Improving Resource Efficency to Combat Marine Plastic Litter

Issue Brief

Prepared by the OECD as input for the 2019 G20 Ministerial Meeting on Energy Transitions and Global Environment for Sustainable Growth

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1. Introduction

1.1. Persistent growth in resource use is creating widespread environmental damage: marine plastics litter is a prominent example

1. Recent decades have seen unprecedented growth in demand for natural resources and the materials derived from them. Around 80 billion tonnes of minerals, fossil fuels, and biomass were fed into the global economy in 2015 and, in the absence of policy action, this will increase with ongoing population growth and improving standards of living. Modelling undertaken by the OECD suggests that resource use will more than double by 2060 under business as usual.[1]

2. The extraction, use, and disposal of natural resources at these scales is creating significant environmental pressure, with serious consequences for ecosystem health, economic growth, and human well-being. Biodiversity loss and climate change are perhaps the two most high-profile examples. However, nowhere are the damages associated with rapidly growing material use more visible than in the case of plastics pollution, which is now ubiquitous across much of the Earth's surface. Plastic is present in all the world's ocean basins, including around remote islands, the poles and in the deep seas, and an additional 5 to 13 million tonnes are estimated to be introduced every year to the oceans.[2] This material will only decompose over the course of hundreds, if not thousands, of years.

3. Improved resource efficiency offers a solution to many of these issues. By using natural resource inputs more efficiently, by slowing the rate at which they pass through the economy, and by recovering a greater share of them at the end of life, economic activity could be decoupled from the use of natural resources, and the associated environmental damages. This realisation, coupled with the potential economic opportunities that are linked to improved resource efficiency,[3] has led to growing international policy attention. In the G7 context, the G7 Alliance on Resource Efficiency was established at Schloss Elmau in 2015, and has been built upon by the adoption of the Toyama Framework on Material Cycles in 2016,[4] and the Bologna Roadmap in 2017. At the Leaders' Summit in Hamburg, G20 governments established the ongoing G20 Resource Efficiency Dialogue to exchange views and experiences on policy options and good practice examples for resource efficiency.

1.2. Improving resource efficiency throughout the plastics value chain could help to address marine plastics litter

4. Growing concern about the adverse environmental impacts of marine plastics litter have led to a number of high-profile multilateral initiatives. The issue was included in the G7 agenda in 2015 in the form of the G7 Action Plan to Reduce Marine Litter, and has remained in the spotlight during subsequent G7 presidencies.[5] Marine plastics were introduced to the G20 in 2017 with the adoption of the G20 Action Plan on Marine Litter, which outlines a set of seven high level principles that could help to address the issue (Box 1. G20 Action Plan on Marine LitterBox 1). These frameworks form part of a broader policy landscape that includes evolving legislation on the use of single-use plastics at the national level as well as a number of private sector initiatives.[6] [7]

Box 1. G20 Action Plan on Marine Litter

The G20 Action Plan on Marine Litter includes seven high level policy principles:

i) Promote the socio-economic benefits of establishing policies to prevent marine litter.

ii) Promote waste prevention and resource efficiency.

iii) Promote sustainable waste management.

iv) Promote effective waste water treatment and storm water management.

v) Raise awareness, promote education and research.

vi) Support removal and remediation activity.

vii) Strengthen the engagement of stakeholders.

5. Despite their negative aspects, plastics generate a set of important benefits for society and the environment. Among other things, they are used to package food, helping to reduce food waste; to manufacture lighter and more fuel-efficient vehicles, helping to reduce greenhouse gas emissions; and to substitute for materials derived from biomass (e.g. wood, paper, cotton), helping to slow land-cover change and biodiversity loss. The challenge facing policy makers is therefore to decouple the beneficial aspects of plastics from the undesirable side effects that are associated with their production, consumption and end of life.

6. Improving resource efficiency throughout the plastics lifecycle offers a promising way forward. By limiting the use of plastics to applications where there are few environmentally preferable alternatives, by ensuring that the plastics that are produced remain in use for as long as possible, and by recovering a greater share of plastics at their end of life, the leakage of plastics into the oceans could be greatly reduced. Improved resource efficiency and the development of sound waste management systems are both key elements of the G20 Action Plan on Marine Litter. The question is what combination of these and other approaches is needed, and what policy measures are required to operationalise them in practice.

7. This brief represents a proposal for how to translate the high level principles in the G20 Action Plan on Marine Litter into a set of concrete actions and commitments that could be implemented at the national level. It has three main parts. The first summarises current patterns of plastics production, consumption, and waste generation, as well as what is known about the ecosystem and human health impacts of plastics once in the ocean. The second outlines the options available to slow the leakage of plastics into the oceans, and touches on their respective strengths and weaknesses. Investment in improved waste collection and recycling systems is identified as a critical element in any long-lasting and effective solution. Trade is touched upon in this context as restrictions on the import of plastics waste to China and several other countries[8] have highlighted pre-existing weaknesses in domestic waste management systems. The final part of this brief diagnoses the key reasons for

underinvestment in waste management infrastructure, and outlines what governments of G20 countries could do to address the problem.

2. The plastics lifecycle: from production and use to disposal and ocean pollution

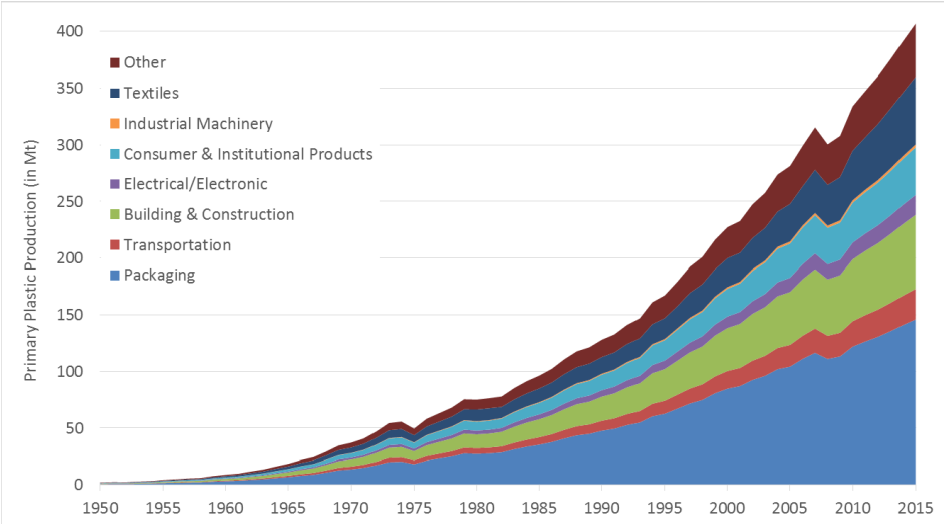
2.1. Plastics production is increasing rapidly

8. Plastics are one of the most commonplace materials on the planet. In 2015, global plastics production reached 407 million tonnes per annum (Mtpa) (Figure 1), making it more than the production of paper (400 Mtpa), fish (200 Mtpa), and aluminium (57 Mtpa).[9] [10] [11] If production continues to grow at similar rates, plastics production is expected to reach 1 600 Mtpa in 2050.[12] [13]

The physical location where plastics production takes place is also important. Policy measures targeting plastics design are often emphasised as a key part of the solution to marine plastics litter, but the ease with which these can be implemented will vary across G20 countries. At present, the main regional producers of primary plastics are the Peoples Republic of China, Europe, and North America (

