would refrain from introducing requirements at the product design stage aimed at improving the recyclability for the more sustainable and much better developed option of mechanical recycling (Hann & Connock, 2020; Manžuch et al., 2021). Composting or organic recycling captures the equivalent technique for biodegradable plastics. Regulation at the waste stage can help reducing the landfilling of plastic products or materials and provide a framework for the incineration and production of energy from plastics. Finally, waste export is an essential aspect of managing plastic waste as it can be a convenient “loophole” for countries producing excessive plastic waste (Barnes, 2019).

2.2 | Policy instruments

Our stocktaking of the instruments used in the policy portfolio is based on existing political science research, and research on environmental governance in particular. Policy targets can be addressed by a range of different tools. These policy instruments range from command-and-control regulations, and market-based instruments, to soft instruments such as information or negotiated agreements (Capano & Engeli, 2022; Holzinger et al., 2011). Importantly, we do not include negotiation-based or voluntary instruments (Mayer & Gereffi, 2010) as our focus in this study is on policy measures adopted in the public realm. Voluntary initiatives do indeed play an important role in the area of plastics, as discussed in previous research (Eckert, 2019; Héri-tier & Eckert, 2008).

We thus focus on three types of instruments. Command-and-control instruments involve a government issuing a “command,” which sets a performance of technological standard and then controls compliance by monitoring and requiring adherence to that standard

(Gunningham & Sinclair, 1999). Market-based instruments, by contrast, primarily work through setting positive (e.g., subsidies) or negative financial (e.g., tax/levy) incentives. Information-based policy instruments rest on the assumption that consumers or investors change their choice decisions when receiving additional information on a given product such as its environmental implications and externalities (Ölander & Thøgersen, 2014). Policy instruments and targets differ in consistency, coherence, and congruence (Howlett & Rayner, 2013). One challenge for an effective policy framework is whether the instruments are logically connected and mutually reinforcing or work against each other (Fernández-i-Marín et al., 2021; Gunningham & Sinclair, 1999). Some instrument combinations have been identified as inherently (in)compatible, while for other combinations it is not possible to predict a positive or negative outcome (Fernández-i-Marín et al., 2021; Gunningham & Sinclair, 1999; Yi & Feiock, 2012). Overall, all policy instruments (and combinations) have their specific strengths and weaknesses (Fernández-i-Marín et al., 2021; Strassheim, 2021; Weaver, 2014). Table 1 presents the policy instrument categories that we have included in our analysis (for the detailed coding scheme see Table A2).

3 | RESEARCH METHODOLOGY

In the previous section, we introduced a policy portfolio approach toward the plastics life cycle. In this section, we elaborate in more detail on how we have operationalized our conceptual approach. We provide essential additional information in the Appendix to this paper (see Tables A1 and A2), while full detail regarding the data collection and analysis is accessible through Data S1 (including Figures OA1–4, Tables OA1–3).

3.1 | Case selection and data collection

Examining plastics regulation in the EU context is important for several reasons. First, the European Union has been a global leader in environmental policy, setting ambitious sustainability goals and standards that often inspire and influence global practices, widely

TABLE 1 Policy instruments.

Command and control instruments	Market-based instruments	Information-based instruments
Obligatory outcome/performance standards	Tax/levy	Taxonomy of sustainable economic activity
Obligatory process standards	Subsidy/grant/tax reduction	Data collection, reporting, and disclosure
Technological standards	Public procurement	Compliance assistance
Prohibition/ban	Deposit scheme	Binding label
	Liability scheme	Nudges

Source: Own illustration.

discussed as the so-called “Brussels effect” (Bradford, 2020). Additionally, given the EU's significant plastic consumption and production (European Commission, 2018, p. 2), the policies enacted here can have substantial impact on the worldwide plastic lifecycle. Last, the EU's multilevel governance structure provides a unique context for analyzing how different levels of governance jointly contribute to tackle the sustainability issues posed by plastics. To that end, we also study the policy portfolio of three member states. Taking the recycling rate of plastic packaging across the EU as an indicator for problem pressure, we have chosen to include one country with a recycling rate above the EU-average (38% in 2020, reported by Eurostat), namely Germany (recycling rate close to 50%), and two countries with a recycling rate below EU-average, namely Poland ranging in the middle (with a rate close to 30%) and Denmark ranging at the lower end (with a range of around 10%). Moreover, the selection of these countries allows us to study cases with a diverging reputation in environmental policy: Germany and Denmark are typically considered as environmental leaders, whereas Poland has the reputation of an environmental laggard (for a nuanced and data-driven critical discussion of these attributions cf. Liefferink et al., 2009).

