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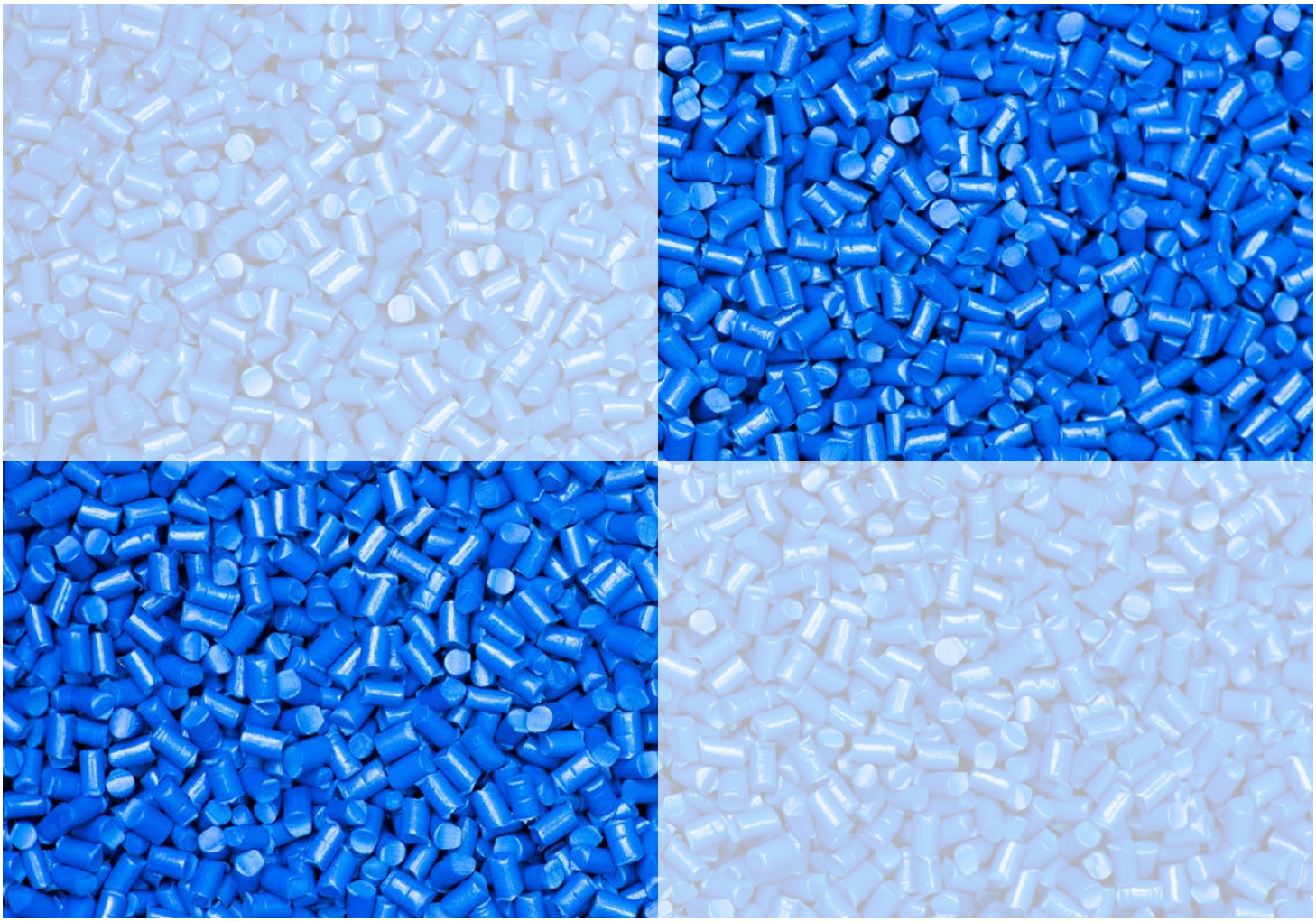
System Initiative on Environment and Natural Resource Security

The New Plastics Economy
Catalysing action

In Collaboration with the Ellen MacArthur Foundation

January 2017



World Economic Forum®

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Preface

In January 2016, the World Economic Forum, the Ellen MacArthur Foundation and McKinsey & Company published the report *The New Plastics Economy – Rethinking the future of plastics*. It was produced as part of MainStream – a multi-industry, global initiative which aims to accelerate business-driven innovations and help scale the circular economy. For the first time, the report provided transparency on global plastics material flows and associated economics. It found that, while plastics and plastic packaging are a key part of the global economy, the current plastics economy has significant drawbacks that are becoming more apparent by the day. In addition, it presented a blueprint for a more effective plastics system based on circular economy principles – in effect, a New Plastics Economy.

In May 2016, the Ellen MacArthur Foundation launched the New Plastics Economy initiative – a bold, three-year project to mobilize the report's recommendations, together with its Lead Philanthropic Partner – the Eric and Wendy Schmidt Fund for Strategic Innovation; its Philanthropic Funders – MAVA Foundation, Oak Foundation, and players of People's Postcode Lottery (GB); its Core Partners – Amcor, the Coca-Cola Company, Danone, MARS, Novamont, Unilever and Veolia; and a broad group of participant companies, cities and governments across the value chain.

This new report is one of the first key deliverables of the New Plastics Economy initiative. It represents a logical next step to the 2016 report: from *rethinking the future of plastics* to *catalysing action*. To trigger action, the report aims to make three original contributions to the transition towards the New Plastics Economy:

- Three distinct transition strategies for three plastic packaging categories covering the entire market (Redesign and innovate; Reuse; Recycle) based on a granular, segment-by-segment analysis and a quantification of the economic value creation potential for core aspects of the Reuse and Recycling categories
- A set of priority actions for each category, mobilizing the strategies and setting a common direction for players across the global plastics packaging value chain
- A targeted plan for the New Plastics Economy initiative to carry out in 2017 to catalyse progress on the priority actions.

Foreword

The World Economic Forum, the Ellen MacArthur Foundation and McKinsey & Company joined forces in 2014 to create Project Mainstream, a cross-industry, CEO-led global initiative to help scale the circular economy by unravelling systemic stalemates. Taking a global, cross-sectoral look at material flows, the project quickly identified plastics as one of the value chains most representative of the current linear model, bringing undisputed functionality to a variety of applications, but also entailing significant economic losses and severe negative externalities.

The resulting report, *The New Plastics Economy: Rethinking the future of plastics*, launched at the World Economic Forum Annual Meeting 2016 in Davos-Klosters, analysed these global flows for the first time and set out a vision for a new and effective plastics packaging system, guided by circular economy principles, and fit for the long term. This compelling vision provided the impetus for the Ellen MacArthur Foundation to set up an ambitious three-year initiative, the New Plastics Economy, to act on the report's insights and turn the vision into reality.

The initiative has made a strong start. Leading players from the plastic-packaging supply chain have committed to it, alongside major capital cities, philanthropists, policy-makers and academics. The momentum gathered is indicative of its exceptionally collaborative approach that builds bridges along value chains, across silos, and between the private and public sectors to initiate a genuine system shift. The interest it has generated echoes a growing consensus on the need to phase out the negative impacts associated with today's patterns of use by notably redesigning certain materials and rethinking business models.

This new report shows that we are now firmly at the action stage. The initiative has solidified its five building blocks – dialogue, harmonization, innovation, analysis and outreach – and each has catalytic actions planned for 2017. All these elements will be needed on the road ahead and the insights presented in this paper make the next steps on that journey clear.

We look forward to following the progress of this singular and powerful initiative over the coming years as it stimulates the innovation, redesign and new thinking needed to pave the way towards creating a plastics system that works.

Dame Ellen MacArthur
Chair of Trustees
Ellen MacArthur Foundation

Richard Samans
Head of the Centre for the Global Agenda
Member of the Managing Board World Economic Forum

Dominic Waughray
Head of Public-Private Partnership and Member of the Executive Committee
World Economic Forum

Prof. Dr. Martin R. Stuchtey
Founder and Managing Partner
SYSTEMIQ

In Support of the New Plastics Economy

We urgently need to transform global plastic packaging material flows if we are to continue to reap the benefits of this versatile material. This report marks a major milestone, calling out specific actions to capture opportunities for redesign and innovation, reuse, and recycling. It's now up to us all to get it done.

Paul Polman – CEO, Unilever * †

Resources management should not be summarised as a matter of cost optimisation but as a powerful driver of shared value creation. This belief runs through our entire business at Danone, fundamental to our relationships with suppliers, partners and our customers. Danone has embedded the principles of the circular economy in its value chain, managing now plastic as a cycle rather than as conventional linear supply chain. We are hugely supportive of the New Plastics Economy report as it lays out actions to turn the challenges posed by plastics today into an opportunity that will deliver value tomorrow. I am excited that Danone is taking a leading role in this initiative to help drive systemic change.

Emmanuel Faber – CEO, Danone

It will take a concerted effort involving various stakeholders to make the systemic changes needed to transition to a circular economy. This is especially true for plastics. Veolia believes that the New Plastics Economy initiative provides an excellent collaborative platform to catalyse the transition. The initiative's latest report, "The New Plastics Economy: Catalysing action", builds on the findings of the previous report and provides a clear roadmap of priority actions for 2017 to drive progress towards a global plastics system that works: a system that will capture material value and contribute to improved economic and environmental outcomes. Veolia looks forward to its continued participation in these efforts.

Antoine Frérot – CEO, Veolia * ‡

Shifting towards a circular economy based systems whereby the biological and technical cycles are linked and driven by innovative products delivered through new supply chains and systems will not be easy, but will result in significant benefits for the economy and environment. To make this transition successful, it is crucial to know where we want to go and what we want to achieve, which is exactly what the first New Plastics Economy report lays out. At Novamont we welcome this second report which now helps develop further our collective learning and is a call to action for the creation of tangible new links between upstream and downstream value chains.

Catia Bastioli – CEO, Novamont

Through innovation and collaboration, The Dow Chemical Company is committed to advancing a circular economy to deliver economic, societal, and environmental value. This important report by the Ellen MacArthur Foundation offers a key step in delivering science-based solutions by providing options that help us close resource loops for plastics and facilitate the transition towards a New Plastics Economy.

Andrew Liveris – Chairman and CEO, The Dow Chemical Company * †

SUEZ is delighted to have contributed to this next milestone and to continue its collaboration within the New Plastics Economy initiative. This report underwrites SUEZ' view of transitioning towards a plastic packaging system in line with circular economy principles, through a concerted, cross-value chain approach. The initiative's Pioneer Projects, with tangible actions and concrete goals, are a great example of how SUEZ aims to overcome plastics challenges.

Jean-Louis Chaussade – CEO, SUEZ * †

Healthy oceans can support healthy people and healthy profits; if we let them. That means governments, business and individual citizens backing an inclusive, circular economy. It means using legislation, innovation and consumer choices to replace plastic related demand and pollution with better alternatives that create jobs and still look after our planet. And it means supporting this initiative by ensuring that each us knows how we can help rethink, reuse and recycle plastic. This report is a great place to start.

Erik Solheim – Executive Director, UN Environment

The New Plastics Economy initiative is undertaking groundbreaking efforts to prove that positive economic and environmental progress can coexist in supply chains that have become increasingly global. The initiative's work complements Mayor de Blasio's OneNYC Plan and New York City's goals of achieving an 80% reduction in greenhouse gas emissions by 2050, and zero waste to landfills by 2030. At NYCEDC, we look forward to opportunities to apply this report's findings to promote innovative and sustainable approaches to design, infrastructure, and new business models.

Maria Torres-Springer – President and CEO, New York City Economic Development Corporation

Carrefour fully supports the New Plastics Economy initiative. Our group pledges to continue its worldwide efforts working with industry partners and other stakeholders to move toward a circular model for plastics. Together we will create innovative and tangible actions to achieve this goal.

Georges Plassat – Chairman and CEO, Carrefour

The New Plastics Economy represents a huge opportunity for design, as evidenced in this report. From more circular products and services to new business models and industry systems, design is needed in the absence of established roadmaps or models that we can simply re-tune or optimise. To deliver the step change in industry practices that is required, we need to recognise that transitioning to the circular economy is one of the biggest creative challenges of our time. The New Plastics Economy initiative plays an important role, inspiring and supporting designers to capture the opportunity.

Tim Brown – CEO, IDEO * ‡

Borealis, as a leading provider of innovative solutions in the field of polyolefins, is committed to realising the opportunities presented by the New Plastics Economy. The initiative has already convened all stakeholders to work effectively together. With this new report, the initiative now offers a roadmap to create effective markets based on circular economy principles – an action plan where Borealis wants to take an active and leading role.

Mark Garrett – CEO, Borealis

As one of the world's leading retailers Schwarz Gruppe relies on packaging materials. If we want to safeguard future resources, eliminate waste and save energy, it is of central importance that we circulate resources -including our packaging- effectively. Ellen MacArthur Foundation's New Plastics Economy initiative is an excellent platform to meet this challenge together with other leading companies.

Gerd Chrzanowski – CEO, Schwarz Central Services (Lidl & Kaufland)

At TriCiclos, we understand the urgency on rethinking the plastic industry worldwide; and strongly support the idea on setting the principles of the New Plastics Economy through cooperation between all the actors of the value chain. We are very proud to be involved with the New Plastics Economy initiative, contributing with our experience on improving plastic packaging design and harmonizing collection and sorting systems towards circular economy models for packages. This report is totally aligned with our mission, as it offers a clear way forward to solve a highly relevant problem. We are eager to carry on the journey!

Gonzalo Munos – Co-founder and CEO, TriCiclos

The world is at a turning point. For millennia, production and consumption cycles were circular, consistent with the "waste = input" flows inherent in nature. The invention of plastics fostered disposable goods and packaging that were cheaper to replace with virgin rather than recycled materials. The age of waste, symptom of the linear economy, unfolded globally. Today, the companies and NGOs participating in the New Plastics Economy initiative are pioneering steps, presented in this report, to move towards a circular economy for plastics. This critical global initiative is urgent, timely and achievable.

Tom Szaky – CEO, TerraCycle *

The City of Phoenix handles more than 54,000 tons of plastics every year, and has been actively working with local partners to boost plastics recycling over the past few years. The report ‘New Plastics Economy: Catalysing action' is helping cities like Phoenix build a framework for systemic change to transition plastics from the linear take-make-dispose model to a true circular economy.

Greg Stanton – Mayor, City of Phoenix *

It is incumbent on companies of every size around the world to take an honest look at how they are using resources, and focus their ingenuity on reducing waste. Sealed Air is committed to deliver even more value for its customers and the wider society, by taking the next steps to make dramatic improvements that prevent waste and reuse resources, as laid out in this new report.

Jerome Peribere – CEO, Sealed Air Corporation

In 2016, the Ellen MacArthur Foundation provided for the first time what had long been lacking – a comprehensive, truly global perspective on plastics innovation needs at a societal level, and on the business opportunity for industry. Now, the 2017 report nicely advances the thinking, with specific, actionable priorities that strike the right balance between 'evolutionary' and ‘revolutionary' – respecting current materials in the market, while simultaneously creating space for significant new materials innovation.

Marc Verbruggen – CEO, Natureworks ‡

As one of the world's leading manufacturers of flexible packaging and labels, Constantia Flexibles understands the importance of modern plastic packaging design. We are delighted to see how the New Plastics Economy initiative is bringing together other major players in the plastic packaging value chain to improve design and thus create both economic and environmental benefits for all stakeholders.

Alexander Baumgartner – CEO, Constantia Flexibles

Think Beyond Plastic believes in harnessing the forces of innovation and entrepreneurship to advance the New Plastics Economy. Essential for the success of this endeavor is building the entire innovation eco-system and mobilizing the cumulative power of the participants of the New Plastics Economy initiative.