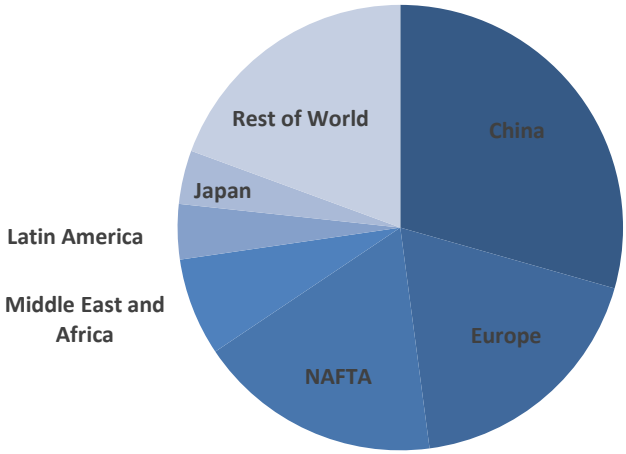
9. Figure 2). Reliable cross-country data on plastics production are sparse. Data compiled by VDMA indicates that the United States and Canada represent 83% and 9% of total NAFTA production, and Germany, France, Italy, and the United Kingdom represent 26%, 15%, 7%, and 5% of total European production. Taken together, these data suggest that greater than 70% of global plastics production takes place in G20 countries.[14]

Figure 1. Global plastics production: 1950 to 2015



Source: Geyer, Jambeck and Law, 2017

Figure 2. Global plastics production by region in 2018



Note: Data relates to resins and does not include PET or polyamide and acrylic fibres.
Source: Plastics Europe, 2018[15]

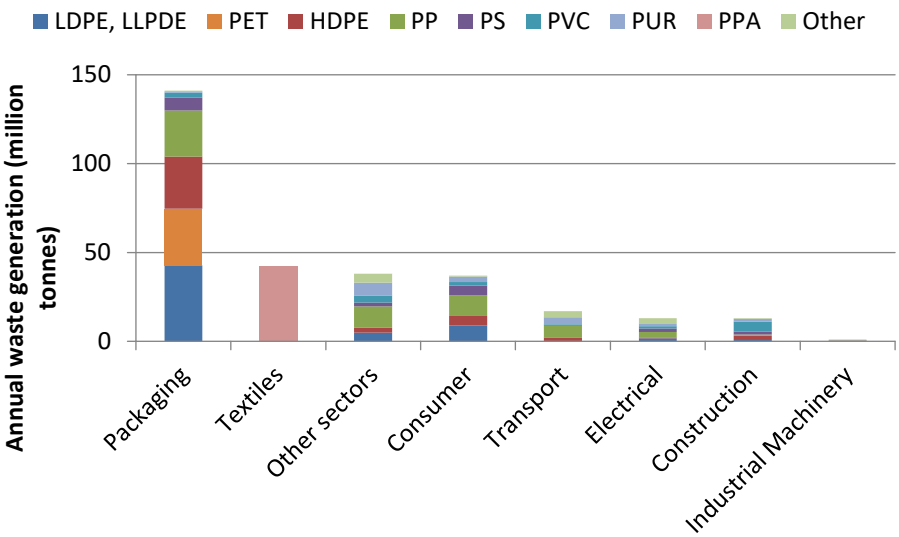
2.2. Plastic use is diverse

10. At least eight major polymer types are widely used,[16] and a range of chemical additives are introduced at the manufacturing stage in order to improve polymer performance.

The versatility of plastics has led to their use in almost all major product categories (

Figure 3). Plastics packaging is the largest application by weight, but plastics are also used widely in the textile, consumer goods, transport, and construction sectors. Some polymers of plastic are used primarily in a single application (e.g. polyethylene in packaging), while others are used more widely (e.g. polypropylene). This distinction also has implications for end-of-life plastics management: developing effective sorting and recycling technologies is likely to be simpler for polymers used in large volumes in a narrow range of applications.

Figure 3. Global plastics use by polymer and sector



Note: The polymer breakdown for each product category has been translated on a proportional basis from 2015 production data. Polyester, polyamide, and acrylic (PPA) fibres are assigned exclusively to the textiles sector following Geyer, Jambeck, and Law (2017).
Source: Geyer, Jambeck, and Law, 2017

2.3. Plastics waste generation is increasing and so is the amount of mismanaged plastic waste

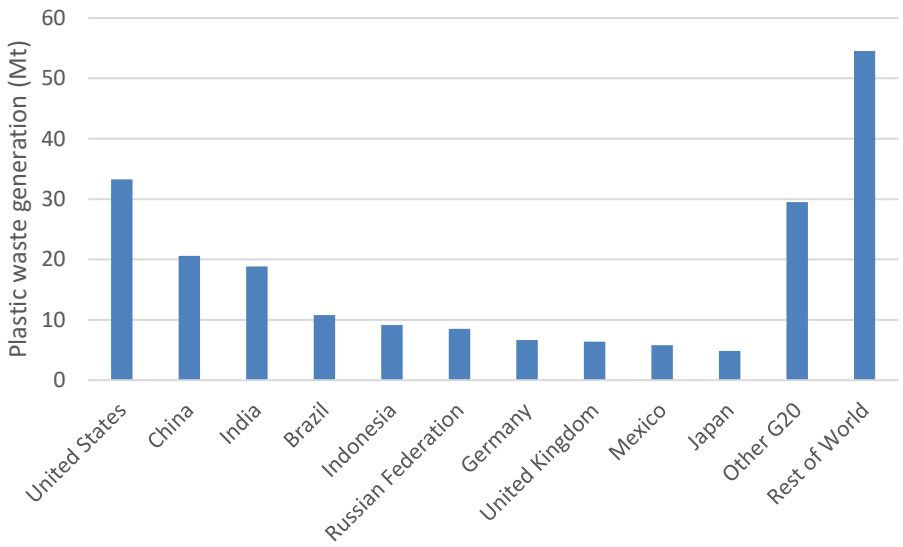
11. Global plastics waste generation continues to increase in response to both economic growth and the use of plastics in a wider number of applications.[17] Around 300 Mt of plastics waste was generated in 2015,[18] and modelling undertaken by the same authors suggests that 25 000 Mt of plastic waste will have been produced by 2050 under business as usual.

12. Although data are scarce, it appears that the majority of annual plastics waste generation originates from short-lived applications that become waste relatively quickly (e.g. plastics packaging or textiles). Primary microplastics – those that are either intentionally manufactured or that originate from product wear and tear during the use phase – are of particular concern given how easily they are ingested and how difficult they are to clean up.

They are thought to account for 1.8 – 5.2 Mt of plastics waste, or around 1% of total plastics waste.[19]

13. At the national level, per-capita waste generation is roughly proportional to per-capita economic activity: countries with higher levels of consumption tend to generate relatively large volumes of waste.[20] [21] A similar relationship exists for plastics waste. Per-capita plastics waste generation in G20 countries varies between around 100 kilograms per year in the United States and United Kingdom to around 15 kilograms per year in China, India, and Turkey.[22] [23] In absolute terms, G20 countries currently account for around 75% of the plastic waste contained in municipal solid waste (Figure 4). The United States generates the largest volume of plastic waste each year, followed closely by a group of middle-income countries: China, India, Brazil, and Indonesia.