Changes in policy targets and policy instruments were assessed by scrutinizing relevant EU legislation between 2000 and 2021 and national legislation in 2021. We used *EUR-Lex* to detect and track all relevant legal acts as well as the changes and amendments made throughout the observation period. Since *EUR-LEX* does also list national implementing acts of EU directives it is further a valuable source for national legislation. In addition we consulted the official national repositories and additional sources where needed, namely: for Germany the *Bundesanzeiger* as well as the (private) legal database *buzer.de* to track changes in laws over time; for Denmark *Retsinformation*, the Danish national system for legal texts; for Poland the *Interntowy System Aktów Prawnych* (ISAP, Internet System of Legal Acts) of the Lower House of the Polish Parliament. ISAP provides access to the publications of *Dziennik Ustaw* und *Monitor Polski*, the official outlets of Polish law. The main keywords used to identify all potentially relevant text were plastic/s or plastic polymer/s. To identify legal text

pertaining to air pollution deriving from plastic, we searched air pollutants that are prevalent and highly associated with plastic production (dioxins in particular tetrachlorodibenzo-p-dioxin, furans, mercury, and polychlorinated biphenyls). Overall, we hand-coded 29 EU, 43 Danish, 17 German, and 15 Polish legal acts concerning the regulation of plastics (for further details see the listing of national legislation in Data S1, Table OA3). Additional checks of data reliability and completeness were carried out based on legal commentaries and secondary literature.

3.2 | Operationalization and coding

Our operationalization is guided by the primary purpose of this study, namely, to systematically map and assess the policy output along the life cycle of plastics. In essence, this implies that the policy targets and instruments considered should be abstract enough to classify and group different types of policy measures but, at the same time, concrete enough to (still) allow for meaningful interpretation. Table A1 in the Appendix lists in detail how we have coded the policy targets under scrutiny, assigning them to one of the five life cycle phases, and adding a brief description. Table A2 in the Appendix makes our coding of the instrument dimension transparent.

In addition to policy targets and instruments, we have added two more subdimensions. Existing instruments can become stricter due to changes in either the instruments' level or scope (Steinebach & Knill, 2017). The level refers to the exact calibration of the policy instrument. For instance, in the case of a green tax or levy, the *level* prescribes the exact amount of money to be paid. The instrument *scope*, in turn, covers specific cases addressed or targeted by a certain policy instrument, e.g., all plastic bags versus plastic bags sold by main retailers. By including level and scope in our illustration of policy changes, we take account of the fact that even when a given target instrument combination has been addressed, policy-makers still have plenty of room to increase their policy engagement. A detailed coding manual helped extract the relevant information (policy targets and instruments) from the legal documents in a systematic manner.

4 | THE POLICY PORTFOLIO ON PLASTICS AT EUROPEAN AND NATIONAL LEVEL

Rising plastics production and pollution is an urgent policy problem both globally and at the European level. Global production of plastics went up from 15 million tons produced in 1964 to 360 million tons produced in 2017 (PlasticsEurope, 2019; World Economic Forum, Ellen MacArthur Foundation, & McKinsey & Company, 2016, p. 25). The forecast for the share of global oil production going into plastics production amounts to 20% by 2050 in comparison to around 8% in 2016 (PlasticsEurope, 2019; World Economic Forum et al., 2016). In Europe plastics production amounted to 61.8 million tons in 2018, of which 29.1 million tons were collected, and 9.4 million tons were sent to recycling according



to industry reporting, which would amount to around 15% of total production (PlasticsEurope, 2019).

EU policymakers have been considering the environmental and health issues caused by plastics since the 1980s, first focusing on the special case of poly-vinyl-chloride (PVC), as well as on sensitive product groups such as plastic toys (Héritier & Eckert, 2008, pp. 203–204; Vogel, 2012). In this early phase policy measures were adopted with a varying focus on life cycle stages, materials and product applications, mostly at the waste phase and use phase. A comprehensive approach considering the entire plastics life cycle has become the predominant approach over the last decade when European policymakers started to embrace a Circular Economy agenda, with a plastics-specific strategy as a key component (European Commission, 2015b, 2018). Following up on a 2013 report on the environmental issues caused by plastics (European Commission, 2013), a first tangible measure targeting plastics was proposed in November 2013 and adopted in April 2015, namely a directive (2015/720) aimed at reducing the consumption of lightweight plastic carrier bags. The 2015 action plan for the Circular Economy “Closing the loop” (European Commission, 2015a) announced the adoption of a material-specific plastics strategy, issued in January 2018 (European Commission, 2018). The strategy announced some policy objectives to be achieved by 2030: all plastic packaging on the EU market should be either reusable or recyclable; more than half of plastic waste should go to recycling; separate collection of plastics should reach high levels; the consumption of single-use plastic items should be reduced. In June 2019, EU policymakers adopted the single-use plastics directive (EU 2019/904) that banned eight product categories, stipulated requirements in terms of binding recycled content, introduced collection targets, and established a scheme of extended producer responsibility (EPR) for a number of single-use products. Finally, the Commission issued an updated Circular Economy Action Plan in March 2020 (European Commission, 2020b) stressing the need for further action to address problems caused by microplastics, to facilitate the use of bioplastics, and to increase the uptake of recycled materials. A concrete policy measure following up on these objectives was the introduction of a tax on non-recycled plastic packaging as a new resource category [Article 2 of Council decision (EU, Euratom) 2020/2053].