Daniella Russo – CEO, Think Beyond Plastic Innovation Accelerator

As a global leading provider of technology for handling post-use plastics, TOMRA aims to be a frontrunner in the transition towards a New Plastics Economy. We engage in this initiative because we believe it provides a common vision for the industry combined with a unique platform for pre-competitive collaboration and action. With this report these two elements are now complemented by tangible guidance for the way forward.

Stefan Ranstrand – President & CEO, TOMRA Systems ASA

MMBC supports the New Plastics Economy initiative as a platform for the creation of a global circular plastics system. While MMBC has been able to achieve significant progress in recycling plastics at a local level, we need this type of initiative to be able to address the growing issue of plastics at a global scale.

Allen Langdon – Managing Director, Multi-Materials British Columbia (MMBC)

P&G believes transformational change can be achieved by combining the perspectives of all stakeholders, including industry, governments and consumers. We are actively engaged in several multi-stakeholder collaborations that seek to improve recycling uptake, quality and economics. The New Plastics Economy initiative's collaborative way of working is aligned with ours and represents a powerful opportunity to drive positive change in the plastics system.

Virginie Helias – Vice President Global Sustainability, Procter & Gamble †

Through first-hand experience, KKPKP knows how recyclable plastics create income for waste pickers in India. The New Plastics Economy initiative attempts to ambitiously take a detailed and long term view on the trade with a multi-pronged approach of value enhancement - critical for informal recyclers - and format and delivery model redesign for plastics packaging. This new report has tremendous potential to influence policy at the global and local levels and we look forward to how it will impact the recycling economy.

Malati Gadgil – Treasurer, Kagad Kach Patra Kashtakari Panchayat (KKPKP)

The New Plastics Economy initiative represents a truly momentous and unique opportunity to completely rewrite the rules of global resource management, in line with the circular economy principles. Whilst the ambition is breathtaking this report sets outs some key steps to transition to the New Plastics Economy. The London Waste and Recycling Board is proud to be part of this initiative.

Wayne Hubbard – COO, London Waste and Recycling Board *

As a family owned company, Werner&Mertz is fully committed to capturing the value of plastic packaging after use, and so creating economic and environmental benefits. By using post-consumer recycled plastics for our branded goods packaging, we show how recycling allows to close the loops while meeting the highest quality standards. We whole heartedly support the New Plastics Economy initiative and are happy to be part of this tremendous important programme.

Reinhard Schneider – CEO and sole owner, Werner & Mertz Group

We are proud to explore together with the New Plastics Economy initiative how plastic packaging design can enable circular material flows in addition to the delivery of safe, high-quality products to our customers. This report shows the crucial role of such design in moving towards a plastics system that works economically, socially and environmentally. Crucially it offers a practical transition strategy for the different packaging applications enabling us to turn theory into reality rapidly and with scale.

Mike Barry – Director, Plan A, Marks & Spencer *

As an innovative recycling company, APK Aluminium und Kunststoffe AG continuously strives to improve the quality and economics of plastic packaging recycling. Connecting different players in the supply chain, from designers to recyclers, will be crucial to create an effective plastics system, as laid out in this report. The New Plastics Economy initiative's collaborative approach is exactly what is needed to turn this endeavour into a success.

Klaus Wohnig – CEO, APK Aluminium und Kunststoffe AG

As shown in this report, innovation is essential for a successful transition to the New Plastics Economy. As an innovator, Loop Industries is proud to support this shift with our high-quality depolymerisation technology.

Daniel Solomita – Founder and CEO, Loop Industries

As one of the leaders in the field of polyethylene recycling, RPC bpi recycled products understands the many benefits of closing material loops. This new report shows how we can further strengthen recycling economics, by moving towards the New Plastics Economy - a promising journey we are pleased to be part of!

Gerry McGarry – Managing Director, RPC bpi recycled products

WRAP welcomes this new report on the New Plastics Economy as it provides a global vision that builds on the extensive work WRAP has focussed on in the UK over the last few years, including packaging design, collection harmonisation and plastic packaging recycling infrastructure.

Marcus Gover – CEO, WRAP *

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At Surfdome many of our staff, customers, suppliers and I are regularly faced with the results of a dated linear economy, with plastic pollution consistently visible in our oceans. We've been working hard to reduce our impact on the world, protect our waves, and the waters they belong to, but it's dramatically clear how the plastic pollution crisis is escalating. This report from the New Plastic Economy initiative is vital for guiding all on the best path to improve the negative impact and unavoidable outcome that will arise if action isn't taken.

”

Justin Stone – Founder & Managing Director, Surfdome

“

Recycling Technologies believes that fundamental innovation is needed to move some of the most challenging plastic packaging segments forward, as explained in this report. As a recycling technology innovator, we are eager to drive industry collaboration within the New Plastics Economy initiative towards a system in which plastics never become waste.

”

Adrian Griffiths – CEO, Recycling Technologies

“

Transforming the current plastics system is a key priority for OVAM and Circular Flanders, our public private partnership to boost the circular economy in Flanders. This report is a major step towards the New Plastics Economy vision described in the previous report, and clearly outlines the key actions for the plastic packaging value chain to focus on. As a participant of the initiative, we are excited to start working on this plan!

”

Henny De Baets – CEO, Public Waste Agency of Flanders (OVAM)

“

Bringing many benefits, plastics have become an indispensable part of our daily life. Currently this versatile material also entails serious economic and environmental disadvantages, to which a solution needs to be actively and consequently pursued. Thanks to the Ellen MacArthur Foundation's New Plastics Economy initiative, renowned companies from the plastics industry, non-profit organisations and municipalities are working together to achieve such a solution.

”

Axel Kühner – Chairman of the Board, Greiner Group ‡

“

Zero Waste Scotland was involved in the New Plastics Economy initiative from the beginning, and we continue to support its aims. Scotland is a small nation making big steps towards a more circular economy. We know that redesigning, reusing and optimising the recycling of plastics can create new economic opportunities as well as stop the harmful impacts of the linear economy. To achieve that goal, collective endeavours like the New Plastics Economy initiative need widespread support and commitments to turn ideas into action - and this report provides an excellent blueprint to do so.

”

Ian Gulland – CEO, Zero Waste Scotland *

“

Nextek believes industry leaders should take a close look at this valuable work of the New Plastics Economy initiative, so that they, together with governments and NGOs, can transform the current plastics economy into a circular one. In this way we do not only respond to pressures on resources and waste reduction, but also create a value-adding plastics system at every level.

”

E**dward Kosior** – Managing Director, Nextek

Advisory Board Members of the New Plastics Economy Initiative

The New Plastics Economy initiative is grateful for the support of its Advisory Board members:

Lead Philanthropic Partner

Eric & Wendy Schmidt Fund for STRATEGIC INNOVATION

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MAVA FONDATION POUR LA NATURE

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Supported by players of PEOPLE'S POSTCODE LOTTERY Awarding funds from POSTCODE DREAM TRUST

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Unilever * †

VEOLIA * †

* Denotes an Ellen MacArthur Foundation CE100 Member

† Denotes a World Economic Forum Partner

‡ Denotes a World Economic Forum Member

Executive Summary

Global momentum for a fundamental plastics rethink is greater than ever. Plastics have become the ubiquitous workhorse material of the modern economy: combining unrivalled functional properties with low cost, their use has increased twentyfold in the past half-century. While plastics and plastic packaging are an integral part of the global economy and deliver many benefits, their archetypically linear, take-make-dispose value chains entail significant economic and environmental drawbacks. It is only in the past few years that the true extent of these drawbacks has become clear. We now know, more than 40 years after the launch of the first universal recycling symbol, that only 14% of plastic packaging is collected for recycling globally. Each year, $80 billion-$120 billion plastic packaging material value is lost to the economy. Given projected growth in production, in a business-as-usual scenario, by 2050 oceans could contain more plastics than fish (by weight). Across the entire range of plastic products, not just packaging, concerns are raised about the potential negative impact of certain substances on society and the economy. Businesses and governments are now, for the first time, recognizing the need to fundamentally rethink the global plastics system.

This growing recognition is triggering action across the world. Policy-makers continue to broaden and refine regulations for plastics, introducing landmark legislation worldwide throughout 2016, such as restrictions and bans on single-use plastic (carrier) bags. The European Commission is planning to publish a strategy on plastics as part of its Circular Economy Action Plan by the end of 2017. NGOs and the wider public are increasingly calling for change, with movements such as the #breakfreefromplastic campaign gaining traction. Front-running businesses and industry groups are taking action. It is clear that the topic of plastics is coming to a head. The key question is, will societies gradually reject the material due to its negative effects and forgo its many benefits, or will they carve out a future for it characterized by innovation, redesign and harmonization, based on circular economy principles?

The New Plastics Economy presents a bold and much-needed vision for a plastics system that works. It provides a new way of thinking about plastics as an effective global material flow, aligned with the principles of the circular economy. It aims to harness the benefits of plastics while addressing its drawbacks, delivering drastically better system-wide economic and environmental outcomes. This vision, laid out initially in the 2016 report, *The New Plastics Economy – Rethinking the future of plastics*, has inspired businesses, policy-makers and citizens worldwide. It forms the basis for the ambitious New Plastics Economy initiative, launched in May 2016 and supported by dozens of leading businesses, philanthropists, cities and governments.

This report is the first to provide a concrete set of actions to drive the transition, based on three strategies differentiated by market segment. Thorough analytical work, including a detailed segment-by-segment analysis of the plastic packaging market, numerous interactions with players across the plastics value chain and discussions with experts revealed that a programme of concerted action across three key areas could trigger an accelerated transition towards the New Plastics Economy. The three key transition strategies and related priority action areas are:

1. Without fundamental redesign and innovation, about 30% of plastic packaging will never be reused or recycled. Today, these packaging applications – representing at least half of all plastic packaging items, or about 30% of the market by weight – are, by their very design, destined for landfill, incineration, or energy recovery, and are often likely to leak into the environment after a short single use. This segment includes *small-format* packaging, such as sachets, tear-offs, lids and sweet wrappers; *multi-material* packaging made of several materials stuck together to enhance packaging functionality; *uncommon* plastic packaging materials of which only relatively low volumes are put on the packaging market, such as polyvinyl chloride (PVC), polystyrene (PS) and expanded polystyrene (EPS, sometimes referred to under its brand names Styrofoam or Thermocol); and highly *nutrient-contaminated* packaging, such as fast-food packaging.

Their lack of a viable after-use pathway and often small size make these items particularly prone to escaping collection systems and ending up in the natural environment, especially in emerging economies where most of the leakage occurs. Even when collected, their after-use material value is hard or impossible to capture at scale. Fundamental redesign and innovation are required: for some segments, this means reinvention from scratch; for other categories, it means scaling existing solutions or accelerating progress made so far. As many of these packaging items have important functional benefits, their drawbacks should not be seen as arguments to remove *all* these applications from the market *today;* rather, they set the direction and focus for redesign and innovation. Priority actions for the global plastic packaging value chain include:

- Fundamentally redesign the packaging formats and delivery models (and after-use systems) for *small-format* plastic packaging, avoiding such small formats where relevant and possible
- Boost material innovation in recyclable or compostable alternatives to the currently unrecyclable *multi-material* applications as described above
- Actively explore replacing PVC, PS and EPS as *uncommon* packaging materials with alternatives (converging to a few key materials being used across most of the market, while continuing to allow for innovation and entry of new materials into the market)
- Scale up compostable packaging and related infrastructure for targeted *nutrient-contaminated* applications
- Explore the potential as well as the limitations of chemical recycling and other technologies, to reprocess currently unrecyclable plastic packaging into new plastics feedstocks

2. For at least 20% of plastic packaging, reuse provides an economically attractive opportunity. New, innovative delivery models and evolving use patterns are unlocking a reuse opportunity for at least 20% of plastic packaging (by weight), worth at least $9 billion. New models that effectively replace single-use packaging with reusable alternatives are already being demonstrated in the cleaning- and personal-care market by only shipping active ingredients in combination

with reusable dispensers. For other applications, recent policy developments have demonstrated societal acceptance of reusable alternatives, exemplified by large reductions in the usage of single-use bags after the introduction of relatively minor levies. This societal acceptance could also reinvigorate tried and tested reuse systems, including returnable beverage bottles in cities. In addition, several companies have already successfully demonstrated the benefits of reusable packaging in the business-to-business market, where there remains significant room for scaling up. As always, when evaluating the shift to, or scaling up of, reuse models, it is important to take a system perspective and understand the broad impact of each solution, including environmental and societal aspects. Priority actions in the area of reuse include:

- Innovate towards creative, new delivery models based on reusable packaging
- Replace single-use plastic carrier bags by reusable alternatives
- Scale-up reusable packaging in a business-to-business setting for both large rigid packaging and pallet wrap

3. With concerted efforts on design and after-use systems, recycling would be economically attractive for the remaining 50% of plastic packaging. Implementation of good practices and standards in packaging design and after-use processes as part of a Global Plastics Protocol, allowing for regional differences and continued innovation, would reinforce recycling as an economically attractive alternative to landfill, incineration and energy recovery. It would add an estimated $190-$290 of value to every tonne of mixed plastic packaging collected, or $2 billion-$3 billion annually across OECD countries. In addition, it would improve resource productivity and reduce negative externalities, such as greenhouse gas emissions. Even though it would lift *average* profitability into positive territory, certain technological and economic barriers would remain for specific packaging segments, such as flexible films. Given the current fragile economics of recycling, demand-pull for recycled plastics and other supporting policy measures could trigger progress in the near term. As part of the redesigned and reused packaging described above will also lead to recycling, the 50% mentioned here should not be interpreted as an upper limit for a recycling target. In regions with high levels of leakage into the natural environment, another critical short-term action is to deploy basic collection and management infrastructure – requiring dedicated and distinct efforts. This is already under way at the local level through, for example, the Mother Earth Foundation in the Philippines and, globally, through the Ocean Conservancy's Trash Free Seas Alliance. Priority actions for improving recycling economics, uptake and quality include:

- Implement design changes in plastic packaging to improve recycling quality and economics (e.g., choices of materials, additives and formats) as a first step towards a Global Plastics Protocol
- Harmonize and adopt best practices for collection and sorting systems, also as part of a Global Plastics Protocol
- Scale up high-quality recycling processes
- Explore the potential of material markers to increase sorting yields and quality
- Develop and deploy innovative sorting mechanisms for post-consumer flexible films
- Boost demand for recycled plastics through voluntary commitments or policy instruments, and explore other policy measures to support recycling
- Deploy adequate collection and sorting infrastructure where it is not yet in place

Design is essential to move ahead on all three categories above. To shift towards the New Plastics Economy, the entire plastic packaging value chain needs to be involved – from packaging designers at the beginning of the chain to recyclers at the end. The analysis in this report has revealed that design (of materials, packaging formats and delivery models) plays a particularly important role and is essential to mobilize the transition strategies for each of the plastic packaging categories, as reflected in the set of priority actions.

In addition to the priority actions above, sourcing virgin feedstocks from renewable sources would accelerate the transition to the New Plastics Economy by helping decouple plastics from fossil feedstocks.