Figure 4. Plastic waste generation in municipal solid waste in G20 countries

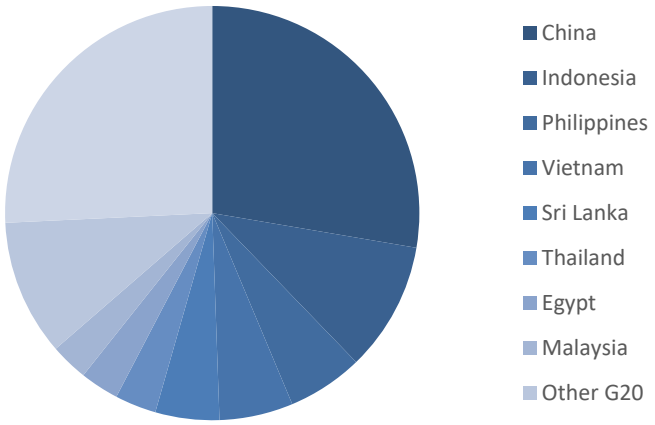


Note: Data presented in this figure are approximations only. Plastics waste generation is derived from data on total waste generation and estimates of the proportion of this waste that is plastic. Data for India is extrapolated from countries with a similar level of national income.
Source: World Bank, 2018

14. Once generated, plastics waste is either collected through (formal or informal) waste management systems, or leaks into the natural environment. Modelling undertaken by Jambeck et al. suggest that around 10% of global plastics waste generation (or 30 Mt) was mismanaged in 2010 (

15. Figure 5).[24] [25] G20 countries are thought to account for around 50% of this mismanaged material, with a small group of low- and middle-income countries accounting for another 25%. This highlights the importance of improving waste collection services in these countries.

Figure 5. Mismanaged plastics waste by country in 2010



Source: Jambeck et al., 2015

2.4. Plastics reach oceans through different pathways and generate a range of impacts

16. Jambeck et al. estimate that 5 – 13 Mt of plastics waste enters the ocean each year.[26] Microplastics are thought to account for 8 – 30% of this.[27] The leakage of plastics into the oceans takes place along a variety of pathways, although the relative importance of each remains unclear.[28] For most macroplastics, the dominant route is probably via streams and rivers: mismanaged plastics waste is washed into watercourses during heavy rainfall and subsequently transported downstream. Macroplastics may also enter the ocean more directly, either through beach litter or the loss of plastic fishing equipment further offshore. Microplastics from cosmetic products, pellet spills, and the deterioration of textiles and vehicle tyres tend to enter the ocean via other pathways, such as municipal waste water networks.[29]

17. Once in the ocean, plastics have a number of adverse impacts. Marine wildlife is harmed through ingestion of plastics or entanglement, with negative implications for ecosystem health and the overall sustainability of fisheries. Ingestion of plastics, or entanglement in them, has been documented in around 500 species of marine mammals, fish, and seabirds, with negative consequences for marine ecosystems, coastal tourism and the fishing industry.[30] Taken together, the economic cost of these impacts has been estimated at USD 13 billion per year.[31]

18. Plastics pollution also poses risks for human health. The presence of plastic in fish and shellfish, and their subsequent consumption by the public has led to concerns about chemical bio-accumulation in the food chain, even if empirical evidence for this is currently limited.[32] [33] [34] Plastics are also entering the food chain more directly. Microplastic contamination has been reported in tap and bottled water,[35] [36]sea salts,[37] beer,[38] and honey.[39]

19. Marine plastics pollution warrants considerable attention for two additional reasons. The first relates to the longevity of plastics: those that accumulate in the natural environment will only decompose over hundreds, or even thousands of years, during which time they fragment into microplastics. The second relates to uncertainty about the magnitude of the damages. Significant quantities of plastic have only been introduced into the natural environment relatively recently. While the full impact on marine and terrestrial ecosystems will only emerge in the longer term, some environmental effects of plastics pollution are already clearly visible.

3. Various options are available to address marine plastics litter

20. As highlighted in the G20 Action Plan on Marine Litter, the leakage of plastics litter into the oceans can be addressed in a variety of ways throughout the plastics lifecycle:

- **Source reduction**, such as through the selection of alternative materials in the place of plastics at the design stage, can reduce the production and use of plastics in the first instance.
- **Waste prevention strategies**, either through the more widespread use of reusable plastic products, or through product "light-weighting",[40] serve to slow the generation of plastics waste, its leakage into waterways, and ultimately, into the oceans. The

development of biodegradable or de-toxified plastics may help to reduce the environmental impact of the plastic waste that is generated.

- **Better waste management systems**, by facilitating higher waste collection and recycling rates, allow plastics waste to be captured before it begins impacting the natural environment.
- **Clean-up and remediation activities**, such as beach clean ups and technology to collect plastics from oceans, would allow the removal of plastics already in the natural environment.

21. Effectively addressing marine plastics litter will require a combination of these approaches to be applied, even if there are risks associated with each. The use of alternative materials in the place of plastics can reduce the use of plastics, but may lead to shifts in the environmental burden (for instance when plastic is replaced by paper there is a bigger impact on land use). Substituting away from plastics may also negate the use-phase energy savings (in transport for example) that plastics can bring in the first place. Waste prevention is a widely accepted means of reducing plastics pollution, but is only feasible for a limited subset of plastics applications. Shifting to bio-based or biodegradable plastics may also have unintended consequences. In particular, enhanced biodegradability can increase the dispersion of microplastic fragments in the environment if degradation is incomplete.[41] Finally, clean-up and remediation activities are a potentially important way of addressing the legacy plastics that are already in the ocean. These activities vary in scale, ranging from community-led beach litter collections, to larger budget ocean cleaning systems such as that launched recently by The Ocean Cleanup project.[42] Clean-up activities hold considerable promise, even if their cost effectiveness and applicability to certain types of plastics (e.g. microplastics) are yet to be demonstrated.

22. Higher waste collection and recycling rates are not without risks,[43] but have the twin advantages of allowing the continued realisation of the beneficial aspects of plastics use, while also addressing the associated negative environmental side effects. The greenhouse gas footprint of recycled plastics is a fraction of that of virgin plastics, and high quality waste management systems reduce the risk of plastics leaking into the environment. The development of better waste management systems can also be seen as a form of "future-proofing". Plastics production and use has been projected to increase by a factor of four by 2050,[44] and some proportion of this material will inevitably make its way into the environment unless waste management systems improve.

4. Investment in better waste management systems is required and capturing more of the value embedded in plastics waste could help fund it

23. The development of better waste management systems in G20 countries could significantly reduce the amount of plastic waste that leaks into the ocean each year. However, mobilising the investment needed to finance the underlying infrastructure is problematic. Waste management assets – collection vehicles, transfer stations, sorting plants, disposal facilities etc. – deliver a public good (the protection of people's health and the environment), and therefore tend to rely heavily on government funding for their construction and operation.

In this setting, achieving long-lasting improvements in the coverage and quality of waste management systems implies significant increases in public spending.