Retracing this trajectory of policy formulation helps us to contextualize the patterns of concrete policy output—such as the aforementioned plastics bag directive, the single use plastics directive or the plastic tax—that we can identify based on our policy portfolio analysis. Our mapping of the EU's policy output on plastics from 2000 to 2021 as presented in Figure 2 further substantiates the evolution of plastic-related policy measures. The vertical dimension of Figure 2 indicates the policy instruments used. The policy instruments are “ordered” by the instrument type, including hierarchical forms of intervention, and market-based policy instruments alongside soft and information-based measures. The horizontal dimension, in turn, shows the policy targets covered. As discussed in the previous section, the policy targets follow a life cycle logic that covers the material input, product design, production, consumption, waste management, and end-of-life phase. The target instrument combinations are filled in different colors (gray scales) depending on the number of reform events

increasing the strictness of the respective policy instruments. Reform events that dismantle existing policy provisions were found to be very rare and can be neglected. In fact only two measures – Directive (EU) 2018/851 (European Parliament & Council of the European Union, 2018) and Commission regulation (EU) No 494/2011 (European Commission, 2011)—lowered the scope of existing policy measures creating derogations for some products and substances.

The first aspect that stands out when considering the portfolios presented in Figure 2 is the strong expansion of the overall policy measures taken. In 2000, the EU had only seven target-instrument-combinations in place. In 2021, this number grew to about 50. This implies a remarkable sevenfold increase in the size of the EU policy portfolio on plastics.

The policy target that is addressed through the largest number of different policy instruments (number of filled boxes) is waste to recycling (seven boxes), followed by recycled content (five boxes). The targets with the most reform events are (again) waste to recycling (27 in total), followed by the regulation of stabilizers (eight in total) and plasticizers (seven in total). As discussed above, this is indicated by the dark(er) coloring of the respective boxes. Regarding the types of instruments, we see an ongoing diversification of the instrument mix over time, i.e., a move from a focus on performance and process standards combined with reporting and disclosure requirements to a broader toolset that also includes some, but limited market-based initiatives.

Despite this strong expansion and diversification of the EU policy portfolio on plastics, some targets remain unaddressed. Figure 2 reveals that the EU has no binding policy provisions addressing the material input stage, i.e., addressing reduction in the input of fossil- or bio-based feedstock or the mandatory use of recyclates. Likewise, there are no regulatory measures in place prescribing or promoting the use of certain alternative technologies for waste management. This includes both the move from mechanical to chemical recycling as well as the increased use of industrial or home composting.

Upon a detailed examination of the implemented measures, it becomes evident that EU policymakers have not fully utilized the entire array of possible policy instruments. In 2000, mandatory command-and-control standards were primarily used alongside information-based instruments. These two types of instruments were employed to tackle issues related to the recyclability of product design and waste recycling. By 2010, liability schemes were introduced to further boost recycling efforts and reduce reliance on landfilling and incineration methods. Moreover, the scope of command-and-control standards was broadened beyond recycling to target areas closely related to human health issues, such as the use of additives (like plasticizers and stabilizers) and the control of air pollution. Mandatory standards were also employed to address all aspects of the lifecycle design phase, with the exception of durability.