To catalyse the transition, the New Plastics Economy initiative has mobilized a systemic and collaborative approach across five building blocks – with a targeted action plan for 2017. In May 2016, the Ellen MacArthur Foundation launched the New Plastics Economy initiative – an ambitious global programme, which has secured over $10 million funding to date and involves over 40 key stakeholders across the value chain – to accelerate the shift to the New Plastics Economy. This report forms the basis for a catalytic action plan the initiative will use to tackle this complex issue from all relevant angles. These catalytic actions for 2017 fit the five interlinked and mutually reinforcing building blocks on which the New Plastics Economy initiative is set up. The following actions are planned for 2017 (the initiative will continue to explore other areas in 2018 and beyond):

- **Dialogue Mechanism**: Put cross-value chain collaboration at the heart of the initiative by convening a group of over 40 leading companies, cities and governments across the plastic packaging value chain twice a year, and continuously driving collaborative pioneer projects.
- **Global Plastics Protocol**: Take the next step towards a Global Plastics Protocol by collaboratively developing a cross-value chain perspective on the top opportunities for design shifts; this will allow the prioritization of changes that would most enhance recycling economics and material health.
- **Innovation Moonshots**: Launch two innovation challenges to inspire a generation of material scientists and designers to develop solutions for the 30% of packaging that requires fundamental redesign and innovation.
- **Evidence Base**: Finalize the ongoing study with the Plymouth Marine Laboratory on the socio-economic impact of plastics in marine environments. Bridge other knowledge gaps such as, for example, the potential and limitations of material markers and chemical recycling.
- **Stakeholder Engagement**: Encourage the wider stakeholder group to work towards a system shift – designers, in particular, whose involvement is critical for successful action on each of the three transition strategies, and policy-makers, who can trigger progress in the near term. Launch and build on the Circular Design Guide – an online reference point on circular design – together with leading global design company IDEO, to inspire and support designers, innovators and change makers. Engage and inform policy-makers on the New Plastics Economy's vision and recommendations.

Through these actions, the New Plastics Economy initiative aims to set direction, inspire innovation and build momentum towards the vision of a plastics system that works, moving the plastics industry into a positive spiral of value capture, stronger economics and better environmental outcomes.

Global Momentum for a Plastics Rethink is Greater than Ever

The case for rethinking plastics, starting with packaging

While plastics and plastic packaging are an integral part of the global economy and provide it with many benefits, their typically linear value chains currently entail significant drawbacks, which are becoming more apparent by the day. Projected growth in plastics production could lead by 2050, in a business-as-usual scenario, to the oceans containing more plastics than fish (by weight), and the entire plastics industry could be consuming 20% of total oil production and 15% of the annual carbon budget. Looking at the full range of plastic products (not just packaging), concerns have been raised about the potential negative impact of some substances, such as certain phthalates in PVC and bisphenol A in polycarbonate, on society and the economy. Plastic packaging – the focus of the New Plastics Economy initiative – is plastics' largest application, representing 26% of the total volume, and encountered by virtually everyone daily.[1] Most plastic packaging is used only once and 95% of its value, estimated at $80 billion-$120 billion annually, is lost to the economy after its initial use. Additionally, plastic packaging, which is particularly prone to leakage into the environment, generates negative externalities, degradation of natural systems and greenhouse gas emissions, that have been valued conservatively by UNEP at $40 billion.[2] For these reasons, plastics and plastic packaging have gradually morphed from a fringe to a mainstream issue.

The global momentum for a plastics rethink has triggered a broad group of stakeholders to act. Policy-makers are introducing landmark legislation worldwide, affecting plastics and plastic packaging, with examples from 2016 including: further national regulations on single-use plastic bags in Indonesia, Colombia, and Morocco; a ban on non-biodegradable plastic cutlery, cups and plates in France; and a ban on EPS packaging in San Francisco.[3] In November 2016, citizens of California approved Proposition 67, which prohibits grocery and other stores from providing customers with single-use plastic takeaway bags. This is in addition to more 130 regulations, at a city level and county-wide, across 20 states, governing plastic packaging in the United States alone.[4] Importantly, the EU Commission aims to publish a strategy on plastics as part of its Circular Economy Action Plan by the end of 2017. The NGO community is also intensifying its efforts, as shown by the #breakfreefromplastic movement.[5] Launched in September 2016, the movement, which aims for a future free from plastic pollution, grew to over 500 member organizations in just a couple of weeks.

Academic experts are increasingly studying plastics and their impact on the economy and society. Aside from plastics leakage into the ocean, the impact of substances of concern in plastics (not just packaging) is one active area of research. Besides polymers, plastics contain a broad range of other substances, with some of them raising concerns about complex long-term exposure and compound effects on human health. As discussed in *The New Plastics Economy – Rethinking the future of plastics*, while scientific evidence on the exact implications of substances of concern is not always conclusive, some stakeholders are already acting.[6] They are motivated by different reasons – regulators are often driven by the precautionary principle and potential cost to society, and businesses anticipate reputational risks and aim to capture potential economic value.[7] For example, the European Commission continued in 2016 the development of science-based criteria for endocrine disruptors – chemicals which are considered within the EU chemicals policy (known as REACH; Registration, Evaluation and Authorization of Chemicals) to be of similar regulatory concern as substances already classed as being of very high concern.[8]

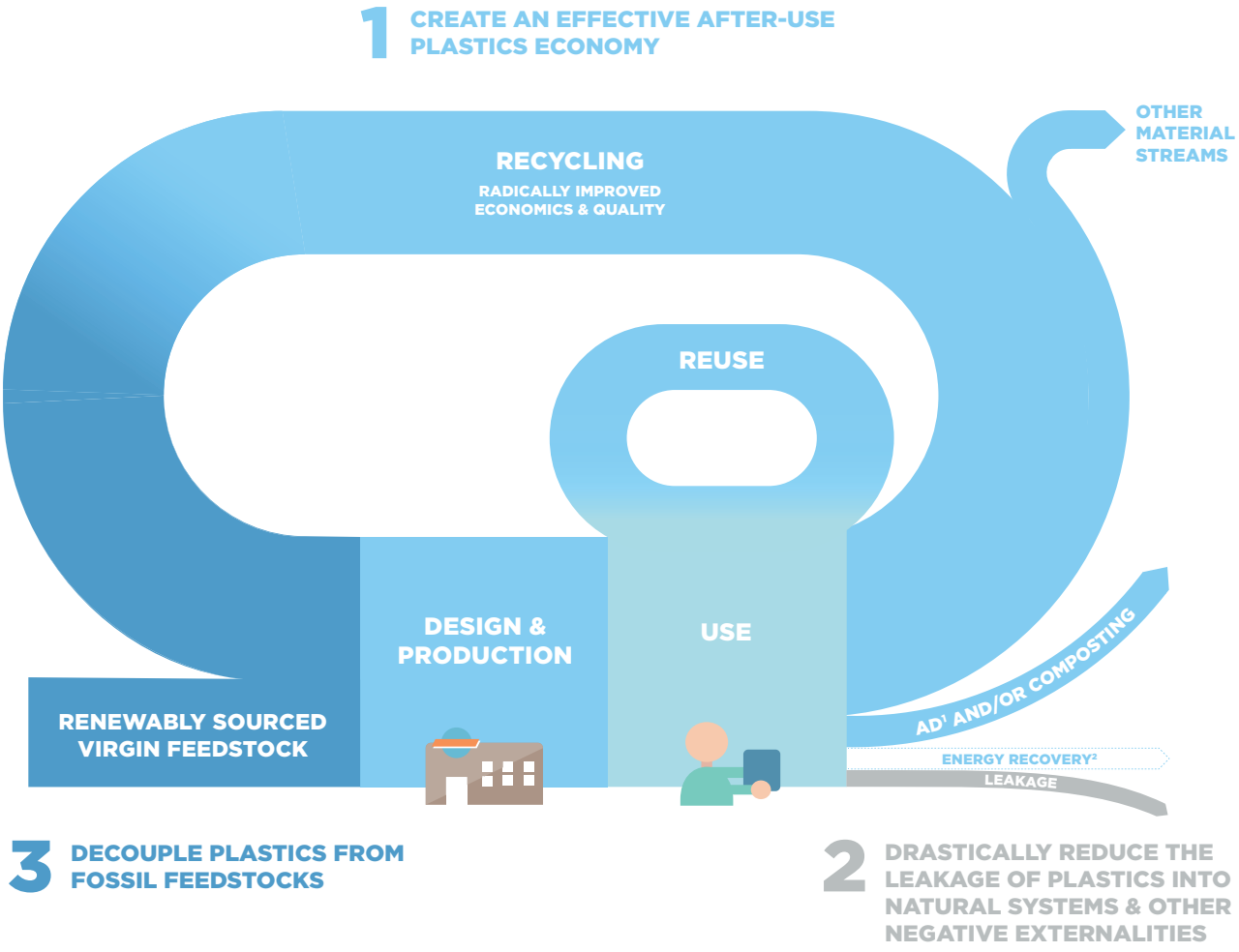
Front-running businesses and industry groups are already responding in a variety of ways. They are improving the design of their products, packaging and delivery models, including, for example, public commitments on sourcing recycled content or eliminating single-use carrier bags. Companies are also collaborating to work on solutions across the after-use value chain, such as the REFLEX, FIACE and MRFF projects to improve recycling of flexible packaging.[9] Examples of industry-wide initiatives include the Recycling Partnership, Closed Loop Fund and, launched in October 2016, the Polyolefin Circular Economy Platform.[10]

The New Plastics Economy: a vision of a more effective system, in line with the principles of the circular economy

As laid out in the report, *The New Plastics Economy – Rethinking the future of plastics*, the New Plastics Economy offers a much-needed, fundamental rethink for plastics and plastic packaging. It presents an ambitious target state, enhancing system effectiveness to achieve better economic and environmental outcomes while continuing to harness the many benefits of plastic packaging. This bold vision builds on and aligns with the principles of the circular economy, an economic model that is restorative and regenerative by design. To move the plastics value chain into a positive spiral of value capture, stronger economics and better environmental outcomes, the New Plastics Economy has three main ambitions (see Figure 1):

1. Create an effective after-use plastics economy by improving the economics and uptake of recycling, reuse and controlled biodegradation for targeted applications. This is the cornerstone of the New Plastics Economy and its first priority, which will help it to realize the following two ambitions.
2. Drastically reduce leakage of plastics into natural systems (in particular, the ocean) and other negative externalities.
3. Decouple plastics from fossil feedstocks by – in addition to reducing cycle losses and dematerializing – exploring and adopting renewably sourced feedstocks.

Figure 1: The New Plastics Economy and its three ambitions



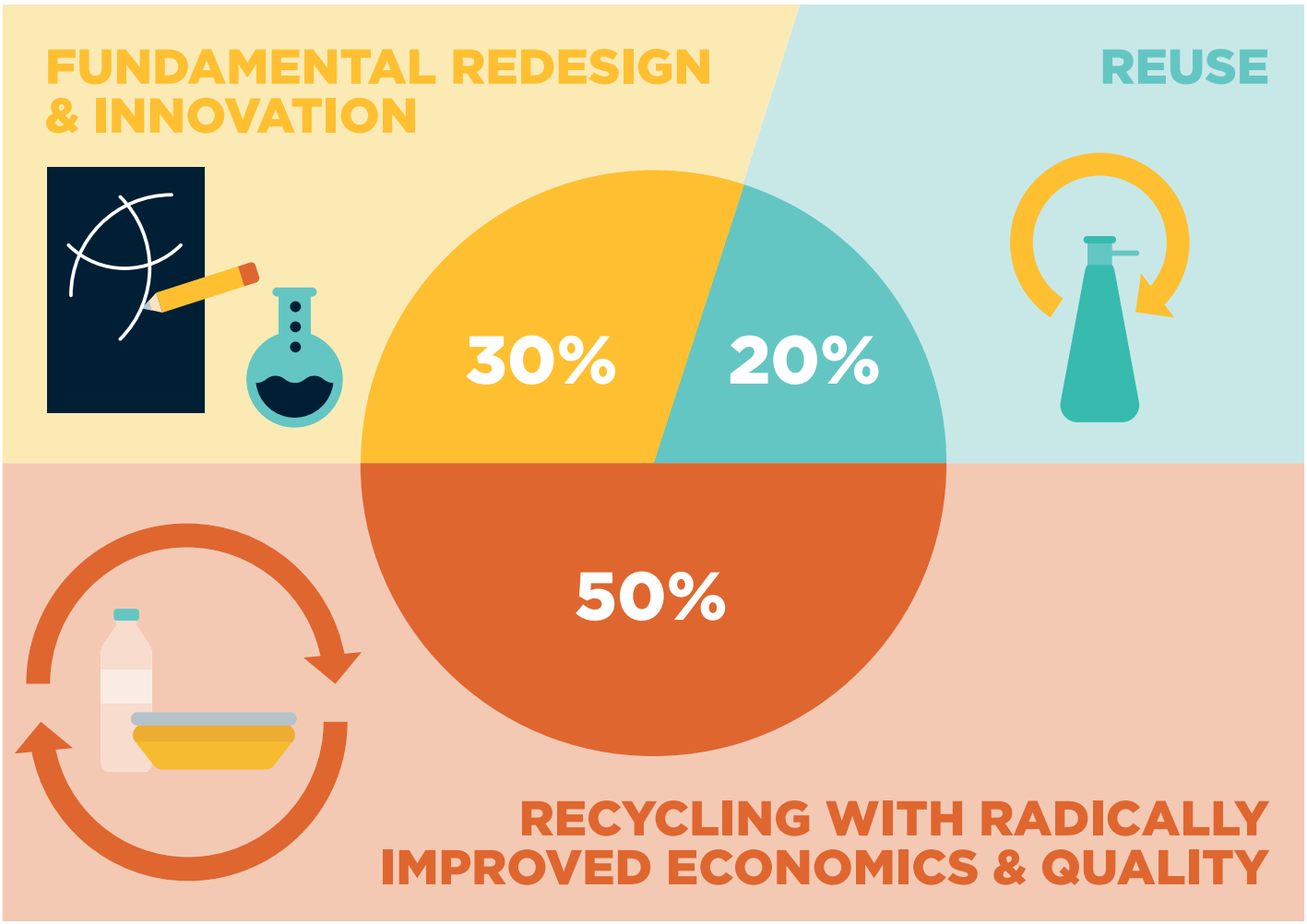
Source: *The New Plastics Economy – Rethinking the future of plastics*

The Road Ahead: Three Distinct Strategies to Drive the Transition

For the first time, a concrete set of priority actions for the global plastic packaging value chain to trigger an accelerated transition towards the New Plastics Economy has been identified. These actions are based on three major new insights. These insights were revealed through thorough analytical work, including a granular segment-by-segment analysis of the plastic-packaging market, numerous interactions with players across the plastics value chain and discussions with over 75 experts. The three insights, which have the potential to drive a genuine transformation within the plastic-packaging sector and herald the shift to the New Plastics Economy, are (see Figure 2):

- Without fundamental redesign and innovation, about 30% of plastic packaging will never be reused or recycled
- For at least 20% of plastic packaging, reuse provides an economically attractive opportunity
- With concerted efforts on design and after-use systems, recycling would be economically attractive for the remaining 50% of plastic packaging

Figure 2: Three distinct transitions strategies to accelerate the shift towards the New Plastics Economy (share of plastic-packaging market by weight)



Source: New Plastics Economy initiative analysis (see Appendix for details)