24. Ensuring that all sources of funding for waste management activities are fully leveraged could reduce the pressure on government budgets and improve the business case for private investment. Extended Producer Responsibility (EPR) schemes have a clear role to play here. The producer fees generated by these schemes extend into the billions of dollars, and already help to finance waste management operations in many G20 countries.[45] [46]

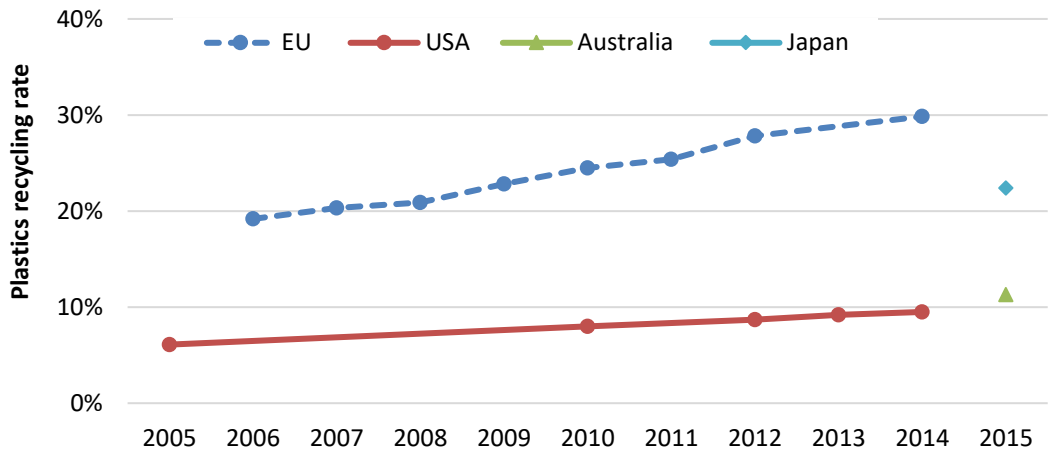
25. The revenues resulting from the sale of recyclables are also important. For some materials – certain metals and paper for example – these revenues more than cover the cost of the underlying collection, sorting and recycling processes. The fact that this is not the case for plastics reflects the low intrinsic value of plastic waste, as well as poorly functioning markets for recycled plastics.[47] The latter manifests itself across a wide range of market outcomes, from limited liquidity and high price volatility, to very limited trade volumes and overall low rates of recycling.

26. Plastics recycling continues to be an economically marginal activity. Recycling rates are thought to be 14–18% at the global level. The remainder of plastic waste is either incinerated (24%), or disposed of in landfills or the natural environment (58–62%).[48] Plastics recycling rates are substantially lower than those for other widely used materials. Recycling rates for major industrial metals – steel, aluminium, copper, etc. – and paper are thought to exceed 50%.[49] [50]

Treatment routes for waste plastics vary considerably across countries. Recycling rates are highest in the European Union (

27. Figure 6), and may exceed 50% in some EU Member States.[51] [52] Plastics recycling is also relatively well developed in China and Japan, with recycling rates in excess of 20%.[53] [54] Recycling rates in low to middle-income countries are largely unknown, but may be significant in situations where there is a well-established and effective informal sector. Data from Wilson et al. indicates that plastics recycling rates may be approaching 20 – 40% in some developing-country cities.[55]

Figure 6. Plastics recycling rates in high-income countries



Source: OECD, 2018

5. The design of plastics and plastic-containing products is often a barrier to higher rates of plastic collection and recycling

28. Plastics manufacturers – and the manufacturers of products that plastics are incorporated into – have strong incentives to design products in a way that maximises functionality and performance during the use phase. Relatively little attention tends to be given to designing products with end of life management in mind, largely because manufacturers see few of the benefits of doing so. These divergent incentives are a key reason for many of the characteristics that make the management of plastic waste so challenging. The proliferation of polymer types and structures, the widespread use of chemical additives, and the growing complexity of plastic containing products are all explained to some extent by the desire of manufacturers to improve product performance. These design features complicate "closing the loop" on plastics use in a variety of ways:

The diversity of plastic polymers and structures. At least eight major types of polymers are widely used (

- Figure 3), and new variants are continually emerging. When plastics eventually enter the waste stream, this diversity serves to complicate the sorting process, making it difficult to produce a consistent and clean source of feedstock for recycling. In

addition, certain types of plastic structures remain unrecyclable given current technologies.[56] The thermoset plastics used widely in transport and consumer goods applications are the best-known example, and are likely to become increasingly problematic as they replace traditional materials in a search for improved fuel efficiency.

- **The widespread use of chemical additives.** Plasticising compounds, flame-retardants, degradability enhancers, and other chemicals are often used to improve the performance characteristics of plastics. However, these additives may pose risks to human and ecosystem health,[57] and can also represent a significant barrier to higher recycling rates. For manufacturers of recycled plastics, uncertainty about the presence of these additives in plastic waste feedstock can hinder recycling altogether, either because the resulting output is of poor quality (when degradability enhancers are incorporated for example) or because it poses potential health risks in certain applications (e.g. food packaging or children's toys).
- **The growing complexity of many plastic containing products.** Plastics are widely used in packaging, transport, construction, and a range of consumer goods, typically in close conjunction with other materials or other polymers of plastic. The complexity of many of these products often means that disassembly, sorting, and recycling of the constituent components at the end of life is difficult and costly. Thus, separating the metallic and plastic films that comprise multi-layer packaging is problematic, as is disassembling and sorting the multiple polymers of plastic used in various mobile phone or vehicle components.

29. Increasing the proportion of plastic and plastic-containing products that are designed with end of life management in mind could significantly improve the economics of plastics recycling, and thereby help to stimulate investment in better waste management systems. A number of industry-led initiatives on plastics design have emerged recently,[58] but the introduction of additional policy measures will also be required to foster improved design practices. Governments of G20 countries, especially through concerted action, could play an important role here given that around 70% of global plastics production currently takes place within their borders.

30. Policy makers can target plastics and product design in various ways. Design mandates are already an important part of the broader policy landscape in many G20 countries,[59] and could be extended to explicitly address some of the problematic design issues relating to plastics. Extended Producer Responsibility (EPR) schemes also have a role to play. By making plastic and product manufacturers at least partially responsible for the cost of managing their products at the end of life, EPR can incentivise better design practices, while also creating an additional source of funding for waste management activities.[60] [61] [62]

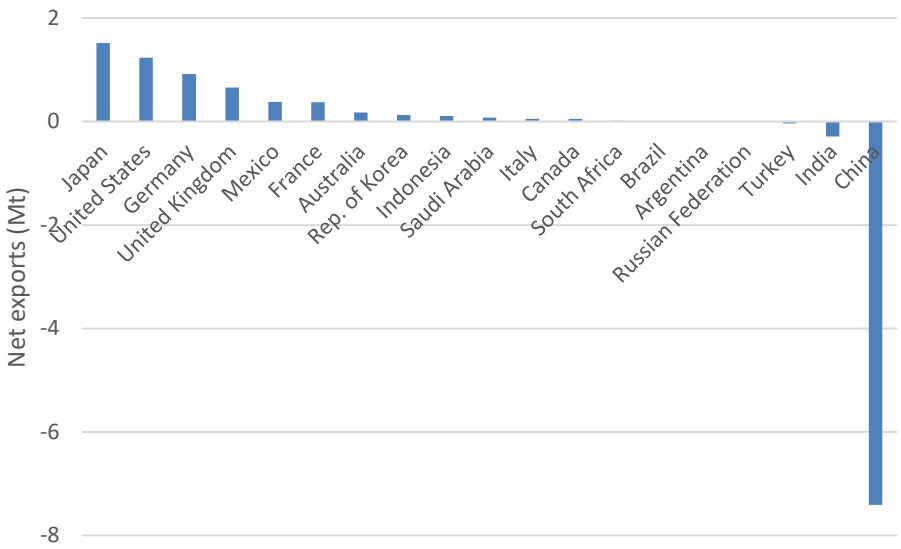
6. Trade in plastics waste could also help to support global recycling rates, but is increasingly hindered by trade restrictions

31. Allowing waste plastics (and other materials) to flow towards jurisdictions with a comparative cost advantage in sorting or recycling can help to boost global recycling rates, while also generating shared economic benefits and improved environmental outcomes.[63]