By 2021, the implementation of prohibitions and bans had become widespread, targeting diverse areas such as reducing consumption and addressing terrestrial and marine pollution. The adoption of classification systems had also gained popularity, proving to be versatile tools addressing various targets across all lifecycle stages, barring material input. Taxes were introduced to regulate

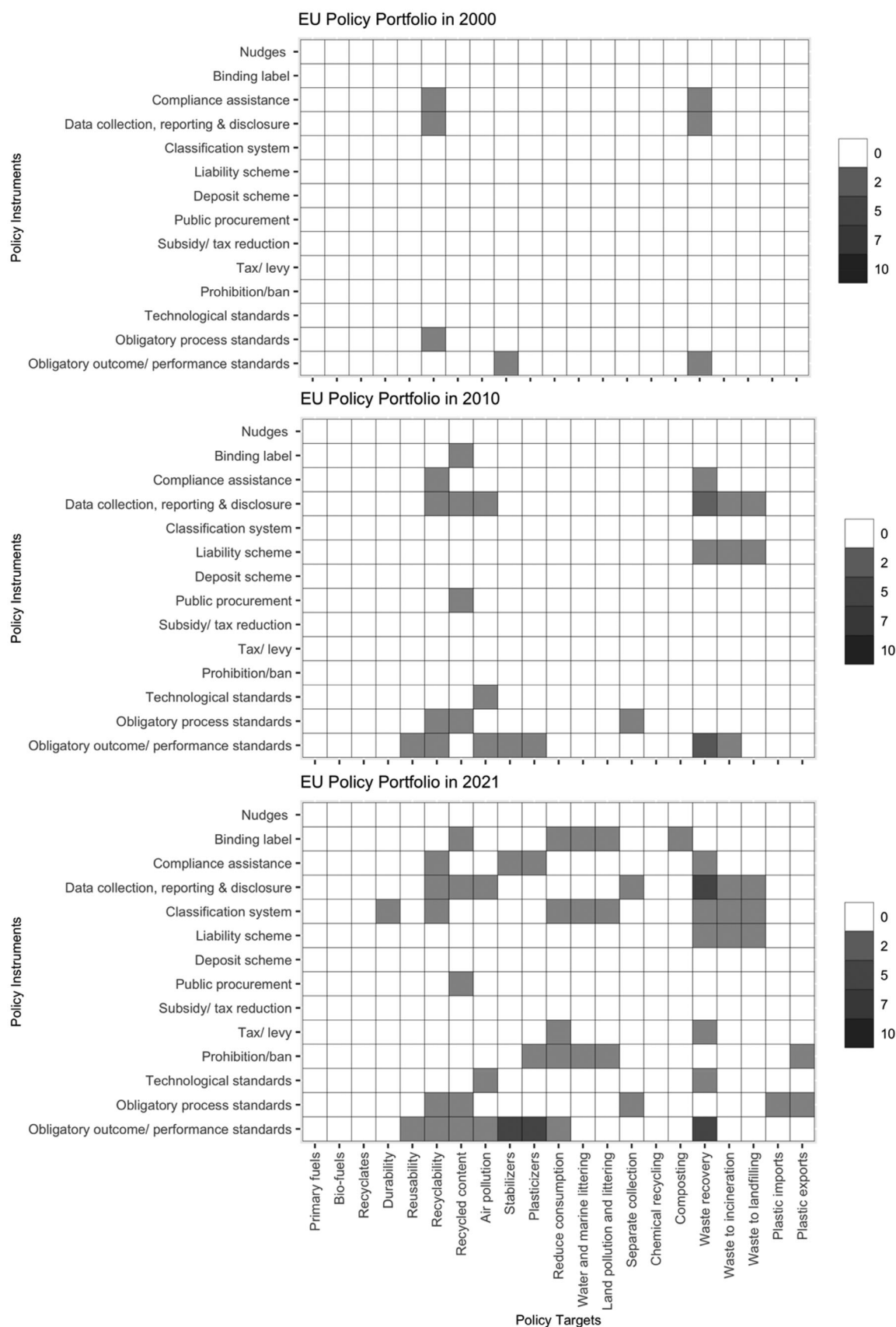


FIGURE 2 Policy output on plastics in the EU (2000–2021). Gray boxes indicate that a given policy target-instrument-combination is addressed. The gray scales indicate the number of policy reform events increasing the “strictness” of the policy instrument used.

consumption and promote recycling. However, in general, the utilization of market-based instruments remained limited, with tools like subsidies, public procurement, and deposit schemes remaining noticeably underused. Exceptions include the 2004 public procurement requirements for the construction sectors (Directive 2004/17/EC, European Parliament & Council of the European Union, 2004); the charges on plastic carrier bags introduced in 2015 (Directive 2015/720, European Parliament & Council of the European Union, 2015); and the 2020 budget reform requiring all member states to pay a uniform call rate for the amount of non-recycled plastic packaging waste as part of their national contribution to the EU (Council Decision 2020/2053, Council of the European Union, 2020).