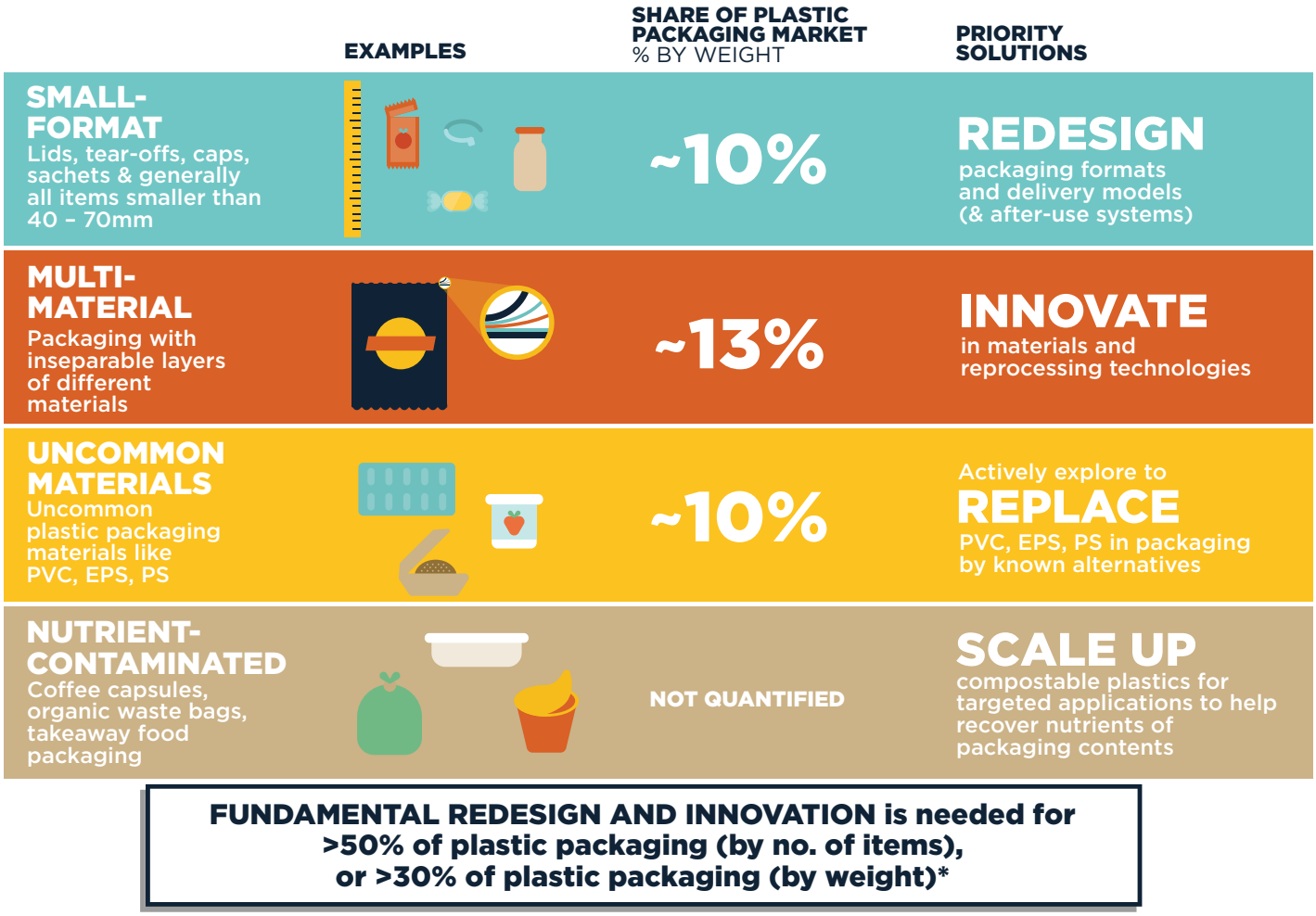
Without Fundamental Redesign and Innovation, about 30% of Plastic Packaging Will Never Be Reused or Recycled

This category, representing at least half of the plastic packaging items and about 30% of the total market by weight, consists of four segments: *small-format* packaging; *multi-material* packaging; *uncommon* plastic packaging materials; and *nutrient-contaminated* packaging (see Figure 3). While often offering high functionality, these packaging types do not have a viable reuse or recycling pathway and are unlikely to have one at scale in the foreseeable future. To shift these segments to a more positive material cycle, fundamental redesign and innovation of materials, formats, delivery models and after-use systems is required.

There are four plastic packaging segments which have a variety of barriers impeding an effective after-use pathway

***Small-format* plastic packaging (about 10% of the market, by weight, and up to 35%-50% by number of items), such as sachets, tear-offs, lids, straw packages, sweet wrappers and small pots, tend to escape collection or sorting systems and have no economic reuse or recycling pathway**. The small size of these items means they are likely to leak out of the system into the natural environment. This can be witnessed in emerging countries where their low after-use value makes them less likely to be collected by the informal sector (i.e. waste management activities carried out by waste pickers)[11] and in advanced economies, where items like lids, caps, straws and sweet wrappers are consistently mentioned as some of the plastic packaging items most found in litter.[12] Cleaning up these small-format items after they have escaped collection systems is particularly hard precisely because they are small. Sachets are a typical small-format example: they are used all over the world, but particularly in emerging markets, to sell products such as condiments and shampoo in small quantities, making them more convenient and affordable. Especially in countries without a formal collection system, many of these sachets end up as litter.

Figure 3: Plastic packaging segments that need fundamental redesign and innovation



* Total is not the sum of separate categories due to overlap
Source: New Plastics Economy initiative analysis (see Appendix for details)

Even when they are collected, small-format items are hardly ever recycled due to significant technical and economic barriers. A study ordered by the industry association, PlasticsEurope, estimated the effective recycling potential for this segment to be zero, even in an optimistic scenario.[13] The main barrier is the difficulty of sorting small-format items – a critical step in the recycling process. One of the first stages in automated sorting facilities is a screen that removes all small items, such as loose dirt, stones and other materials that could damage equipment in subsequent sorting steps. During this process, all items smaller than 40mm-70mm fall through the mesh in the screen, end up in the fines fraction, and are sent for energy recovery, incineration or landfill.[14] Due to the small size and low value of these items, a successive layer of sorting technology to extract the plastics from the fines fraction is not economically viable and is unlikely to be so in the foreseeable future.[15] In theory, manual sorting could perhaps overcome the technical barriers small-format items pose to automated sorting, but it is economically challenging given the low volume-to-time ratio of sorting these items.

Multi-material **packaging (about 13% of the market, by weight) currently cannot be economically, and often not even technically, recycled.** By combining the properties of materials, multi-material packaging can often offer enhanced performance versus its mono-material alternatives and resulting functional benefits, such as providing oxygen and moisture barriers at reduced weight and costs**.** However**,** this combination of multiple materials means that many of these applications, like those combining plastic and aluminium layers, are economically, and in some cases even technically, unrecyclable.

For some applications, technologies exist that, in theory, could capture part of the material value through downcycling, i.e. the process of converting materials into new materials of lesser quality, economic value and/or reduced functionality. For example, compatibilizers are chemical substances that can allow some multi-material packaging to be downcycled into blended materials. Still, such technologies lead to significant loss of material value in the recycling process and likely add just one extra use-cycle rather than creating a truly positive, virtuous material cycle.

Uncommon **plastic packaging materials (about 10% of the market, by weight), while often technically recyclable, are not economically viable to sort and recycle because their small volumes prevent effective economies of scale.**[16] The economics of plastics sorting, which is a critical step in the recycling process, are highly dependent on scale. If the volume of a certain material is too low, the additional sorting step becomes unaffordable. This is particularly relevant for business-to-consumer packaging, mainly collected as a mixed plastic packaging stream, as opposed to business-to-business packaging, where sometimes mono-material volumes are collected in bulk.

PVC, PS, and EPS stand out as uncommon plastic packaging materials to focus on first. They collectively represent 85% of the uncommon plastic packaging materials, so dealing with these three would make a huge impact on this segment. Their low volumes lead to poor outcomes: less than 5% of PVC packaging is recycled in Europe,[17] and PS and EPS are rarely sorted from household waste and recycled[18] (although there are occasional exceptions, including some very large-scale facilities in Germany).[19] Even if volumes were higher, problems remain. For instance, EPS is often used in takeaway food packaging such as clamshells, which become heavily contaminated with organic matter and disposed of in public bins for residual litter, further reducing recycling potential. Also, these materials frequently contaminate streams of other plastics and harm their recycling economics. For example, even very small concentrations of PVC (0.005% by weight) lead to significant quality reductions in recycled polyethylene terephthalate (PET)[20] and EPS is a known contaminant for polyolefin recyclers as it is not removed during the float-sink separation process. In addition, there are safety concerns about PVC. It often contains vinyl chloride monomers, which are carcinogenic to humans, and many additives, including phthalates, a class including substances like bis(2-ethylhexyl) phthalate (DEHP), about which concerns have been raised relating to negative effects on human health and the environment.[21]

Nutrient-contaminated **packaging is often difficult to sort and clean for high-quality recycling.** This segment includes applications that are prone to be mixed with organic contents during or after use. This could either be by design, such as in coffee capsules, or because the application leads to a high food waste-to-packaging ratio after use, such as food packaging for events, fast food restaurants and canteens. Either way, when there is high contamination with organic nutrients, recycling becomes problematic, as organic residues and odours might be hard to separate from the packaging in the recycling process.

A combination of redesign and innovation solutions is required to make progress in these four challenging plastic packaging segments

Given the wide variety of barriers impeding effective after-use pathways for the four segments, it is unlikely there will be one instant and effortless solution at scale for them all. However, when looking at each category individually, clear priority redesign and innovation areas emerge, as outlined below. As always, when making progress in these segments, it is important to take a system perspective and understand the broader impact of interventions, including the impact of packaging on packaged goods. Given that these products have significant functional benefits, their drawbacks are not necessarily arguments to remove them *all* from the market *today* but rather to start on a path of reinvention as outlined.

Format and delivery model redesign could reduce or eliminate the need for *small-format* plastic packaging items, while providing the same or even better functionality. Beverage cans are a classic example of the potential of format redesign. The tear-off tab, being a small-format item, was difficult to collect and prone to leakage until it was replaced in the 1970s by the stay-on tab that is prevalent today. The potential of format redesign can also be witnessed in innovative personal care bottles and tubes for which separate, small-format components have been designed out. Examples include the flip-top cap for ketchup or shampoo bottles, which connects the closure to the main packaging, or the Nephentes bottle concept, by which items can be closed without a cap.[22]

Delivery-model redesign could involve reusable or returnable packaging items, or even reduce the need for the packaging in its current form. For example, a dispenser could replace sachets in restaurants or shops; such a delivery model would have the potential to supplant billions of small-format items being used every year. The Disappearing Package illustrates how redesigning the packaging concept could work for several packaging applications, including laundry detergent pods. The new pods are water-soluble and stitched together forming a sheet, so the user can tear off a pod each time and use them one-by-one. With the last pod, the package itself is gone.[23]

While redesigning formats and delivery models is the most powerful approach for the small-format segment, such redesign efforts take time and might not be applicable to *all* small-format items. For some targeted applications, designing small-format items with compostable materials could be another potential solution – though its implementation brings a series of challenges that need to be addressed first. Also, the redesign efforts should be combined with actions focusing on after-use collection, sorting and reprocessing innovations for small-format items.

For *multi-material* packaging, both material and reprocessing technology innovations would need to be explored. Replacing layers of different materials by one material, while maintaining the same functionalities, could lead to packaging which is more suitable for recycling. For example, Dow Chemical, together with Printpack and Tyson Foods, developed a mono-material, stand-up pouch with improved recyclability versus the existing multi-material alternatives, suitable for a specific set of applications (e.g., certain frozen food segments).[24] Another potential way ahead is the development of compostable multi-material packaging, which combines enhanced performance due to the use of multiple layers of different materials, with an effective after-use pathway (such as composting or anaerobic digestion). The benefits of such compostable packaging, and the conditions needed for it to work, are laid out further in this section, when discussing solutions for nutrient-contaminated applications. To replace multi-material packaging with recyclable mono-material or compostable packaging – with similar performance, weight, and costs – continued innovation-at-scale is needed.

Innovation in reprocessing technologies could also create new, viable after-use pathways for multi-material packaging (and possibly some of the other plastic packaging segments for which there are currently no technical or economic recycling routes). Two prominent examples are:

– Thermochemical recycling technologies, such as pyrolysis, could, in theory, provide a closed-material loop for currently unrecyclable packaging items. They work by breaking down the material into a mix of hydrocarbon molecules, which could be refined into precursors for making new plastics. These technologies should not be relied on as silver bullets – they are an energy-intensive outer loop where little material value is retained, compared with, for example, reuse or mechanical recycling. Furthermore, it remains to be proven that these technologies, in practice, can realize closed-material loops with high yields of hydrocarbon output being fed back into the polymer production processes. Current applications of the technology are still largely confined to the conversion of plastics into a (non-renewable) fuel. This provides a brief second use but also leads to the definite loss of the material and so perpetuates a linear, take-make-dispose model. Other issues to be explored within this process are the potentially fragile economics, energy requirements and how it relates to substances of concern.[25]
– Disassembly of multi-material laminates could provide another alternative. Companies like Saperatec (delaminating),[26] Cadel Deinking (delaminating)[27] and APK (dissolving)[28] are developing or scaling up technologies that separate materials after use. Like the thermochemical recycling technologies, they currently only exist at pilot scale, with the first industrial-scale plants just built or planned to be built over the coming years. The potential impact of these technologies, and how their performance could be influenced by packaging design (e.g., design for easy disassembly), remains to be seen.

In summary, innovation in reprocessing technologies should be explored but not relied on as the single, simple solution. Rather, it should be investigated as part of the broad range of redesign and innovation activities outlined above to propel the multi-material segment and possibly some other plastic-packaging segments for which, at the moment, there are no technical or economic recycling routes.

Replacing the *uncommon* materials PVC, EPS, and PS in packaging with known alternatives would need to be actively explored. This would enhance recycling economics and reduce the potential negative impact of substances of concern. As discussed in the 2016 *The New Plastics Economy – Rethinking the future of plastics* report, for many PVC, PS, and EPS packaging applications alternative solutions are already in place.[29] Also, the use of these materials in packaging is already declining, as businesses and policy-makers alike are reducing or phasing them out – their replacement represents an accelerated evolution rather than a revolution.[30] For cases where no clear solutions with similar cost and functionality yet exist, research and innovation would need to be focused on developing alternatives.

Of course, not *all* uncommon plastic packaging materials should be replaced by known alternatives. By definition, any new material will, on introduction to the market, initially have small volumes and there should be space for such innovation – it is a core aspect of the transition to the New Plastics Economy.

Scaling up the use of compostable materials and the infrastructure for targeted *nutrient-contaminated* applications could help return organic nutrients to the soil, thus contributing to natural capital maintenance. For example, when made of compostable materials, fast-food packaging could be disposed of, together with its contents, in an organics bin. This would increase the value capture of organic material through composting or anaerobic digestion. Compostable materials could also reduce the impact of unintentional leakage, if the material can truly degrade safely and completely in a range of different, uncontrolled environments – a strong assumption that would need serious innovation to become reality across a wide range of applications.

Of course, as laid out in *The New Plastics Economy – Rethinking the future of plastics*, several elements need to be in place to make wider use of compostable plastics beneficial. These include the development of adequate infrastructure to handle such materials (e.g., separate collection of organics, composting or anaerobic digestion facilities) – infrastructure which is emerging but not yet widely available in many parts of the world.