Despite that, global trade in plastics waste is small relative to overall plastics waste generation. Of the 300 million tonnes of plastics waste generated in 2015 ,[64] only around 14 million tonnes (or 4%) was exported outside the country of origin.[65] [66]

32. Trade flows have historically been concentrated in a handful of countries (Figure 7). The People's Republic of China was the largest market for plastics waste in 2016, accounting for around 8 million tonnes (or 60%) of global imports.[67] The next largest importers were Hong Kong (2 million tonnes),[68] Germany (0.5 million tonnes), and the United States (0.4 million tonnes). The largest exporters of plastics waste in 2016 were the United States (1.6 million tonnes), Japan (1.5 million tonnes), and Germany (1.4 million tonnes). Taken together, G20 countries accounted for around half of all exports of plastics waste in 2016, with a total value of USD 2.8 billion.[69]

Figure 7. Plastics waste trade flows: net exports from G20 countries in 2016



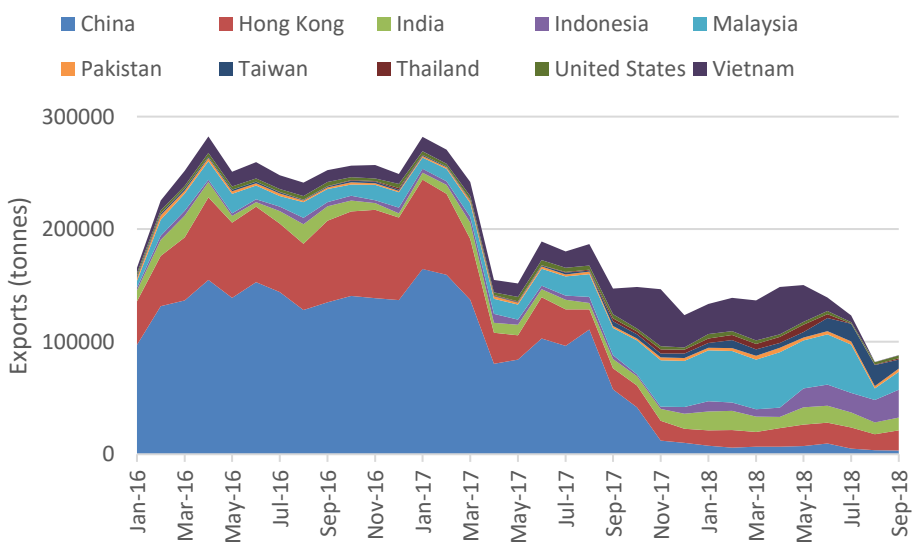
Source: UN COMTRADE, 2018

33. The introduction of restrictions on the import of plastics waste by the People's Republic of China has resulted in significant reductions to pre-existing trade flows.[70] China's imports of plastics waste from the European Union fell from around 100 000 tonnes in June 2017 to less than 5 000 tonnes in September 2018 (

34. Figure 8). China's imports of plastics waste from the United States fell by a similar amount, from 75 000 tonnes in January 2017 to 6 000 tonnes in December 2017.[71]

35. Reduced access to Chinese markets has led to increased domestic incineration and landfilling rates in exporting countries, as well as the diversion of material to third party countries such as Thailand, Malaysia, Vietnam, Turkey, and India, some of which have started to restrict imports in recent months.[72] The effects of the import restrictions can also be observed in China itself. The rapid fall in imported waste plastics has led to feedstock shortfalls for China's recycling industry, and a surge in prices for domestic waste plastics.[73] These impacts simultaneously highlight i) the role that trade has historically played in supporting global recycling rates, and ii) the limitations of existing plastics sorting and recycling infrastructure, even in many high-income countries.

Figure 8. Monthly exports of plastics waste from the EU by destination: 2016 to 2018



Source: Eurostat, 2018[74]

7. To address the key challenges G20 countries could consider a range of policy responses

36. G20 countries account for around 70% of global plastics production and around 75% of global waste generation (Section 2). In addition, modelling suggests that 50% of the plastics that leak into the oceans do so from these countries. The fact that so much of the plastics value chain resides within the G20 clearly highlights the role that the governments of these countries could play in solving the marine plastics litter problem.

37. The leakage of plastics into the oceans can be addressed throughout the plastics value chain. Clean-up and remediation activities are needed to reduce the concentration of legacy plastics already in the oceans, but action higher in the value chain will ultimately also be required to turn off the plastics tap. In the first instance, manufacturing products with materials other than plastic could be considered in situations where it would not result in an overall increase in environmental footprint. Opportunities to reduce unnecessary plastics use could also be seized, such as in the case of recent restrictions on the use of microbeads and single use plastics.[75] But, in many cases, plastics will likely remain the best possible material. It is therefore important to increase efforts towards a more sustainable design of the material and the products that contain them, in order to minimise the amount of waste generated.

38. In the longer term, the projected growth in plastics production and use, and the increase in waste generation that this implies, highlights the importance of collecting and recovering a greater proportion of plastics waste. Improved waste management systems are urgently needed, although the exact requirements differ between countries.

7.1. The coverage of formal waste collection and disposal services could be improved in many middle-income countries

39. More than 2 billion people worldwide currently lack access to formal collection services.[76] Although some waste collection does take place in middle-income countries, it is often carried out by the informal sector, and therefore tends to focus on waste materials for which there is an existing business case (metals and certain types of paper for example). For materials such as plastic, where there are few willing buyers, waste often accumulates in the urban environment or in open dumps, from where it inevitably leaks into the natural environment and oceans.

40. Expanding the coverage of formal waste collection systems to a greater share of the populations of middle-income countries, coupled with the development of a network of sanitary landfills where this waste could be safely disposed, could significantly reduce the leakage of plastics into the oceans. There are two main bottlenecks to doing so: the disruptive effect that the introduction of formal waste management systems can have on existing informal sector employment, and the potential shortages of funding required to introduce these systems.

Policy focus #1: Introduce formal waste collection and disposal systems in a way that is sensitive to the economic realities of informal sector workers

41. The introduction of formal waste collection and disposal can pose a significant threat to the 15 million people who rely on litter picking and the sale of recyclables for their livelihoods.[77] Formal collection services need to be introduced in a way that is sensitive to the economic realities of these individuals. In practice, this requires high levels of collaboration between local government and the informal sector to ensure that existing workers are fully integrated into the new system.[78]

Policy focus #2: Consider the use of fiscal transfers from central governments to help fund municipal waste collection and disposal

42. As discussed in Section 4, waste management assets – i.e. collection vehicles and disposal facilities – do not generate economic rates of return, and therefore rely heavily on taxpayer funding for their construction and operation. While this issue is by no means unique to middle-income countries, it is particularly challenging in this context given competing policy priorities (the provision of electricity and wastewater infrastructure for example), as well as issues with affordability and household willingness to pay for waste management related costs. Fiscal transfers to local governments may therefore be needed in order to overcome these obstacles.

7.2. Stronger domestic policy frameworks could help to stimulate investment in better collection and sorting infrastructure

43. The loss of China as a viable export destination for plastics waste has highlighted the low quality, and often contaminated nature, of domestic waste streams in many high-income G20 countries. There is a need for additional high-quality plastic sorting capacity, as well as the establishment of improved collection practices further upstream.

44. The investment needed to finance this infrastructure is likely to be significant. Although much of this investment could be made possible through increases in local taxes or the expansion of EPR schemes, capturing more of the revenue from the sale of recyclables would help to reduce pressure on government budgets. At present, and in contrast to materials such as metal and paper, much of the potential value embedded in plastics waste is lost – global plastics recycling rates are in the vicinity of 14 – 18%. This has implications throughout the plastics value chain, including further upstream where incentives for the development of high quality plastic collection systems are limited.