As of the end of 2021, four key targets have seen a significant diversification in the types of policy instruments used. Addressing recycling at the waste management stage has remained, since 2000, the most commonly targeted aspect, both in terms of the number and the variety of instruments used. Additionally, the goal of reducing consumption has been tackled comprehensively using a diverse range of instruments, including command-and-control, informational, and market-based tools. This target has received increased focus over the past decade, especially in recent years, as it was essentially unaddressed before this period. Furthermore, two targets related to the design phase—incorporating recycled content and ensuring recyclability—have also drawn regulatory attention, although with a lesser degree of instrument diversification, and virtually no employment of market instruments that would have left industry with more flexibility. Policymakers have thus given preference to hierarchical regulation in their effort to bring about change in industrial production processes.

The question that arises from this analysis of supranational regulation is whether or not national regulation is complementary by addressing areas where EU policymakers have not been active. It is a key feature of the so-called EU regulatory state that the policy options at supranational level are limited to regulatory intervention given that member states' governments intentionally restricted the abilities of supranational institutions to adopt policies with strong budgetary or re-distributive implications (Majone, 1994). We could, therefore, expect that the instrument choice at national level diverges significantly from EU plastics regulation. Our comparison of the diverse cases of Denmark, Germany, and Poland shows that this is not the case. Considering the existing portfolio for 2021 (Figure 3, for the longitudinal data 2000–2020 see Figures OA2–OA4 in Data S1) the first aspect that stands out in all three countries is that their portfolios are smaller than those observed for the EU. At first sight, this is surprising given that the policy portfolio in the member states should actually combine the EU and the domestic policy output. The reason for this discrepancy is rather simple: While EU directives need to be transposed into national law, EU regulations are directly applicable in all member states (for further discussion see Hurka & Steinebach, 2021). In other words: national legal documents provide information on domestic policy measures and policies introduced by transposed EU directives, yet they do not carry policy outputs induced by EU Regulations. In the context of our analysis, however, this is not relevant as we only want to learn whether national regulation is more encompassing or sets different priorities in comparison to EU regulation.

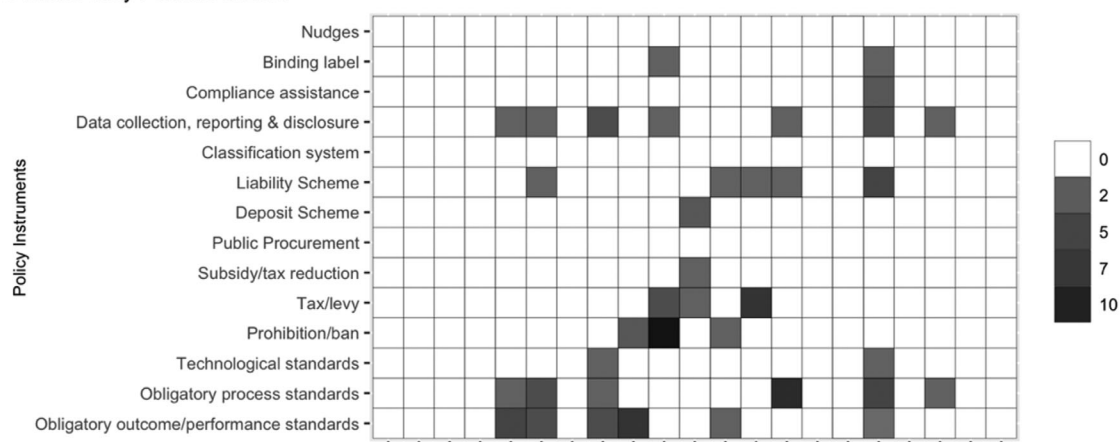
Our comparative analysis of policy output in these three countries shows that the degree to which national regulation complements and fills the gaps left by supranational regulation proves rather limited, especially when it comes to policy targets. Overall, we can detect similar features of the policy portfolio for the national and the supranational level. At member state level, there are no policies seeking to reduce levels of production, addressing the material input stage or policy measures promoting the use of alternative recycling technologies. There are, however, also some instances where national regulation addresses policy targets that had been left unaddressed by EU policymakers. This holds for policy measures introduced in 2012 by the German government in order to target the utilization of recyclates. A liability scheme known as “product stewardship” was introduced stipulating that companies introducing plastics into the market must prioritize the use of recyclable waste or secondary raw materials in the manufacturing of products. National regulation also adds some limited variation to the arsenal of policy instruments in use. Both Germany and Denmark have used market-based instruments to boost recycling. Already in 2003, Germany has introduced a deposit scheme on plastic bottles targeting the consumption of both single-use and reusable beverage containers. Denmark has implemented a similar system, but going a step further. In addition to promoting recycling through deposit schemes, the Danish government has encouraged the distribution of deposit machines through financial incentives and subsidies provided to operators. In contrast to the proactive approaches in Germany and Denmark, Poland has essentially aligned its policies with the broader EU framework, with no significant additions at the national level.