Priority actions to reinvent the 30% of the market without a viable reuse or recycling pathway are:

- Fundamentally redesign the packaging formats and delivery models (and after-use systems) for *small-format* plastic packaging, avoiding such small formats where relevant and possible
- Boost material innovation in recyclable or compostable alternatives to the currently unrecyclable *multi-material* applications as described above
- Replace PVC, PS and EPS, as a priority, as *uncommon* packaging materials with alternatives (converging to a few key materials being used across most of the market, while continuing to allow for innovation)
- Scale up compostable packaging and related infrastructure for targeted *nutrient-contaminated* applications
- Explore the potential as well as the limitations of chemical recycling and other technologies to reprocess currently unrecyclable plastic packaging into new plastics feedstocks

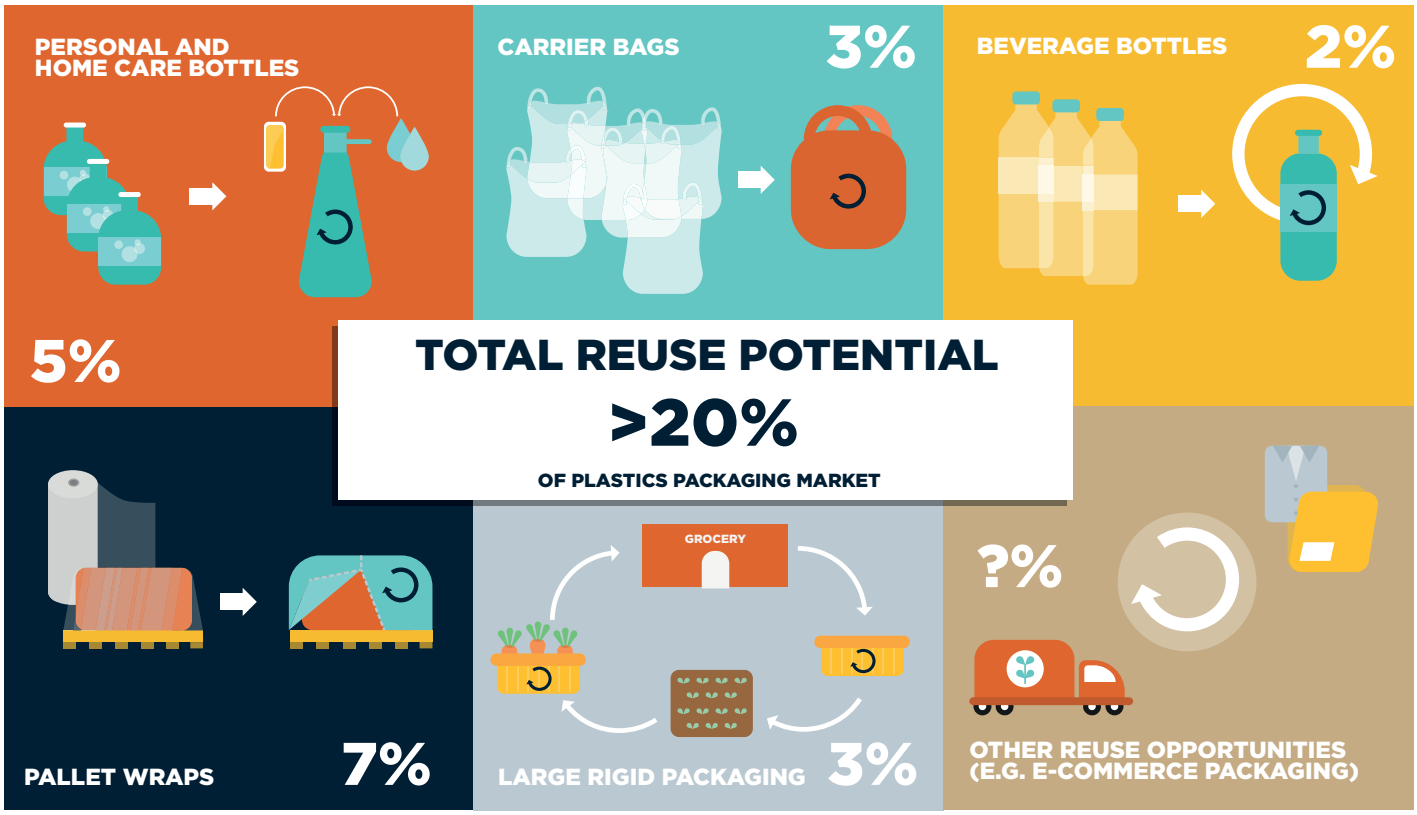
For at Least 20% of Plastic Packaging, Reuse Provides an Economically Attractive Opportunity

Reusable packaging was a common choice until roughly half a century ago. Since then, single-use, disposable packaging has increasingly become the preferred option. Nowadays, recent innovation, evolving use patterns, and societal acceptance are again positioning reuse models as attractive options for some plastic packaging segments. The plastic packaging reuse opportunities identified and quantified in this update report represent at least 20% of today's market, by weight (see Figure 4). The examples of personal and home-care bottles and carrier bags alone could generate about 6 million tonnes of material savings and an economic opportunity of $9 billion. More could be unlocked as business-model innovation continues to push the boundaries of application to create a variety of attractive reuse models. As always, when evaluating different reuse models, it is important to take a system perspective.

Personal and home-care bottles: Innovative delivery models could result in 80%-90% packaging material savings

Innovative delivery models can create value by encouraging the reuse of packaging in the home. Such new models could affect a range of segments, including laundry liquid, home cleaning, as well as bath and shower products. Many of these goods, which usually come in single-use bottles, mainly consist of water, with only a small volume of so-called "active ingredients". A delivery model using refillable bottles, for which only such active ingredients are sold and shipped, can offer significant material and transport savings. Splosh[31] – with dissolvable sachets – and Replenish[32] – with refill pods – show these models are viable. Their innovative delivery models could lead to 80%-90% packaging material savings and 25%-50% packaging cost savings, offering clear incentives for businesses and customers alike.[33]
If such reuse models were to be applied to all bottles in beauty and personal care as well as home cleaning, this would amount to about 3 million tonnes or at least $8 billion packaging cost savings.[34] In addition, shipping only active ingredients would result in 85%-95% transport cost savings. Packaging and transport savings together would represent an 80%-85% reduction in greenhouse gas emissions versus today's traditional single-use bottles.[35] Such delivery models could also apply to other products that mainly consist of water, such as laundry products, sprays for lawn and garden use, pet-care products and even the beverage market, as demonstrated by Sodastream[36] and MiO[37].

Figure 4: Selected plastic packaging reuse opportunities



Source: New Plastics Economy initiative analysis (see Appendix for details)

Carrier bags: Reusable bags could replace over 300 billion single-use carrier bags per year, generating $0.9 billion in material cost savings

About 330 billion single-use plastic carrier bags are produced every year – that is over 10,000 bags per second.[38] They have an average use period ranging from only a couple of minutes to a few hours, after which many leak into the environment and almost none is recycled.[39] In emerging economies, the economics of waste picking are not favourable enough for collecting carrier bags as it takes so long to aggregate a significant mass of material.[40] In advanced economies, bags are prone to leak into the natural environment – plastic bags are among the most-found plastic packaging litter items.[41] Public awareness of this problem is growing and, with reusable alternatives available, so are regulatory interventions: at least 35 countries worldwide have taken action to tax or ban single-use carrier bags.[42] Also, front-running businesses are acting, as shown by the retailer Carrefour, which announced at the UN Climate Change Conference 2016 in Marrakech its commitment to eliminate all free single-use carrier bags throughout its worldwide integrated store network by 2020.[43] Encouragingly, these outcomes have often been achieved by very small charges on bags and without major resistance, indicating the readiness and acceptance of the public for this type of policy. For example, studies reported an instant 80%-95% drop in usage of single-use carrier bags and a reduction of over 90% in the share of plastic bags in the total visible litter items in the first year after such an intervention.[44]

If all countries in the world were to achieve 95% replacement of single-use carrier bags by reusable alternatives, this would represent an annual reduction of over 300 billion single-use plastic bags. Even when considering rebound effects in terms of increased production of reusable bags and bin liners (as single-use bags often get a second use as bin liner), this would lead to over 2 million tonnes of material savings and $0.9 billion material cost savings.[45] The latter is excluding additional cost savings in collecting and reprocessing carrier bags after use and a reduction in negative externalities related to the leakage of single-use carrier bags, such as impacts on infrastructure and the environment.

Beverage bottles: Reuse systems could offer economic and environmental benefits in the right circumstances

Beverage bottles are a major plastic packaging application, representing at least 16% of the market (by weight).[46] While widely collected for recycling, the material value loss of single-use beverage bottles after each use cycle is still significant; even for PET bottles in Europe, this loss is over 50%.[47] As shown by various studies, reuse models – be it returnable bottle systems (with or without deposit) or refillable bottles at home or on the go – can, given the right local conditions, offer an attractive alternative with the potential for lower material costs and a considerably lower carbon footprint than single-use alternatives.[48] Moreover, reuse models for beverage bottles, both plastic and non-plastic ones, have a proven track record.

The success of return systems for beverage bottles relies on several factors: cost of raw materials relative to other input costs; cost and distance of collection and redistribution infrastructure; level of differentiation of packaging; regulatory framework; and use pattern.[49] Each of these factors needs to be considered to evaluate the potential benefits of reusable bottle systems for any specific case.

The success of refillable bottles at home or on the go is impacted by the availability of refill stations (e.g., drinking water fountains) and user preferences. As the global reusable water bottle market (valued by Transparency Market Research at about $7 billion in 2015) is estimated to grow by more than 4% year on year between 2016 and 2024, reuse models are again positioned as an attractive alternative.[50]

Considering the success factors, a reuse model is estimated to offer economic and environmental benefits for at least 10% of all beverage bottles worldwide, or at least 2% of the global plastic packaging market. Whether such a system should be based on returnable (deposit) bottles or user refillable bottles depends on the exact application and local circumstances.

Business-to-business large rigid packaging: Although implemented in some sectors, returnable packaging could create further economic value by increasing its use, pooling, standardization and modularization

Large rigid business-to-business packaging items, such as pallets, crates, foldable boxes, pails and drums (i.e. cylindrical containers used for storing and shipping bulk cargo), have a sufficiently high material value to make reuse business models profitable. They are often used 20 to 100 times depending on the application and the vast majority are recycled afterwards.[51] These plastic reusable packaging items often replace non-plastic alternatives, such as cardboard boxes or wooden pallets. A study on the Schoeller Allibert's Maxinest® tray for food and grocery distribution shows that as soon as this reusable packaging is used 20 times, it is environmentally and economically beneficial versus single-use cardboard boxes. In reality, this type of product is estimated to have over 90 use cycles, on average, before being recycled.[52] The critical part of this reuse business model is the reverse logistics where crates or pallets are sent back, often empty. To overcome this, pooling solutions companies like Brambles offer logistics services, managing a shared pool of standardized pallets and crates across a wide and dense network of companies, leading to significant logistics savings.

There is still economic potential to be captured by implementing standardized returnable rigid packaging systems at scale. Currently, large differences exist in both the use of reusable transport packaging and the share of pooled versus non-pooled reusable packaging, both between and within industries.[53] These differences indicate the potential to capture further efficiency gains and, therefore, economic value. In addition, as mentioned in *The New Plastics Economy – Rethinking the future of plastics*, global standardization and modularization could facilitate pooling and help to realize the vision of the Physical Internet, a logistics system based on standardized, modularized and reusable containers, using open networks across industries with pooled assets and protocols.[54]

Business-to-business pallet wrap: Scaling up existing reuse solutions could create economic and environmental value

Single-use pallet wraps (e.g., stretch wraps and shrink hoods) are currently the default choice to stabilize and secure products on pallets during transport, leading to an estimated annual pallet wrap film production of 5 million-6 million tonnes.[55] Globally, most of the material value of these films is lost after one use cycle – even though in some regions, large and sometimes medium enterprises have dedicated collection systems for commercial film.[56] Several reusable solutions to address this material value loss are available.[57] Lid and strap systems, as provided by Loadhog, are already used in a range of industries, such as postal (e.g., Royal Mail), automotive (e.g., Honda) and healthcare (e.g., Baxter Healthcare UK).[58] Reusable pallet wrappers, offered by companies like Reusa-wraps, Envirowrapper and Dehnco, have already been adopted by other companies across various sectors such as Aldi, Universal, AkzoNobel, Budweiser, Coca-Cola, Pepsico, Verizon and Microsoft.[59] Taking the modularization and standardization of business-to-business packaging one step further, and developing containers that can be interlocked to act as one unit, might even avoid the need for wrapping altogether. This concept has been developed and researched by the MODULUSHCA project,[60] which is aligned with the Physical Internet vision.

Delivery model innovation and continued increase of societal acceptance, and even preference, could unlock further plastic packaging reuse opportunities

Alongside the above examples, other opportunities for reuse business models exist or could be envisioned across different sectors. Repack, for example, is a system for reusable transport packaging in the rapidly growing and packaging-intense e-commerce market. After unpacking the delivered item, people can simply fold the packaging, drop it in the nearest postbox to send it back, free of charge, for reuse, and receive a voucher for doing so.[61] The Repack example illustrates an innovative way of dealing with the reverse logistics challenge, often a key factor for successful implementation of reuse models. With innovators exploring new delivery models and people increasingly accepting – or even actively seeking – such reusable packaging, multiple reuse opportunities are likely to be discovered and successfully deployed.

To capture the reuse opportunity, a set of priority actions has been identified:

- Innovate towards creative, new delivery models based on reusable packaging
- Replace single-use plastic carrier bags by reusable alternatives
- Scale up reusable packaging in a business-to-business setting for both large rigid packaging and pallet wrap

With Concerted Efforts on Design and After-use Systems, Recycling Would Be Economically Attractive for the Remaining 50% of Plastic Packaging

The uptake, economics and quality of plastic packaging recycling are currently in a fragile state. At the moment, only 14% of plastic packaging is collected for recycling globally[62] – a number that reflects the economic challenges of gathering and processing a diversity of packaging formats and materials through fragmented and sometimes under-developed after-use systems. Although recycling economics are stronger for some packaging applications, such as PET beverage bottles, on average, the cost of collection, sorting and recycling outweighs the generated revenues. Estimates suggest that in Europe this cost is about $170-$250 per tonne collected, compared with the cost of collection and disposal of plastic packaging as part of residual waste[63] – an average across widely different collection and sorting systems, regulatory and geographical conditions and packaging types. This net cost estimate excludes the additional environmental and societal benefits of plastics recycling such as: reduced greenhouse gas emissions; reduced environmental impacts on land use, biodiversity and air quality; and job creation. For example, one tonne of plastic collected for recycling avoids emission of an estimated one tonne of carbon dioxide equivalent greenhouse gas compared with a mix of landfill and incineration with energy recovery.[64] This alone has an estimated societal value of more than $100 per tonne of plastics collected for recycling.[65]