45. Modifying domestic policy frameworks to support the functioning of markets for recycled plastics, and improve the competitiveness of the resulting recycled plastics, could help to address many of these issues. Suppliers and buyers of recycled plastics would both benefit from larger and more liquid markets for recycled plastics, but neither party has strong incentives to act alone. In turn, improved market outcomes could, to some extent, become self-fulfilling as scale efficiencies are captured and a more widespread consumer acceptance develops. These factors provide a clear rationale for policy intervention, as well as potential insights into how to do it effectively. In particular, policies are likely to be more effective if they jointly address the challenges – market failures, policy misalignments, and status quo biases – that exist throughout the entire plastics lifecycle.

Policy focus #3: Support the market for recycled plastics

46. Governments of G20 countries could support the market for recycled plastics by introducing policies that level the playing field between recycled and virgin plastics. These include:

- Taxes on the use of virgin plastics, differentiated value added taxes for recycled plastics or plastic products;

- Reform of support for fossil fuel production and consumption;
- Recycled content standards, targeted public procurement requirements, or recycled content labelling; and
- Consumer education and awareness campaigns (concerning the environmental benefits of recycled plastics) in order to stimulate demand for products containing recycled plastics.

Policy focus #4: Address uncertainty about the availability and quality of recycled plastics

47. Governments of G20 countries could stimulate demand for recycled plastics by introducing policies that reduce uncertainty about the availability and quality of recycled plastics. These include:

- Certification standards for recycled plastics;
- The facilitation of better coordination and communication across the plastics value chain, including through the promotion of chemical information systems; and
- Restrictions on the use of hazardous additives in plastics manufacturing.

Policy focus #5: Reduce the cost of recycled plastic production

48. Governments of G20 countries could support the competitiveness of recycled plastics by introducing policies that address the factors that make them expensive to produce. These policies include:

- Requirements for multiple stream collection systems allowing separated collection of recyclables;
- The creation of incentives for better product and plastics design (e.g. design for reuse and recycling), such as through better designed Extended Producer Responsibility, product stewardship and deposit-refund systems;
- Support for R&D for improved plastics management systems and the sustainable design of plastics (e.g. more easily recyclable or more easily biodegradable);
- More ambitious recycling rate targets and harmonisation of the methods used to calculate these rates; and
- Increased stringency of landfill and incineration fees to better reflect the full social cost of these activities.

7.3. Increased international co-operation could also play a role

49. Governments of G20 countries can also improve the business case for plastics recycling, and improved collection practices further upstream, through various forms of international cooperation.

First, by showcasing the public policy developments and private sector initiatives taking place in their respective countries, the G20 could help to promote the spread of best practices

elsewhere. This kind of knowledge sharing is already explicitly highlighted in the G20 Action Plan on Marine Litter. Second, G20 countries could go beyond sharing of best practices by promoting increased international cooperation in the area of plastics management.

Policy focus #6: Direct a greater proportion of Official Development Assistance towards the development of sound waste management infrastructure

50. G20 countries could use Official Development Assistance (ODA) to support the development of effective and environmentally sound waste collection, sorting, and recycling infrastructure, including incentives or requirements for plastics source separation. Despite the health and environmental benefits that robust waste management systems provide, only a very small share of ODA is currently directed towards them. For example, the proportion of ODA originating in countries that are part of the OECD's Development Assistance Committee and that is earmarked for waste management is currently around 0.3%. .[79]

Policy focus #7: Strengthen environmental standards relating to plastic sorting and recycling

51. G20 countries could promote stronger environmental standards in plastic sorting and recycling in emerging and developing countries. Convergence of environmental standards relating to material recovery would allow waste plastics to flow towards countries with a comparative cost advantage in sorting and recycling activities, thereby helping to boost global recycling rates while also generating shared economic benefits and improved environmental outcomes.

Policy focus #8: Support the emergence of innovative plastics designs and sorting and recycling technologies

52. G20 countries could co-operate to boost innovation that supports product design for reuse and recycling.[80] This would reduce contamination in the waste stream, lower the cost of recycling, and ultimately lead to better quality recycled plastics. Modified product design could also help to slow the generation of microplastics that result from the wear and tear of products such as textiles and tyres.[81] Finally, coordinated efforts on the provision of public R&D support and incentives for the development of more efficient processing technologies could help to lower the overall cost of material recovery activities.

References and notes

[1] OECD (2018), *Global Material Resources Outlook to 2060 - Economic Drivers and Environmental Consequences*, http://www.oecd.org/publications/global-material-resources-outlook-to-2060-9789264307452-en.htm.

[2] Jambeck, J. et al. (2015), "Marine pollution. Plastic waste inputs from land into the ocean.", *Science (New York, N.Y.)*, Vol. 347/6223, pp. 768-71, http://dx.doi.org/10.1126/science.1260352.

[3] Improved resource efficiency offers economic opportunities. Reducing the use of natural resource inputs could help to boost domestic manufacturing competitiveness, while the emergence of markets for remanufactured products or recycled materials could lead to new business and job creation possibilities.

[4] In which G7 countries committed to taking ambitious action on resource efficiency.

[5] Including most recently under the 2018 Canadian Presidency, where the leaders of Canada, France, Germany, Italy, the United Kingdom, and the European Union launched the Ocean Plastics Charter. This initiative sets out a series of actions that could G7 countries could take to improve the management of plastics throughout their lifecycle.

[6] There are several examples of such national level initiatives. The Marine Strategy Framework Directive in the European Union is intended to ensure the health of marine areas, and to protect the resource base upon which ocean related economic activity depends. Similarly, Canada launched a national oceans strategy in 2018, setting out the policy framework within which ocean related activities will take place in coming decades.

[7] A number of industry led initiatives concerning plastics have also been launched. Several important consumer goods companies – Adidas and Coca Cola for example – have announced targets for the use of recycled plastics. In addition, several cosmetics producers – L'Oréal, Unilever, and Johnson & Johnson for example – have announced the phase-out of microbeads in certain products.

[8] Malaysia, Thailand, and Vietnam have recently also proposed restrictions on the import of plastics waste. See https://www.waste360.com/legislation-regulation/thailand-ban-foreign-scrap-plastic-imports.

[9] WWF (2018), *Pulp and paper | WWF*, http://wwf.panda.org/about_our_earth/deforestation/forest_sector_transformation/pulp_and_paper/ (accessed on 28 March 2018).

[10] World Bank (2018), *Total fisheries production (metric tons) | Data*, https://data.worldbank.org/indicator/ER.FSH.PROD.MT (accessed on 28 March 2018).

[11] USGS (2016), *Aluminum Legislation and Government Programs*, https://minerals.usgs.gov/minerals/pubs/commodity/aluminum/myb1-2015-alumi.pdf (accessed on 28 March 2018).

[12] The rapid growth of plastics production and use is largely due to the unique properties of the material. Plastics have a high strength-to-weight ratio, can be easily shaped into a wide variety of forms, are impermeable to liquids, and are highly resistant to physical and chemical degradation. Plastics can also be produced at relatively low cost. It is these properties that have led to the substitution of traditional materials (e.g. concrete, glass, metals, wood, natural fibres, and paper) by plastics in many applications.

[13] EMF (2017), *Rethinking the future of plastics and catalysing action*, https://www.ellenmacarthurfoundation.org/assets/downloads/publications/NPEC-Hybrid_English_22-11-17_Digital.pdf.