5 | DISCUSSION AND POLICY IMPLICATIONS

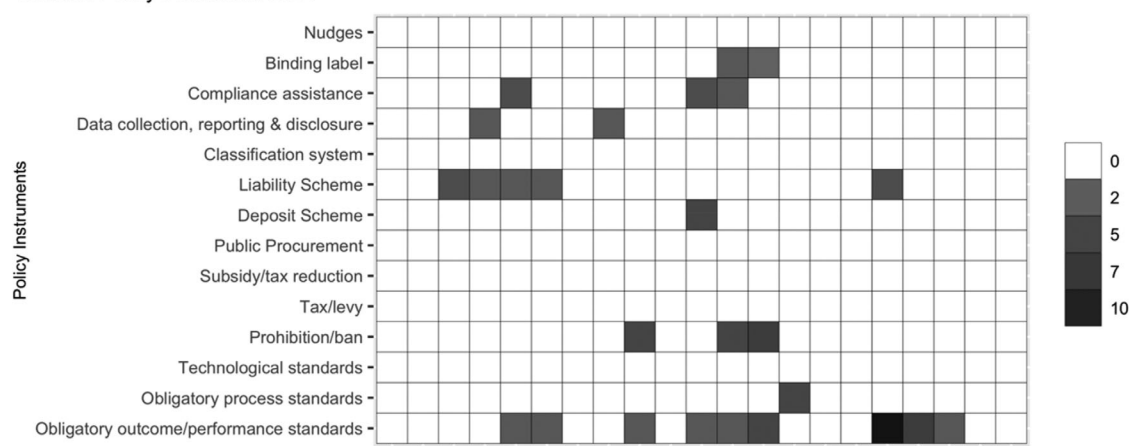
The mapping of the policy output on plastics conducted in this article reveals important patterns that have substantial policy implications. Our longitudinal analysis of EU plastics regulation shows an expansion of policy output that—at least in quantity and number—cannot merely result from a simple rebranding of pre-existing measures (Fitch-Roy et al., 2020). At least in terms of the degree of regulatory activity targeting plastics—leaving aside the aspect of actual ambition—it is therefore inadequate to consider that the EU's policy approach toward the Circular Economy has resulted in a process of deregulation (Leipold, 2021). Rather, the growth in output diverges from the overall pattern of environmental policy where dynamics of stagnation and partial dismantling have been identified over the last decade (Burns et al., 2020).

Aside from the general growth in policy output, however, we find that policy activities target the life cycle of plastics very unevenly both at supranational and national level. While a significant number of measures focus on downstream activities (Potting et al., 2017) and the end-of-life phase, there is no or only limited regulatory activity at the material input stage. The liability scheme introduced by Germany to promote the use of recyclates constitutes a notable exception in this regard. As in other jurisdictions, policy-makers in the EU and its