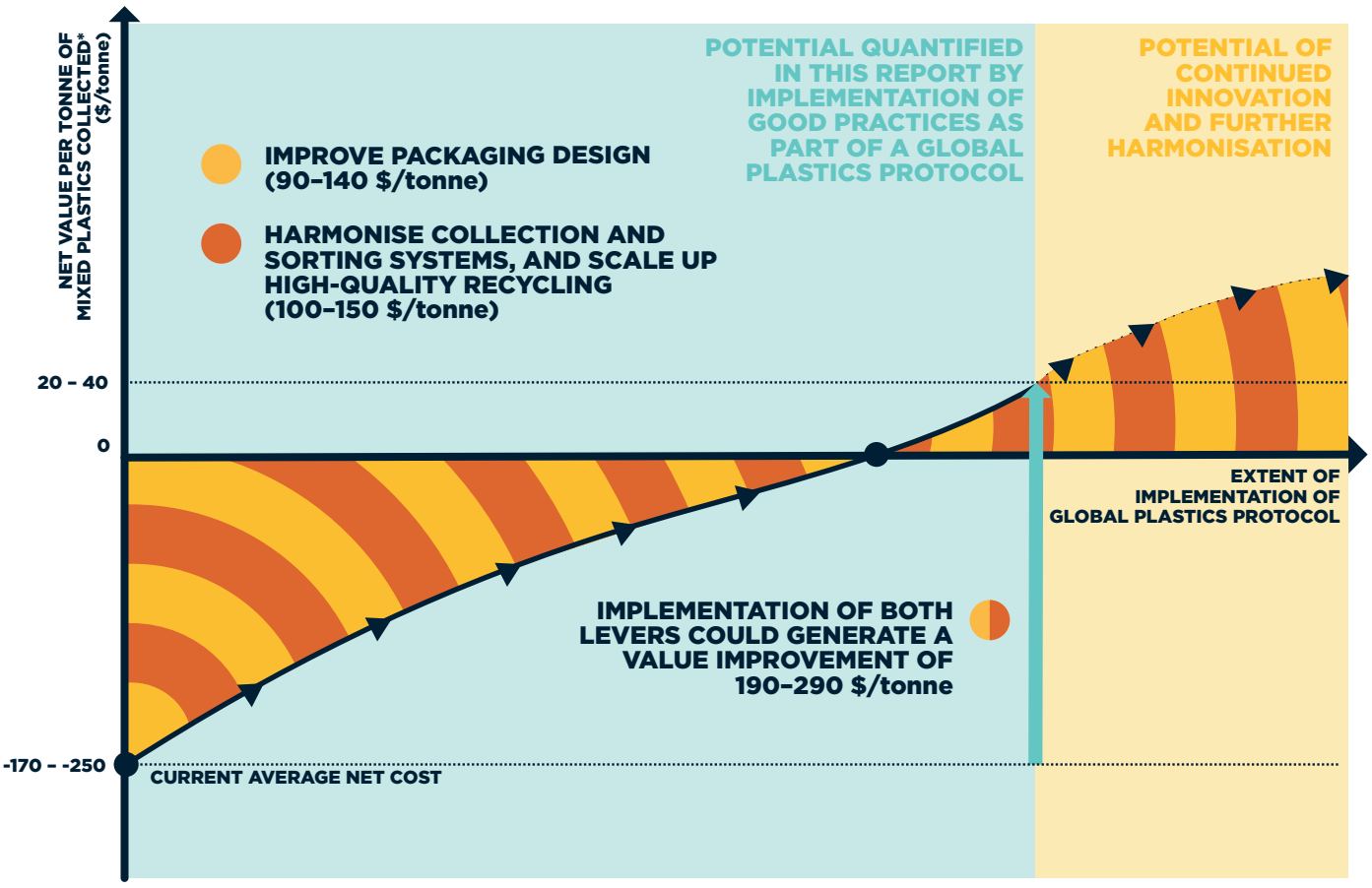
There are several reasons for these fragile economics of collection, sorting and recycling. Plastic packaging materials and formats are diverse and there is a further threat from continued, unrestrained diversification into new materials and formats, which, while often bringing important functional benefits, have lower value in the after-use recycling system and drive up its costs. Also, the entire system of collection and sorting is highly fragmented, which prevents economies of scale and the delivery of consistent, high-quality material streams to recyclers. Furthermore, both virgin and recycled plastic prices have been volatile and declining for many plastic types between 2012 and 2015, especially for PET, when the price of recycled PET dropped by 30%-40%.[66]

A much-needed collaborative approach towards packaging design and after-use systems could increase recycling economics by $190-$290 per tonne collected for recycling67 ($2 billion-$3 billion annually in the OECD region).

A concerted, cross-value-chain, global approach is required to improve plastic packaging recycling uptake, economics and quality. Many – often local and small-scale – initiatives aim for these improvements, demonstrating the broad awareness and appetite for change. However, collectively they have not scaled up to the extent required, as evidenced by the current 14% global recycling rate. As described in *The New Plastics Economy – Rethinking the future of plastics*, a Global Plastics Protocol provides a common target state to innovate towards, that would overcome existing fragmentation and enable the creation of effective markets. It would guide convergence of packaging design (materials and formats) and after-use systems (collection, sorting and reprocessing) towards best practices, while allowing for regional differences and innovation, thus improving recycling economics.

Implementation of good practices in packaging design and after-use processes as part of a Global Plastics Protocol could generate a value improvement of $190-$290 per tonne of plastics collected, lifting economics into positive territory. As detailed below, this improvement, representing $2 billion-$3 billion a year for OECD countries, requires concerted action both on packaging design and after-use systems – neither of these mutually reinforcing areas would be able to trigger this system shift on their own. Implementing such a set of good-practice levers would be no small feat but, if done successfully, would move recycling economics into positive territory (on average) (see Figure 5). In this way, it would reinforce recycling as an attractive, cost-competitive alternative to landfill, incineration, or energy recovery by increasing the capture of material value and resource productivity, as well as decoupling the system from fossil feedstocks and reducing greenhouse gas emissions and other negative externalities. While implementing such a Global Plastics Protocol would lift the *average* profitability of plastic packaging recycling, significant challenges remain for specific packaging segments, such as technological barriers for sorting post-consumer films. Also, the estimates in this report are based on current plastics prices. If these change significantly, the economics of the recycling situation could become very different too.

Figure 5: Potential impact of Global Plastics Protocol implementation on the economics of plastic-packaging recycling (average for mixed plastic packaging collected in EU member states)



* Value is calculated as average net cost/benefit of collection, sorting and recycling relative to net cost of collect/dispose alternative; and as an average across geographies, materials and formats – some market segments have much better economics, some have worse.

Source: New Plastics Economy initiative and SYSTEMIQ analysis (see Appendix for details)

Packaging design improvements could create at least $90-$140 per tonne of plastic packaging collected.

Packaging design has a direct and significant impact on the economics of collection, sorting and recycling. The choice of materials, colours, formats and other design factors determines whether a packaging item will generate positive after-use revenues – and how much – if it is recycled, or whether it will lead to the additional cost of disposal otherwise. Non-recyclable items entering the recycling stream incur an estimated additional net cost of up to $300-$350 per tonne collected, compared with designs that are easily recyclable.[68] For example, with their low recyclability compared to clear bottles, opaque PET bottles (about 5,000-6,000 tonnes sold in France alone each year)[69] add an estimated $1 million-$2 million a year in avoidable costs to the French recycling system.[70]

Implementing four areas of packaging design changes could have a positive impact on recycling economics amounting to $90-$140 per tonne collected ($1.1 billion-$1.6 billion in OECD).[71]

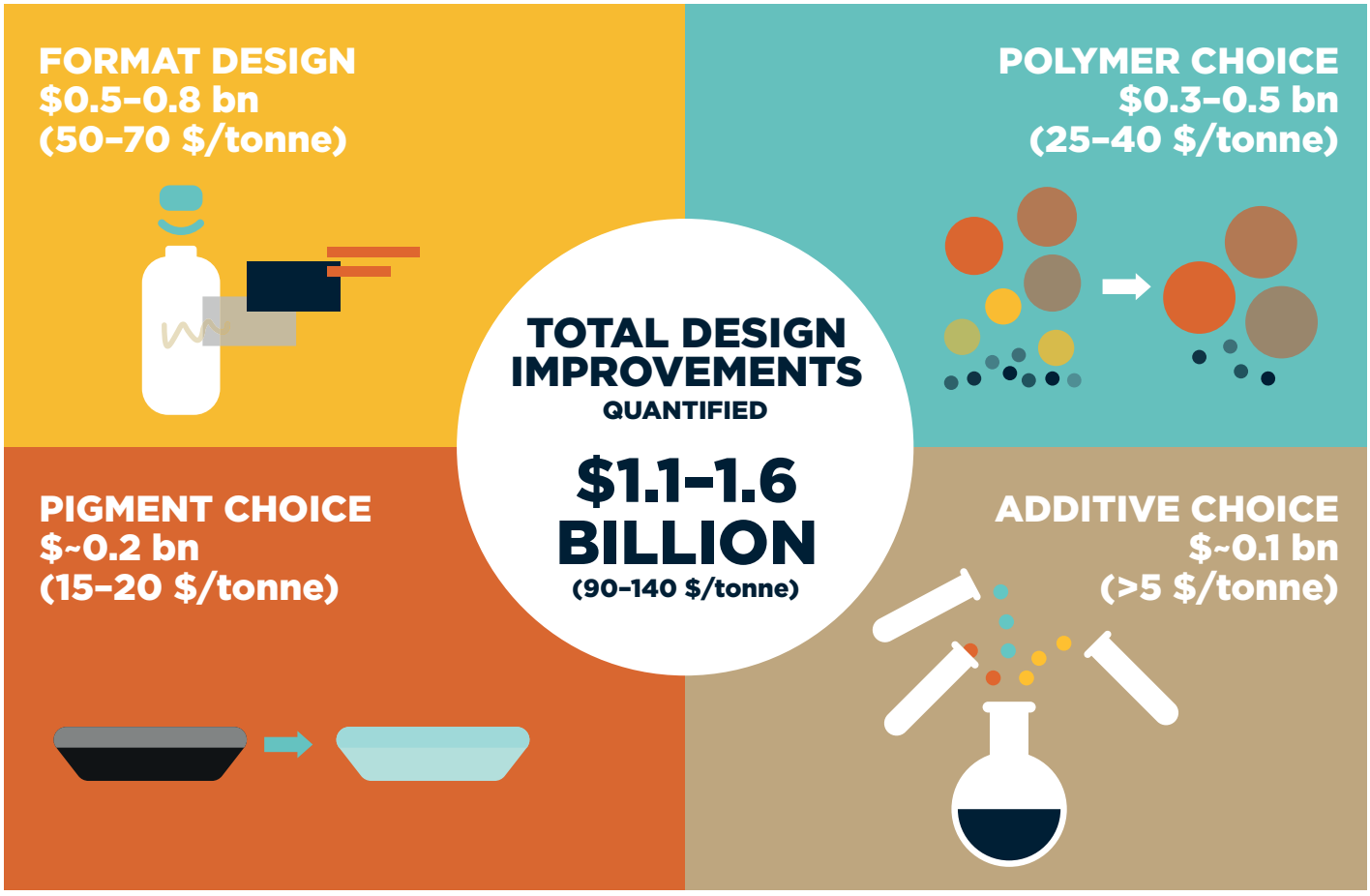
The four areas for which impact has been quantified are (see Figure 7):

1. **Format design ($50-$70 per tonne)**. Format design improvements can have a direct and significant impact on the recycling economics, depending on the type of packaging. Examples include design choices relating to: labels; sleeves; inks and direct printing; glues; closures and closure liners; (silicone) valves, pumps and triggers; attachments and tear-offs; and the form or shape of the packaging. For example, one industry study from the Association of Plastic Recyclers identified that full sleeve shrink labels on PET bottles alone could affect recycler economics by $44-$88 per tonne of recycled PET produced.[72] Input from industry experts and studies indicate that up to 15% of mixed plastic packaging collected is lost during sorting and recycling because of format design issues.[73] Assuming that format design improvements, excluding the changes below, can reduce material losses by 7.5% of plastic packaging collected (i.e. half of the estimated losses), this would lead to economic benefits of $50-$70 per tonne of mixed plastic packaging collected.
2. **Polymer choice ($25-$40 per tonne)**. As pointed out earlier, plastic materials uncommon in packaging are rarely recycled because they do not benefit from economies of scale in sorting and recycling, and they can also hinder the recycling process of more prevalent polymers. As an example, replacing PVC in packaging applications by more common polymers would remove

a source of contamination in the PET recycling process and thus positively impact the yield and recycled PET price. In addition, such replacement would turn collection and disposal costs of unwanted PVC into increased recycling volumes and revenues. Combining these effects, replacing all rigid PVC (1.5%-2% of plastic-packaging market) by more widely recycled polymers would lead to an economic benefit of $15-$20 per tonne of mixed plastic packaging collected. In addition, replacing PS and EPS as packaging materials (6% of the market) with more common polymers would improve system economics in a similar way, by an estimated $15-$20 per tonne of mixed plastic packaging collected. As noted earlier in this report, implementing this change is an acceleration of an existing evolution rather than a revolution. The shares of these materials in the global packaging market are already declining.[74]

3. **Pigment choice ($15-$20 per tonne)**. Colouring plastics using pigments reduces the value of the recycled materials (up to $100-$300 per tonne of recyclate).[75] Therefore, moving a greater share of plastic packaging from coloured or opaque materials to clear or light-coloured translucent materials would create substantial value in the after-use system. As an example, shifting an estimated three quarters of coloured rigid plastic packaging represents an economic opportunity of $10-$15 per tonne of mixed plastic packaging collected. Werner & Mertz is one example of a company explicitly choosing not to colour its high-density polyethylene (HDPE) detergent bottles to allow the material to serve again as a bottle in its next-use cycles.[76] Also, phasing out the carbon black pigment in plastic packaging would reduce losses in the sorting process, as it is not detected by near-infra-red machines commonly used for automatic sorting. These sorting losses result in an avoidable cost of about $200 per tonne of such packaging collected for recycling, compared with packaging without carbon black. Looking at the total plastic packaging market, it is estimated that if all carbon black (used in 1.5%-2% of packaging, by weight) was replaced by other pigments already available, this would generate an economic benefit of $3-$5 per tonne of mixed plastic packaging collected.[77]
4. **Additive choice (at least $5 per tonne)**. Packaging design guidelines and expert interviews highlight that certain additives used in plastic packaging have a negative impact on recycling, even though the precise extent is unclear.[78] For example, PET bottle-to-bottle recyclers have reported discolouration of the recycled material[79] due to certain additives, leading to an estimated 30% decrease in revenues, or up to $300 per tonne of recyclate at current prices, for that specific material. If 2% of the bottle-to-bottle recycled PET is impacted in this way, it represents a $0.5-$1 per tonne of plastic packaging collected across the board. In addition, certain additives affect the density of plastics, leading to avoidable losses during float-sink sorting processes.[80] For each tonne of plastic affected in this way, the additional cost to the after-use system is an estimated $300-$350. Assuming 2% of polyolefins collected for recycling are lost in this way, replacing them by additives without density effects would increase the value by about $3-$5 per tonne of mixed plastic packaging collected. More research is needed to understand the full effect of plastic additives, particularly if the recycling system continues to move to higher-quality processes and products.

Figure 6: Economic value creation potential of selected design changes in four areas (absolute value for OECD region; $; value per tonne of mixed plastic packaging collected, $/tonne)



Source: New Plastics Economy initiative analysis (see Appendix for details)

The above estimates can be considered conservative as they provide a snapshot of economic opportunities from improving packaging design in the current after-use system, without the more complex effects and interdependencies that could lead to higher economic benefits. For example, the impact of certain design improvements is likely to be more apparent in a higher-quality recycling setting, compared with down-cycling processes that are more tolerant of diverse inputs and are still common nowadays.

To successfully implement the design changes above, communication between packaging designers at the front end and the after-use processors at the back end is an important enabler. Such feedback loops would also help to understand further design-improvement potential.

As a key complement to design improvements, harmonization of after-use systems could enhance recycling economics by an estimated $100-$150 per tonne of collected plastic.

Currently, collection and sorting systems are highly fragmented, negatively impacting the recycling economics. As discussed in more detail in *The New Plastics Economy – Rethinking the future of plastics*, after-use systems often operate at a small scale and with widely differing approaches, even within a given country or city. This disparity not only causes confusion for the wider public but also makes it hard for packaging designers to plan a target system, and it prevents the creation of economies of scale in the after-use system. This fragmentation also hinders delivery of consistent, high-quality material streams to recyclers, who frequently source materials from different collection systems and sorting plants. This complicates their operations and increases costs.[81]

Converging after-use collection and sorting systems towards good practice could improve plastic packaging recycling economics by an estimated $80-$110 per tonne collected ($0.8 billion-$1.3 billion in OECD). This improvement estimate assumes that 75% of the total potential of successful harmonization would be captured, including a range of good practices such as a cost structure in line with large-scale sorting facilities in Europe.[82] Of course, given the fragmented nature of the existing systems, such a harmonization effort would take time. Encouragingly, multiple countries and regions (including British Columbia in Canada[83] and the UK[84]) recognize the benefits of this approach and have already started implementing a convergence agenda – a Global Plastics Protocol could play an important role in guiding this convergence worldwide.