[14] VDMA (2016), *Plastics resin production and consumption in 59 countries*, http://www.bpf.co.uk (accessed on 09 May 2018).

[15] Plastics Europe (2018), *Market data: PlasticsEurope*, https://www.plasticseurope.org/en/resources/market-data.

[16] These include low density polyethylene (LDPE), high density polyethylene (HDPE), polyethylene terephthalate (PET), polypropylene (PP), polystyrene (PS), polyvinyl chloride (PVC), polyurethane (PUR), and polyester, polyamide, and acrylic (PPA) fibres.

[17] Data from Eurostat (2018[42]) indicates that per-capita plastics waste generation more than doubled in Germany and Italy between 2004 and 2014.

[18] Geyer, R., J. Jambeck and K. Law (2017), "Production, use, and fate of all plastics ever made", *Science Advances*, Vol. 3/7, p. e1700782, http://dx.doi.org/10.1126/sciadv.1700782.

[19] IUCN (2017), *International Union for Conservation of Nature a Global Evaluation of Sources Primary Microplastics in the Oceans*, https://portals.iucn.org/library/sites/library/files/documents/2017-002.pdf (accessed on 30 July 2018).

[20] UNEP (2015), "Global Waste Management Outlook", https://www.uncclearn.org/sites/default/files/inventory/unep23092015.pdf (accessed on 11 May 2018).

[21] World Bank (2018), "What a Waste 2.0".

[22] These data refer to the plastics waste contained in municipal solid waste.

[23] World Bank (2018), "What a Waste 2.0".

[24] The authors define mismanaged plastics waste as those that arise through littering or dumping in low quality landfill or open dump sites.

[25] Jambeck, J. et al. (2015), "Marine pollution. Plastic waste inputs from land into the ocean.", *Science (New York, N.Y.)*, Vol. 347/6223, pp. 768-71, http://dx.doi.org/10.1126/science.1260352.

[26] Jambeck, J. et al. (2015), "Marine pollution. Plastic waste inputs from land into the ocean.", *Science (New York, N.Y.)*, Vol. 347/6223, pp. 768-71, http://dx.doi.org/10.1126/science.1260352.

[27] IUCN (2017), *International Union for Conservation of Nature a Global Evaluation of Sources Primary Microplastics in the Oceans*, https://portals.iucn.org/library/sites/library/files/documents/2017-002.pdf (accessed on 30 July 2018).

[28] ISWA (2017), *Prevent Marine Plastic Litter - Now*, http://marinelitter.iswa.org/marine-task-force-report-2017/.

[29] Microplastics are plastic pieces that are smaller than 5 mm in size. They originate from the fragmentation of macroplastics (e.g. decomposing plastic bags) or from sources where they have been added intentionally (e.g. in cosmetics).

[30] UNEP (2016), *Secretariat of the Convention on Biological Diversity MARINE DEBRIS: UNDERSTANDING, PREVENTING AND MITIGATING THE SIGNIFICANT ADVERSE IMPACTS ON MARINE AND COASTAL BIODIVERSITY*.

[31] UNEP (2014), "The Business Case for Measuring, Managing and Disclosing Plastic Use in the Consumer Goods Industry", https://wedocs.unep.org/bitstream/handle/20.500.11822/9238/-Valuing%20plastic%3A%20the%20business%20case%20for%20measuring%2C%20managing%20and%20disclosing%20plastic%20use%20in%20the%20consumer%20goods%20industry-2014Valuing%20plasticsF.pdf?sequence=8&isA (accessed on 26 March 2018).

[32] Thompson, R. (2015), "Microplastics in the Marine Environment: Sources, Consequences and Solutions", in *Marine Anthropogenic Litter*, Springer International Publishing, Cham, http://dx.doi.org/10.1007/978-3-319-16510-3_7.

[33] GESAMP (2015), "Sources,Fate and Effects of Microplastics in the Marine Environment: A Global Assessment", https://wedocs.unep.org/bitstream/handle/20.500.11822/9545/-Sources,_Fate_and_Effects_of_Microplastics_in_the_Marine_Environment_A_Global_Assessment.pdf?sequence=2&isAllowed=y (accessed on 28 March 2018).

[34] Koelmans, A. et al. (2017), "Risks of Plastic Debris: Unravelling Fact, Opinion, Perception, and Belief", http://dx.doi.org/10.1021/acs.est.7b02219.

[35] Kosuth, M. et al. (2018), *SYNTHETIC POLYMER CONTAMINATION IN GLOBAL DRINKING WATER*, https://orbmedia.org/stories/invisibles_final_report/multimedia (accessed on 25 April 2018).

[36] Mason, S., V. Welch and J. Neratko (2018), "SYNTHETIC POLYMER CONTAMINATION IN BOTTLED WATER", https://orbmedia.org/sites/default/files/FinalBottledWaterReport.pdf (accessed on 25 April 2018).

[37] Yang, D. et al. (2015), "Microplastic Pollution in Table Salts from China", *Environmental Science & Technology*, Vol. 49/22, pp. 13622-13627, http://dx.doi.org/10.1021/acs.est.5b03163.

[38] Liebezeit, G. and E. Liebezeit (2014), "Synthetic particles as contaminants in German beers", *Food Additives & Contaminants: Part A*, Vol. 31/9, pp. 1574-1578, http://dx.doi.org/10.1080/19440049.2014.945099.

[39] Liebezeit, G. and E. Liebezeit (2013), "Non-pollen particulates in honey and sugar", *Food Additives & Contaminants: Part A*, Vol. 30/12, pp. 2136-2140, http://dx.doi.org/10.1080/19440049.2013.843025.

[40] Light-weighting refers to the process of using less material input to achieve a similar level of functionality.

[41] OECD (2018), "Review of Secondary Plastics Markets", https://one.oecd.org/document/ENV/EPOC/WPRPW(2017)4/REV1/en/pdf (accessed on 28 March 2018).

[42] The Ocean Cleanup is a Dutch based non-profit organisation that is developing technologies intended to remove plastics litter from the ocean. It is currently testing a 600m floating boom in the "Great Pacific Garbage Patch" off the west coast of the United States. See https://www.theoceancleanup.com/

[43] In particular, there are concerns about the role that increased material circularity could play in increasing the diffusion of hazardous chemicals. See https://one.oecd.org/#/document/ENV/EPOC/WPRPW/JM(2018)1/en?_k=95f2gd

[44] EMF (2017), *Rethinking the future of plastics and catalysing action*, https://www.ellenmacarthurfoundation.org/assets/downloads/publications/NPEC-Hybrid_English_22-11-17_Digital.pdf.

[45] For example, in France, EUR 630 million of collected "eco-contributions" were allocated to local authorities to cover the cost of waste management in 2012 (OECD, 2016[25]).

[46] OECD (2016), *Extended Producer Responsibility*, OECD Publishing.

[47] OECD (2018), "Review of Secondary Plastics Markets", https://one.oecd.org/document/ENV/EPOC/WPRPW(2017)4/REV1/en/pdf (accessed on 28 March 2018).

[48] Geyer, R., J. Jambeck and K. Law (2017), "Production, use, and fate of all plastics ever made", *Science Advances*, Vol. 3/7, p. e1700782, http://dx.doi.org/10.1126/sciadv.1700782.