Danish Policy Portfolio in 2021



German Policy Portfolio in 2021



Polish Policy Portfolio in 2021

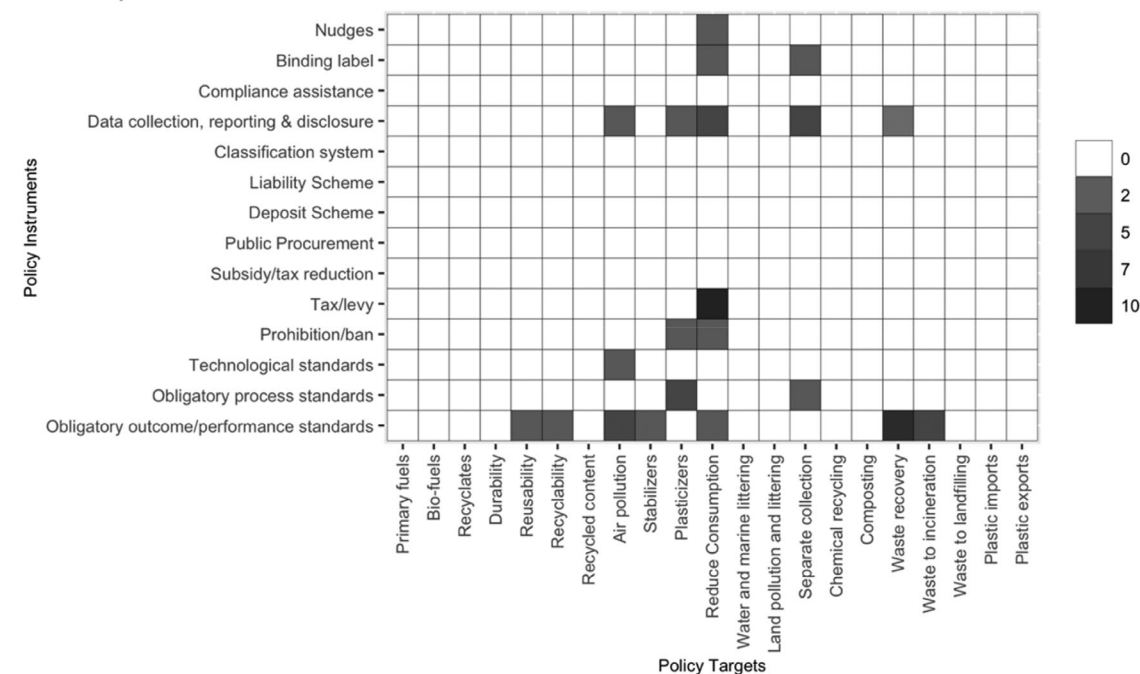


FIGURE 3 Policy output on plastics in Denmark, Germany and Poland (2021). Gray boxes indicate that a given policy target-instrument-combination is addressed. The gray scales indicate the number of policy reform events increasing the “strictness” of the policy instrument used.

member states have prioritized the “waste to recycling” target (Calisto Friant et al., 2021; Potting et al., 2017), yet without prescribing the use of specific technologies such as chemical versus mechanical recycling. This uneven level of policy activity to a certain extent mirrors current technological and business challenges in the plastics sector. Imposing, for instance, stricter requirements demanding the substitution of primary fossil fuels with recyclates would generate re-design and re-production costs and pose technological challenges for the recycling industry to improve the quality of their material outputs. Likewise, the introduction of binding provisions concerning feedstock alternatives could potentially only prescribe quite low shares of total production given the insignificant share of bio-based materials in the markets (Maga et al., 2019). Adopting a more critical viewpoint, it could also be argued that the potential of environmental regulation to drive innovation is being left underexplored. We can thus conclude that in terms of policy targets EU and national plastics regulation cements the status-quo rather than triggering transformative change. This overall finding is well in line with previous assessment of the Circular Economy agenda (Bauer & Fontenit, 2021; Eckert, 2021; Fitch-Roy et al., 2020; Leipold, 2021; Mah, 2021; Simoens & Leipold, 2021). If the EU really wants to “give back to the planet more than it takes” and “advance towards keeping its resource consumption within planetary boundaries” (European Commission, 2020a, p. 4), it must reduce the overall consumption of primary fossil-based materials. Our stocktaking shows that EU and national plastics regulation leave the respective policy targets blank and thus the underlying issues unresolved.

Another finding that has sizable policy implications is the uneven use of the policy toolbox by the EU and in the three countries studied. The plastics agenda is mostly implemented by hierarchical policy instruments, while national regulation adds some variation through the use of economic instruments. We have to make this assessment with the caveat that our empirical analysis on the instrument dimension has not included the use of self-regulation although voluntary instruments play a pivotal role in the plastics sector and have also been advocated as part of the EU's plastics strategy (Eckert, 2019; European Commission, 2018, p. 7; Mah, 2021). The study of industry agreements both at EU and national level thus merits further research. Overall, however, we find it fair to argue that regulation on plastics does not diverge from the governance patterns identified in previous research on EU environmental policy (Holzinger et al., 2006). If we assume that a balanced instrument mix including market- and information-based instruments can boost the effectiveness of a policy framework, this potential remains unfulfilled.

6 | CONCLUSIONS

In this article, we provided a comprehensive assessment of the policy measures adopted at the EU level and in Denmark, Germany, and Poland to tackle the sustainability issues of plastics. To do so, we have developed and applied a conceptual framework that integrates insights from life cycle thinking into a policy portfolio approach.

Our empirical findings show that especially the upstream stage of material inputs is mostly being left unaddressed by policy action. This

is in line with prior assessment of policy measures across the life cycle stages (Milios, 2018, p. 867). Instead, mandatory EU legislation is highly concentrated at the end of the life cycle (Milios, 2018). Likewise, Hartley et al. (2020, p. 3) see a potential policy lever toward circularity in encouraging producers to embrace circularity design principles by establishing design standards and norms. Besides the material input stage, there are no designated instruments to promote innovations in recycling technologies, especially concerning the use of chemical recycling. However, our findings show that the EU does not rely on binding regulation in this area. Rather, policymakers privilege voluntary industry action, as a report on Circular Economy business models illustrates (De Smet et al., 2019). This report identified the need to invest in new “high-risk, disruptive innovations,” including chemical recycling (p. 10). The transformative potential of chemical recycling, which industry seeks to develop and expand for several decades already, is not undisputed given the stagnating role of this technology at a rather low level (Eckert, 2023, p. 239; Mah, 2021, p. 137). Similarly, our finding that market-based instruments are vastly underutilized might not actually be problematic. Indeed, existing research has shown that market-based instruments have done little to curb plastic pollution (Dauvergne, 2018; Nielsen et al., 2020). Also, market-based instruments and voluntary agreements might not be sufficient to move away from single-use products and the use of virgin plastics. Instead, Syberg et al. (2021) see a “great need” for more regulation to facilitate a transition toward circularity. As we show in our analysis, such binding regulation does, however, not address all policy targets of the plastic lifecycle equally and sufficiently.