At the reprocessing stage, a further scale-up of high-quality recycling, that is often low-quality today, could generate an estimated benefit of $30-$40 per tonne collected ($0.3 billion-$0.5 billion in OECD). Increasing the share of high-quality recycling for plastic packaging would enable more high-value applications for the recycled material, with a corresponding increase in sales prices for recycled plastic. This approach has been adopted for PET bottle-to-bottle recycling facilities and is starting to be developed for other segments of the packaging market, particularly PE and PP.[85] While these two plastic types, compared with PET, might present additional challenges to achieving high-quality recycling (e.g., absorption of chemicals or odours), several companies have proven the feasibility of recycling these materials into high-quality applications including packaging (e.g., through the use of hot-washing and degassing).[86] Assuming that 25% of PE and PP recycling would shift to higher-quality recycling, the additional revenues, even minus the additional costs and yield losses, would generate an estimated benefit of $25-$40 per tonne of mixed plastic packaging collected.

New technologies and approaches may provide further opportunities to improve the economics of the recycling system. There are multiple examples of such innovative technologies and approaches, even though it is too early in their development to quantify the potential impact. Material markers, such as chemical tracers or digital watermarks, are currently researched and piloted but industry views vary widely on their importance, feasibility and cost effectiveness.[87] Such markers could provide new sorting possibilities in regions where automatic sorting is available, resulting, for example, in an increasing opportunity to supply higher-value food grade plastics. Global convergence on marking standards would be required to maximize the impact. Finding a solution for sorting different types of flexible plastic packaging, a segment representing approximately one third of post-consumer packaging (by weight) and a production of around 1 trillion units a year, could significantly increase the volume of packaging available for recycling – although the impact on economics remains unclear.[88] Furthermore, depolymerization (a chemical recycling process breaking down polymers into their monomer building blocks) could offer additional opportunities for high-quality recycling – a technology currently most advanced for polyesters like PET.

Combining continued innovation with further harmonization of packaging design and after-use systems would drive a virtuous, positive spiral for the uptake, economics and quality of plastic packaging recycling. While the direct economic impact of implementing a Global Plastics Protocol would be sizeable, making recycling economically viable would also move the system into an upward spiral. There would be a financial incentive to collect and recycle more. Higher volumes would create further economies of scale and allow separation of purer grades, which, in turn, would increase yield. This would set a direct incentive for yet more collection and an indirect incentive for better material designs. Therefore, innovation and harmonization both of packaging design and after-use systems are mutually reinforcing and the positive thrust they could generate would close the loop for a significantly higher share of plastic packaging, including more challenging segments. This upward spiral would eventually allow leakage and economic value loss to be overcome as recyclate quality steadily converges towards virgin material value.

Given the current fragile recycling economics, a demand-pull for recycled plastics and other supporting policy measures is needed to start building positive momentum in the near term.

Measures to support demand for recycled plastics would provide a critical incentive for system improvements. Voluntary industry commitments, public procurement policies and regulations can all create a demand-pull that can build positive momentum in the near term. Moreover, increased demand for *higher-quality* plastics, including for packaging, can be an impetus specifically for investments and improvements in the *high-quality* recycling processes outlined in this report. For example, the establishment of high-quality PET bottle-to-bottle recycling is often attributed in part to strong demand for recycled content from beverage companies[89] and California's Rigid Plastic Packaging Container Law (requiring producers of rigid containers to use at least 25% recycled content)[90] has been mentioned as a boost to HDPE recycling US-wide.[91] Similarly, these incentives could have an important impact on recycled PP and PE uptake, where high-quality recycling supply and demand is emerging but not yet widely seen.[92]

A range of other supporting policy measures could help trigger progress in the short term. Next to creating a demand-pull for recycled plastics, regulatory frameworks can provide other enabling conditions for enhancing the uptake, economics and quality of plastic packaging recycling. Such policy measures could include: recycling targets; levies and/or bans on landfilling and incineration; carbon or resource taxes; extended producer responsibility (EPR) schemes supporting after-use systems; deposit-for-recycling systems; and others. Within this context, it should be noted that, as part of the redesigned and reused packaging will lead also to recycling, the 50% mentioned in this chapter should not be considered as an upper limit for a recycling target. In addition, regulatory policies could specifically support the adoption of good design practices through, for example, eco-design rules or more granular (adaptive) EPR schemes with contributions differentiated per packaging design criteria. All these policy measures come with advantages and disadvantages, which would need to be carefully examined in local context before implementation. They have not been the focus of this report but merit further investigation.

Due to their different starting points, mature and emerging economies require distinct paths towards adopting a Global Plastics Protocol, but improving packaging design is a critical lever for both.

Unlike mature markets, emerging economies often require the deployment of basic collection infrastructure as a critical short-term action. In most mature economies, the vast majority of plastic packaging gets picked up in a formal collection system, whereas in emerging economies, a substantial share often goes uncollected and ends up in natural systems or clogs urban infrastructure. In such regions, a critical first step often is deploying basic collection infrastructure. This report does not look in detail at the solutions to plastics leakage in these countries, as they have been proposed by other initiatives, including local projects such as the Mother Earth Foundation and Coastal Cleanup, both in the Philippines, and global efforts such as the Trash Free Seas Alliance®, initiated by the Ocean Conservancy.[93]

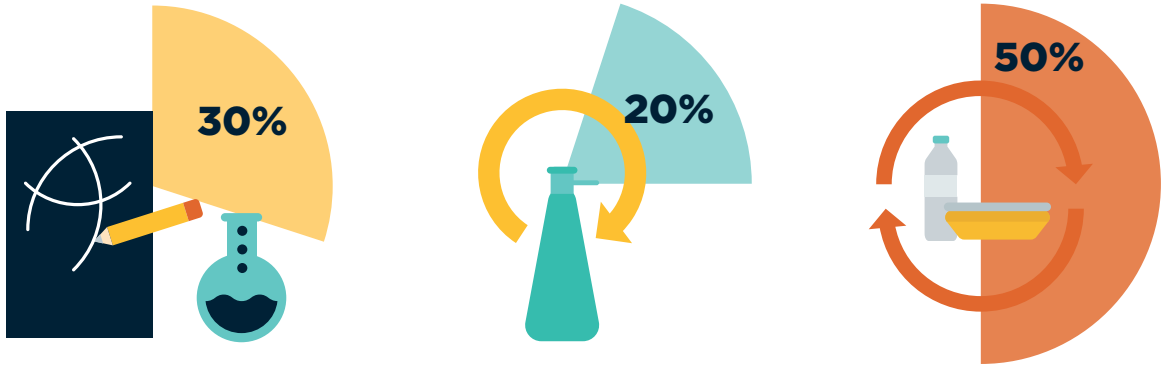
Adopting a Global Plastics Protocol that improves packaging design and after-use processes would make an important contribution to both mature and emerging economies. While the impact modelling in this report is mainly focused on OECD countries, many of its insights are relevant for both mature and emerging markets. This particularly holds true for design improvements. Various studies indicate that waste-pickers operating in the informal sector collect high-value but not low-value plastics.[94] This means designing plastic packaging for increased after-use value would result in higher collection rates and possibly higher incomes for waste-pickers – and would improve the economics of deploying formal collection infrastructure. At the same time, adoption of a Global Plastics Protocol would offer the opportunity to ensure the use of benign materials worldwide, reducing exposure to substances of concern.

Priority actions to enhance the uptake, quality and economics of recycling are:

- Implement design changes in plastic packaging to improve recycling quality and economics (e.g., choices of materials, additives and formats) as a first step towards a Global Plastics Protocol
- Harmonize and adopt best practices for collection and sorting systems, also as part of a Global Plastics Protocol
- Scale up high-quality recycling processes
- Explore the potential of material markers to increase sorting yields and quality
- Develop and deploy innovative sorting mechanisms for post-consumer flexible films
- Boost demand for recycled plastics through voluntary commitments or policy instruments, and explore other policy measures to support recycling
- Deploy adequate collection and sorting infrastructure where it is not yet in place

Figure 7 presents an overview of the priority actions identified for global plastic value chain. These actions will mobilize the distinct transition strategies for the three plastic packaging categories (covering the entire market) as discussed in this chapter.

Figure 7: Priority actions for the global plastic packaging value chain to mobilize the three transition strategies towards the New Plastics Economy



FUNDAMENTAL REDESIGN & INNOVATION	REUSE	RECYCLING WITH RADICALLY IMPROVED ECONOMICS & QUALITY
• Fundamentally redesign the packaging formats and delivery models (and after-use systems) for small-format plastic packaging, avoiding such small formats where relevant and possible	• Innovate towards creative, new delivery models based on reusable packaging	• Implement design changes in plastic packaging to improve recycling quality and economics (e.g. choices of materials, additives, and formats), as a first step towards a Global Plastics Protocol
• Boost material innovation in recyclable or compostable alternatives to the currently unrecyclable multi-material applications as described above	• Replace single-use plastic carrier bags by reusable alternatives	• Harmonize and adopt best practices for collection and sorting systems, also as part of a Global Plastics Protocol
• Replace PVC, PS, and EPS, as a priority, as uncommon packaging materials with alternatives (converging to a few key materials being used across most of the market, while continuing to allow for innovation)	• Scale up reusable packaging in a business-to-business setting for both large rigid packaging and pallet wrap	• Scale up high-quality recycling processes
• Scale up compostable packaging and related infrastructure for targeted nutrient-contaminated applications		• Explore the potential of material markers to increase sorting yields and quality
• Explore the potential as well as the limitations of chemical recycling and other technologies, to reprocess currently unrecyclable plastic packaging into new plastics feedstocks		• Develop and deploy innovative sorting mechanisms for post-consumer flexible films
		• Boost demand for recycled plastics through voluntary commitments or policy instruments, and explore other policy measures to support recycling
		• Deploy adequate collection and sorting infrastructure where it is not yet in place

Source: New Plastics Economy initiative analysis

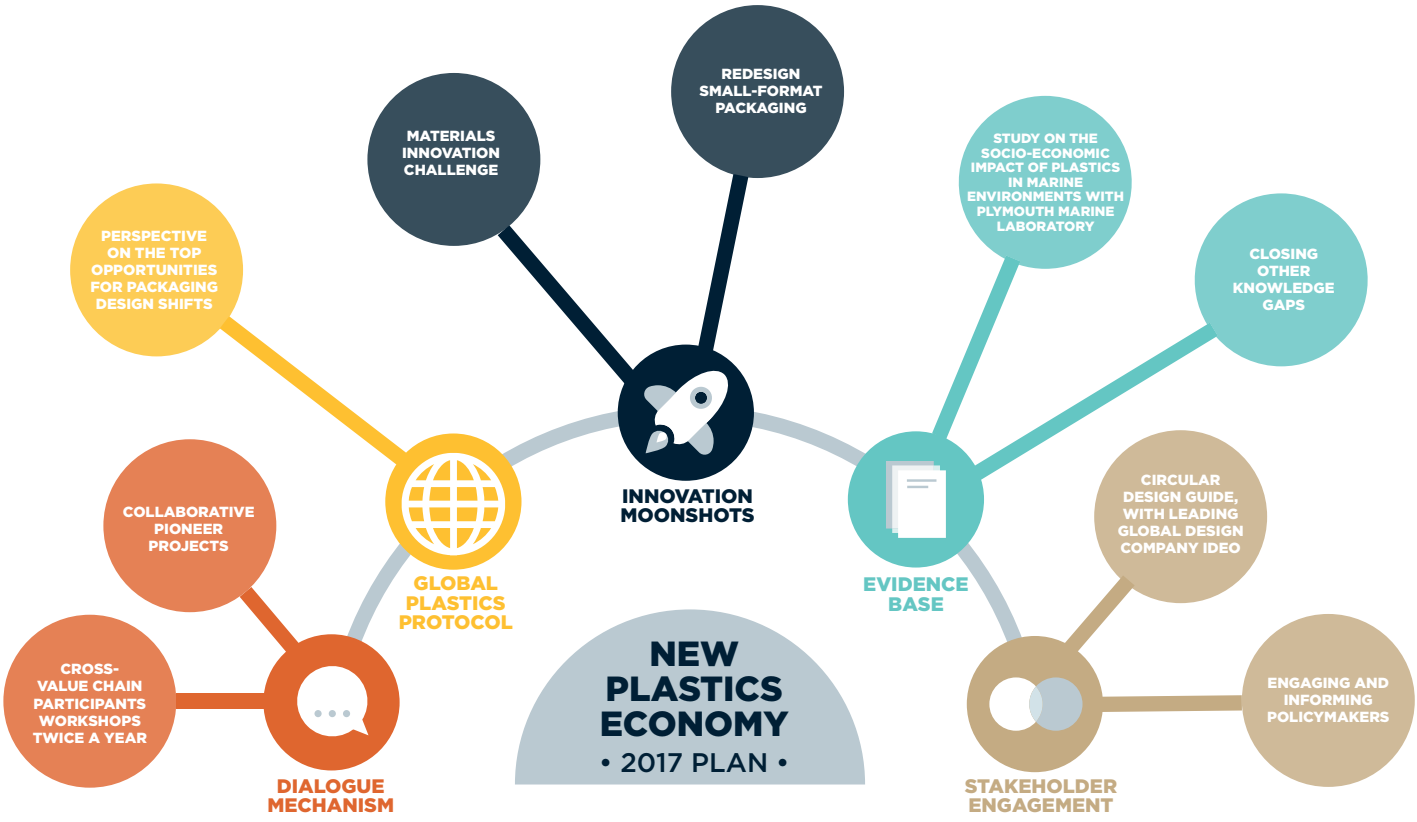
The New Plastics Economy Initiative: A Catalyst for Change

The New Plastics Economy is an ambitious, three-year initiative to build momentum towards a plastics system that works. Applying the principles of the circular economy, the initiative brings together key stakeholders to rethink and redesign the future of plastics, starting with packaging. Launched in May 2016, the initiative is spearheaded by the Ellen MacArthur Foundation, in collaboration with a broad group of leading companies, cities, philanthropists, policy-makers, designers, academics, students and NGOs.

The New Plastics Economy focuses on five interlinked and mutually reinforcing building blocks to create the enabling conditions for a transformative system shift. These building blocks are: Dialogue Mechanism; Global Plastics Protocol; Innovation Moonshots; Evidence Base; and Stakeholder Engagement. Since its inception, the initiative has made significant progress across all these key elements. Based on the analysis and insights from this report, the New Plastics Economy initiative has now defined a series of focus *catalyst actions* to drive further progress in 2017 (see Figure 8).

The Dialogue Mechanism places cross-value chain collaboration at the heart of the New Plastics Economy initiative. It brings together a group of global consumer goods companies, retailers, plastics producers and packaging manufacturers, governments, cities and businesses involved in plastics collection, sorting and reprocessing. This group informs the other building blocks and the initiative's direction more broadly, together with the joint philanthropic-business advisory board and a group of civil society representatives.

Figure 8: Overview of the New Plastics Economy initiative's five building blocks and 2017 catalyst actions



Source: New Plastics Economy initiative analysis

Concrete actions within the Dialogue Mechanism include biannual *participant workshops* and the implementation of collaborative *pioneer projects*. The first two participant workshops took place in May 2016 and December 2016, bringing together a group of about 40 participant organizations and initiating the first collaborative pioneer projects.

In 2017, the initiative will continue to host six-monthly participant workshops and drive implementation of the collaborative pioneer projects launched in 2016.

The Global Plastics Protocol aims to provide a common target, helping to overcome existing fragmentation and enable the creation of effective markets. Today's ineffective plastics economy is the result of decades of highly fragmented, uncoordinated and incremental innovation, which has not been able to make progress on economic value capture and negative externalities. By fundamentally rethinking the system and driving convergence, the Global Plastics Protocol enables the creation of effective markets.

In 2016, the potential economic impact of a Global Plastics Protocol was assessed and the analysis clearly indicated that the implementation of changes to design and after-use systems as part of such a protocol would improve the economics of plastic packaging recycling.

In 2017, the initiative will take the next step towards the concrete development of a Global Plastics Protocol. It will collaboratively determine the top opportunities for design changes to enhance recycling quality and economics, as well as material health.