[49] UNEP (2013), *Environmental risks and Challenges of Anthropogenic Metals Flows and Cycles*, http://wedocs.unep.org/bitstream/handle/20.500.11822/8451/-Environmental%20risks%20and%20challenges%20of%20anthropogenic%20metals%20flows%20and%20cycles-20138.%20Environmental%20Risks%20and%20Challenges%20of%20Anthropogenic%20Metals%20Flows%20and%20Cycles (accessed on 28 March 2018).

[50] Van Ewijk, S., J. Stegemann and P. Ekins (2017), "Global Life Cycle Paper Flows, Recycling Metrics, and Material Efficiency", *Journal of Industrial Ecology*, http://dx.doi.org/10.1111/jiec.12613.

[51] Different methodologies are used to calculate recycling rates in different countries. In some cases, recycling rates are calculated as the proportion of waste generation that is recycled (i.e. proportion of waste that becomes secondary raw material suitable for reintroduction into manufacturing processes). In other cases, recycling rates are calculated as the proportion of waste generation that is *collected* for recycling. The latter method does not account for contaminated batches and residual materials that are generated during the recycling process and need to be disposed of, and can therefore overstate the true recycling rate.

[52] PlasticsEurope (2017), "Plastics – the Facts 2017", https://www.plasticseurope.org/application/files/5715/1717/4180/Plastics_the_facts_2017_FINAL_for_website_one_page.pdf (accessed on 28 March 2018).

[53] Geyer, R., J. Jambeck and K. Law (2017), "Production, use, and fate of all plastics ever made", *Science Advances*, Vol. 3/7, p. e1700782, http://dx.doi.org/10.1126/sciadv.1700782.

[54] OECD (2018), "Review of Secondary Plastics Markets", https://one.oecd.org/document/ENV/EPOC/WPRPW(2017)4/REV1/en/pdf (accessed on 28 March 2018).

[55] Wilson, D. et al. (2009), "Building recycling rates through the informal sector", *Waste Management*, Vol. 29/2, pp. 629-635, http://dx.doi.org/10.1016/J.WASMAN.2008.06.016.

[56] With the possible exception of early stage chemical recycling technologies.

[57] Exposure to chemicals from plastics is widespread with biomonitoring studies detecting bisphenol A and phthalates in over 90% of participants (see Calafat et al. (2008), "*Exposure of the U.S. population to bisphenol A and 4-tertiary-octylphenol: 2003-2004*"). Exposure to bisphenol A and phthalates has been associated with a range of adverse human health impacts (see Katsikantami et al. (2008), "*A global assessment of phthalates burden and related links to health effects*" and Rochester, 2013, "*Bisphenol A and human health: A review of the literature"* for example) . The effects of exposure to bisphenol A are, however, a matter of controversy. A recent assessment by the US Food and Drug Administration concluded that the substance is essentially safe in the food contact applications where it is authorised.

[58] For example, Marks and Spencer is currently assessing the feasibility of using a single polymer for all its plastic packaging (Ellen Macarthur Foundation, 2018[53]).

[59] Consider fuel efficiency standards in the automobile industry and restrictions on the use of potentially harmful chemicals in many consumer products.

[60] New business models could also be promoted. For example, business models that involve providing access to products, rather than ownership of them, can provide similar design incentives to Extended Producer Responsibility schemes.

[61] OECD (2016), *Extended Producer Responsibility*, OECD Publishing.

[62] OECD (2016), *Extended Producer Responsibility*, OECD Publishing.

[63] Provided that environmental standards in importing countries are sufficiently stringent.

[64] Geyer, R., J. Jambeck and K. Law (2017), "Production, use, and fate of all plastics ever made", *Science Advances*, Vol. 3/7, p. e1700782.

[65] There are important differences across countries. For example, data from Eurostat indicates that the proportion of domestic plastics waste generation that is exported beyond the EU varies between 5% (Bulgaria, Hungary, and Italy) and 40% (Germany and the United Kingdom). See http://ec.europa.eu/eurostat/web/waste/waste-generation-and-management/generation and http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=env_wastrd&lang=en

[66] UN COMTRADE (2018), *United Nations Statistics Division - Commodity Trade Statistics Database (COMTRADE)*, https://comtrade.un.org/db/default.aspx (accessed on 21 March 2018).

[67] UN COMTRADE (2018), *United Nations Statistics Division - Commodity Trade Statistics Database (COMTRADE)*, https://comtrade.un.org/db/default.aspx (accessed on 21 March 2018).

[68] The vast majority of plastics waste imported by Hong Kong is re-exported to China.

[69] UN COMTRADE (2018), *United Nations Statistics Division - Commodity Trade Statistics Database (COMTRADE)*, https://comtrade.un.org/db/default.aspx (accessed on 21 March 2018).

[70] China made three notifications concerning plastics waste to the World Trade Organisation (WTO) in 2017 and 2018. Concerns about protecting the environment and human health were the stated rationale in each case. The first notification lists 24 kinds of solid waste – including some plastics – that are prohibited from import from 1 January 2018. The second notification is an import restriction that sets out maximum acceptable levels of contamination for 11 types of imported materials, including plastic waste and scrap. It came into force on 1 March 2018. The third notification is an import prohibition on a further 32 types of solid waste (including plastic waste and scrap from post-industrial sources), which will take effect in December 2018. In combination with the already existing prohibition of imports of post-consumer plastics, this measure is anticipated to stem the flow of all plastic waste and scrap to China.

[71] ISRI (2018), *2017 Trade Flows*, http://www.isri.org/2017-trade-flows (accessed on 06 April 2018).

[72] Some of these countries have announced plans to implement import restrictions of their own. According to Waste360 (2018[50]) and Waste360 (2018[49]), Malaysia revoked import licences for plastics waste from 140 factories in August 2018. In addition, Vietnam will stop issuing new licences for the import of various waste materials, and Thailand will ban all imports of plastic waste by 2021.

[73] Jing, D. and Z. Ge (218), *Suddenly, China said no. United States and European Union into panic (translated with Google Translate)*, http://industry.people.com.cn/n1/2018/0123/c413883-29780510.html.

[74] Eurostat (2018), *Eurostat - Data Explorer - Generation of Waste*, http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=env_wasgen&lang=en (accessed on 28 March 2018).

[75] A number of initiatives intended to limit unnecessary plastics use have been launched recently. Bans and taxes on single use plastics have been announced by a number of countries and regions, including New Zealand, the United Kingdom, and the European Union (Global Citizen, 2018[48]). In addition, several large cosmetics manufacturers – L'Oréal, Unilever, and Johnson & Johnson for example – have announced the phase-out of microbeads in certain products.

[76] UNEP (2015), "Global Waste Management Outlook", https://www.uncclearn.org/sites/default/files/inventory/unep23092015.pdf (accessed on 11 May 2018).

[77] World Bank (2018), "What a Waste 2.0".

[78] A number of countries have successfully introduced formal waste collection systems without alienating the existing network of informal workers. Colombia and Brazil are both good examples. See OECD (2016[25]) and World Bank (2018[12]) for additional information.

[79] Waste Aid (2018), *Marine Plastic Pollution: From the Land to the Sea*, https://wasteaid.org.uk/marine-plastic-pollution-from-the-land-to-the-sea/.

[80] In recognition of the role that innovation could play in addressing the plastics challenge, G7 Environment Ministers also launched the G7 Innovation Challenge to Address Marine Plastic Litter. The initiative is intended to, "promote scalable solutions to reduce plastic waste and marine litter, including technological and social innovations in plastics use and management".

[81] Modelling by Eunomia (2016[54]) and IUCN (2017[10]) suggests that the abrasion of textiles and tyres during use accounts for around 55% of all microplastics generation.