We have developed a comprehensive foundation to expand scholars' efforts to monitor and assess policy responses to the plastic crisis. Future research might take our approach and apply it to other jurisdictions, both within and beyond Europe. This way, we might be in a position to explain differences in (national) plastics policies by exploiting cross-country and -temporal variation and link these differences in policy outputs to varying levels of policy outcomes such as the reduction in plastics use or recycling rates.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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APPENDIX A

TABLE A1 List of CE policy targets.

CE phases	Policy targets	Description
Material input	Fossil-based feedstock	Reducing reliance on fossil-based feedstock in production.
	Bio-based feedstock	Promoting alternatives to fossil-based feedstocks such as biofuels or other materials.
	Recyclates (secondary material)	Substitution of virgin fossil-based feedstock by recyclates as a secondary plastic materials.
Product design	Durability	Products designed to support durability and robustness to decrease waste and pollution.
	Reusability	Products designed to facilitate reuse as is or with slight remanufacturing.
	Recyclability	Products designed to facilitate recycling of product materials into secondary materials.
	Recycled content	Products designed to incorporate recycled materials.
Production	Air pollution	Reducing the indicative air pollutants (dioxins, tetrachlorodibenzo-p-dioxin, furans, mercury, and polychlorinated biphenyls) from plastic manufacturing and incineration recycling operations.
	Water and marine littering and pollution	Minimizing water and marine littering and pollution from both solid plastics and microplastics.
	Land pollution and littering	Minimizing land pollution and littering from both solid plastics and microplastics.
	Stabilizers	Reducing the use of chemical additives to stabilize plastic in the production process that have been found to be harmful to human health including lead-based, cadmium-based substances.
	Plasticizers	Reducing the use of chemical additives to stabilize plastic in the production process that have been found to be harmful to human health such as phthalates (DEHP or BPA).
Consumption	Plastic consumption	Reducing the consumption of plastics, especially single-use plastics as well as non-recyclable plastics.
Waste management and end-of-life	Separate collection	Promoting separate collection of different material wastes specifically plastic to allow for better waste management.
	Waste to recycling	Ensure that plastic waste is not simply thrown away but feed into the recycling process.
	Alternatives in recycling technologies (from mechanical to chemical recycling)	Promoting alternative recycling technologies (from mechanical to chemical recycling).
	Alternatives in recycling technologies (industrial or home composting)	Promoting alternative recycling technologies (intensifying the use of industrial or home composting).
	Landfilling	Reducing the landfilling of plastic products or materials.
	Incineration	Regulating the incineration and the production of energy from plastic products or materials.
	Exporting waste	Restricting the exporting of waste as a waste management method.
	Importing waste	Restricting the importing of waste as a waste management method.

TABLE A2 List of CE policy instruments.

Instrument	Description
Command and control instruments	
Obligatory outcome/ performance standards	A legally enforceable numerical or quality standard
Obligatory process standards	A measure prescribing the use of a certain process when handling certain materials
Technological standards	A measure prescribing the use of a specific technique or technology
Prohibition/ban	Total or partial prohibition/ban on certain activities, emissions, and products
Market-based instruments	
Tax/levy	A tax or levy for a certain levy on a certain product or activity
Subsidy/grant/tax reduction	A measure by which the state grants a financial advantage to a certain product or activity
Public procurement	Preferential treatment of certain products or activities in public procurement procedures
Deposit scheme	A measure prescribing the establishment of a deposit (refund) scheme
Liability scheme	A measure that allocates the costs of environmental damage to those who have caused the damage (including extended producer responsibility)
Information-based instruments	
Taxonomy of sustainable economic activity	A measure that classifies an economic activity as environmentally sustainable economic activity
Data collection, reporting, and disclosure	Specific programme for collecting data
Compliance assistance	Information and advice provided by public authorities on how to reduce plastic waste, etc.
Binding label	Prescription of a clear and simple indication of the quality/content/externalities of a given product
Nudges	Prescription of certain choice architecture or educational measures affecting plastics consumption