The Innovation Moonshots programme aims to mobilize innovations that could redefine what is possible across the whole system and create the conditions for a new economy. The global economy is being rewired by digitization, automation and artificial intelligence. Fields as disparate as biology, engineering and design are merging, making the time for such moonshots now.

In 2016, over 100 experts from academia, industry, start-ups and disruptive innovators, NGOs and emerging markets were engaged in exploring which areas of innovation could be mobilized as a priority and through which mechanisms. Three key insights emerged through these consultations:

The Innovation Moonshots programme should initially focus primarily on the most challenging segment of the market; i.e. the 30% of plastic packaging for which currently there is no viable reuse or recycling pathway.

Alongside innovations aimed at solving *today's* priority challenges, the initiative should explore the potential of more disruptive innovations, which, if successful, could redefine the entire plastics system in the future. Just a few examples of such innovations include: 3D printing and other additive manufacturing; a universal identification system for all (packaging) materials; high-quality chemical recycling of complex and contaminated material streams; and triggers for biodegradation (e.g., like a banana skin).

There is no one silver bullet moonshot; multiple innovations are required to further accelerate the transition to the New Plastics Economy.

In 2017, the Innovation Moonshots programme will focus on the 30% of plastic packaging for which fundamental redesign and innovation are required. It will inspire a generation of material innovators by launching a challenge to find recyclable or compostable alternatives to materials for which there is no viable reuse or recycling pathway today. It will ignite a programme of redesign by launching a contest to redesign formats and delivery models that can address, for example, some of the most challenging small-format packaging.

The Evidence Base offers a robust foundation from which to guide improvement and inform the global debate. It closes critical knowledge gaps by building an economic and scientific knowledge base from which to draw insights.

In 2016, the initiative has focused its Evidence Base efforts on the creation of this report. This included a granular, segment-by-segment analysis of the plastic packaging market to define an action plan for the global value chain that would accelerate the transition to the New Plastics Economy. This analytical work has been supported by SYSTEMIQ.

In 2017, the initiative will drive progress on different knowledge pieces by:

– Finalizing an ongoing study, together with Plymouth Marine Laboratory, to understand the socio-economic impact of plastics in marine environments – a large-scale literature review is ongoing to extract insights, understand existing knowledge gaps and determine research priorities
– Bridge other knowledge gaps such as, for example, the potential and limitations of material markers and chemical recycling

Stakeholder Engagement involves a wide set of key players across the system to learn from, to inform and to work with on amplifying solutions. Businesses, policy-makers, students, educators, academics, designers, citizens, NGOs, industry associations and other stakeholders all play a role in transitioning to a new system – the initiative learns from, informs and engages all these stakeholders.

In 2016, insights and recommendations from *The New Plastics Economy – Rethinking the future of plastics* reached millions of people around the world. Thousands of news articles were published across five continents highlighting the report's insights, including coverage in the *Financial Times, USA Today, The Guardian, Times of India, CNN* and *Al Jazeera*. High-powered individuals including US Secretary of State John Kerry, Academy Award-winning actor Leonardo DiCaprio, various Members of the European Parliament, and founder of *The Huffington Post* Arianna Huffington, have quoted the report publicly. Their recognition of the report indicates its contribution to raising awareness of plastics issues and – importantly – the need for solutions. The report was one of the most successful topics on social media to date of the World Economic Forum, with an estimated reach of millions of people. Members of the New Plastics Economy initiative team have presented the initiative's vision and recommendations at over 20 conferences and high-level meetings, including the World Economic Forum Annual Meeting 2016 in Davos-Klosters, the Our Ocean 2016 conference, the UN COP22 climate conference in Marrakech, and multiple high-level industry and policy-maker events. To understand how future generations of designers and innovators could be informed and inspired at scale, the initiative piloted in November 2016 a prototype workshop on redesigning plastic packaging specifically tailored to school pupils in Scotland, who learned about the New Plastics Economy and participated in an immersive plastics packaging re-design activity.

In 2017, the initiative will continue to reach out to the wider stakeholder group, with a focus on designers, whose involvement is essential for successful action on each of the three transition strategies outlined in this report, and on policy-makers, who can trigger progress in the near term by setting the right enabling conditions. The initiative has partnered with IDEO, a leading design and innovation consultancy, to develop the Circular Design Guide – an inspiring, online reference point on circular design, to inspire and support designers, innovators and change-makers to rethink and redesign products, delivery models and the broader ecosystems. Being co-created and prototyped with leading universities, entrepreneurs and corporates, it is available as a freely accessible website featuring over 20 practical methods (http://www.circulardesignguide.com), which will be further developed in 2017. In parallel, the initiative will build on the prototype workshop piloted in Scotland to explore how to reach an entire next generation of designers at scale. Policy-makers will be further engaged and informed through sharing latest insights at various meetings and gatherings.

How to measure success?

The success of these actions will be measured against the three ambitions of the New Plastics Economy. A key metric to measure success in *creating an effective after-use plastics economy* – the focus ambition of this update report – is the share of plastic packaging going into a circular after-use pathway (i.e. reuse, recycling or composting).

Regarding *drastically reducing leakage of plastics into natural systems and other negative externalities*, a key metric could be volume (tonnes) of plastics leaked into the environment. Success in reducing other negative externalities, such as the impact of substances of concern on human health and the environment, would need separate metrics.

For *decoupling plastics from fossil feedstocks*, a key metric could be the quantity of oil and gas used as virgin feedstocks for plastic packaging. Decreasing this volume could be realized by increasing reuse and recycling rates, reducing total production volumes, and exploring and adopting renewably sourced feedstocks.

Taking the actions outlined in this report will contribute to achieving these ambitions, which together represent a systemic shift and the advent of an economically and environmentally effective plastics system – a New Plastics Economy.

Appendix: Key Analytical Assumptions

The insights described in this report are the result of a detailed segment-by-segment analysis of the plastic-packaging landscape, many of which are revealed for the first time. By its very nature, this requires assumptions, which are laid out below. When the analysis uses existing data, the sources are mentioned.

Analysis on "Redesign and innovate" segment (30% of market, by weight)

Small-format packaging. The charity WRAP[95] found that about 12% (by weight) of plastic household packaging in materials recovery facilities (MRFs) ends up in the fines fraction (the samples were put on a 45mm x 45mm wire mesh and any articles that fell through the screen without assistance were classified as fines). Application of the 12% to the share of household packaging (about 70% of the plastic-packaging market) in combination with the assumption that in business-to-business packaging the proportion of small-format items is only a third of that used in business-to-consumer packaging, results in an estimate of 9.5% of the market being made up of small-format items. This is in the same order of magnitude as the Austrian company Denkstatt's estimate of 7.5% based on data from Gesellschaft für Verpackungsmarktforschung, the German Society for Packaging Market Research.[96]

The share of small-format plastic packaging items in the market has been estimated based on a segmentation of the plastic-packaging market volume by packaging type. This has been arrived at by allocating a lower-bound and upper-bound estimated average weight to each of those packaging segments (e.g., small format 1g-3g; PET bottles 10g-15g, etc.). This resulted in an estimated 35%-50% of all plastic-packaging items being small-format.

Multi-material packaging. In 2011, the French recycling company, Eco-Emballages, reported that over 6% (by weight) of rigid household plastic packaging was multi-material. [97] Assuming none of the business-to-business rigid plastic packaging is multi-material, this represents 3% of total plastic-packaging market volume. For the purposes of this report, it was estimated that around 26% (by weight) of all flexible plastic packaging is multi-material, which represents 10% of the total plastic-packaging market by weight. This estimate is based on a US report on the flexible packaging market produced by the Flexible Packaging Association[98] and on analysis by the New Plastics Economy team. This is in line with estimates made by other industry experts during interviews. Together, this represents 13% of the plastic-packaging market by weight.

Uncommon packaging plastic types. Volumes of plastic materials other than PE, PP and PET used in rigid and flexible plastic packaging are based on Smithers Pira market reports.[99] [100] The main uncommon plastic packaging materials are PS (4.7% of plastic-packaging market by weight), PVC (2.5%) and EPS (1.3%). All others combined represent another 1.4% of the total global plastic-packaging market by weight. Together, this represents around 10% of the plastic-packaging market by weight.

Overlap. The three segments mentioned above overlap to some extent. A few straightforward assumptions were made when estimating this overlap, such as: share of small items is the same for uncommon packaging plastics and common packaging plastics; and all uncommon packaging plastics used in films are part of multi-layer films. Under these assumptions, the overall size of the segment requiring fundamental redesign and innovation is estimated at about 30% of the total global plastic-packaging market by weight.

Share of plastic packaging items. This category represents at least 50% of all plastic-packaging *items* (and 30% of market by weight) as it includes: (a) 35%-50% of all items which are small-format packaging (see above); and (b) multi-material packaging, uncommon plastic packaging materials and nutrient-contaminated packaging, which are collectively estimated to represent around 20% of the market by weight (taking into account the overlap discussed, and excluding small-format items) and at least as much in terms of number of items. The latter is based on the vast majority of multi-material packaging being flexible packaging (so low weight items), and typical applications of the other materials (e.g., PS used for yoghurt pots, PVC used for pharmaceutical blister packs, nutrient contamination happening in a takeaway food context) assumed to have at most an average packaging weight.

Analysis on "Reuse" segment (20% of market, by weight)

Exchange rate. The euro to US dollar exchange rate used was $1.185 per €1, which is the average exchange rate for January 2014 to October 2016.[101] This exchange rate has also been used for the analyses on recycling.

Personal- and home-care bottles. Analysis for this sector was based on confidential data from companies active in this segment. Numbers shown in this report assume 10 to 15 refills per bottle. The percentage savings from these companies' business models were applied to all bottles (i.e. PET, HDPE and others) in the beauty and personal-care sector, as well as in home care, based on Euromonitor 2015 data.[102] The economic value opportunity depends on the type of reuse model and the underlying costs and revenues. The potential for refill models based on selling and shipping active ingredients only could go beyond personal and home-care applications, but this was not included in the analysis.

Carrier bags. This analysis starts from a global annual production of 2.5 million tonnes or around 330 billion units of single-use plastic carrier bags – an estimate based on a calibration of data from different sources, including: the number of carrier bags put on the market in the UK;[103] a Denkstatt report showing that plastic carrier bags represent 3.2% of after-use plastic packaging in the EU by weight;[104] US single-use plastic packaging production of around 100 billion bags;[105] European single-use plastic packaging production of 0.77 million tonnes;[106] and estimated global single-use carrier bag production of 500 to 1,000 billion bags a year.[107] The conversion from volume (tonnes) to units (bags) is based on a study by Zero Waste Scotland.[108]

Beverage bottles. The starting point for this analysis was a global production figure of 12.5 million tonnes of PET beverage bottles.[109] In Germany, around 20%-25% of PET beverage bottles are refillable.[110] Acknowledging that not all regions in the world have the infrastructure or

ability to organize such return-systems, the applicable, densely populated region was approximated by the global urbanization rate (52%).[111] Combining these numbers, a reuse model is estimated to offer economic and environmental benefits for at least 10% of all beverage bottles worldwide, or at least 2% of the global plastic packaging market.

Business-to-business large rigid packaging. The share of large rigid items in the global plastic packaging market is based on the UK share of large rigid items in the total non-bottle rigid business-to-business plastic-packaging market (35%) applied to the share of non-bottle rigid business-to-business plastic packaging in the global plastic-packaging market (6%).

Business-to-business pallet wrap. The volume of pallet wrap is based on a global production of stretch wrap used as pallet wrap of around 4 million tonnes (taken from HJResearch, *Global Stretch Wrap Industry Market Research 2016)*. This number is then expanded to include stretch and shrink hoods based on the European split of pallet wrap by type (stretch wrap represents 70% of total pallet wrap in Europe, and stretch and shrink hoods the other 30%; outlined in the Applied Market Information Ltd – AMI consulting, *Palletisation Films Europe 2016* report), leading to an estimated annual pallet wrap film production of 5 million-6 million tonnes.

Analysis on "Recycle" segment (remaining share of the market)

Baseline model. The baseline for the recycling analysis is calculated from EU member states (EU-28) average costs, yields and net greenhouse gas emissions of collection, sorting, recycling and disposal of plastic packaging as published by Plastic Recyclers Europe (PRE)/Deloitte.[112] It follows the 2012 baseline inputs in that published model with adjustments made for the average price decrease in recycled PET since 2012. Operational costs include amortized investment costs for each stage and use EU-28 average costs of sorting and recycling, assuming no export of plastics for recycling outside the EU. All numbers are EU-28 averages and it should be noted that the economics of recycling vary significantly across countries, regions, packaging types and uses of packaging (e.g., consumer or industrial). The estimated net cost of mixed plastic-packaging collection, sorting and recycling also assumes local processing without the export of plastics for recycling outside the region.

The analysis covers the costs related to the share of plastic packaging collected for recycling (about 40% of all plastic packaging put into the market in EU, with collection systems in many countries targeting the packaging that is easiest to recycle[113]). Costs related to other plastic packaging items not collected for recycling (e.g., a segment of residual waste collection) are not part of the scope of this analysis. All cost-per-tonne values are costs per tonne of plastic packaging collected for recycling.

The baseline has been adapted to allow a more granular approach for modelling system improvements: by consumer versus industrial; by resin type; and by format (flexible, rigid). Several experts in collection, sorting and recycling have reviewed the data inputs for the baseline model.

When the costs of collection, sorting, and recycling are compared with collection and disposal of plastic packaging as part of residual waste, disposal was modelled as a 50/50 ratio between landfill and incineration with energy recovery. This gives an estimated average cost of collection and disposal of residual waste of $200 per tonne.[114]

Results expressed as total value for OECD have been scaled up from the EU-28 analysis, as based on the plastic packaging volume collected for recycling in OECD countries, which is estimated at 11 million tonnes a year.[115]

Lever quantification. Levers are applied to the baseline model assuming an inferred effect on cost, yield and recyclate price. To keep costs comparable to the baseline, no changes have been assumed in the volumes collected. The effect of higher capital investment costs on operational cost (which already includes amortized investment costs) is not incorporated in the model. The inputs used for quantifying the impact of these levers have been drawn from published material, case examples, expert interviews and assumptions as shown below. For calculating the effect of packaging design improvements, a synergy effect on the average price of recycled plastic (+8%) is assumed to account for the cumulative effect of applying design and after-use levers together (effect of higher-quality recycling on average plastic prices).

Format design. The report uses a top-down estimate of the effect of improving format design specific to types of plastic packaging. Examples include design choices relating to labels, sleeves, inks and direct printing, glues, closures and closure liners, valves, pumps and triggers, attachments or tear-offs, and form or shape of packaging. Expert interviews and published reports indicate that format design changes (not including material, pigment and additive changes already considered in other design levers) could avoid material losses during sorting or recycling of up to 15% of plastic packaging collected (compared with 38% material loss in the overall sorting and recycling process).[116] This lever assumes that format design improvements would reduce the overall material losses by 7.5% (half of the material losses attributable to format design issues).

Material choices.

- **PVC**: One percentage point increase in recycling yields is assumed for PET recycling due to avoided sorting losses prior to the extrusion (reprocessing) stage as the removal of PVC would lead to unintended losses of recyclable material. A small increase in the average price of recycled PET is modelled (+3%) to account for the effect of PVC contamination on optical and mechanical properties of recycled PET, and the substitution of rigid PVC for alternatives that are more likely to be recycled, reduces cost and increases value for the recycling system.
- **EPS/PS**: It is assumed that EPS and PS in plastic packaging are not recycled in most countries because they are present in small volumes and do not warrant investment in additional sorting equipment. The model estimates the effect of substituting EPS/PS for materials that are more likely to be recycled (e.g., PET, PE, PP resins). Recyclers also indicated that PS can affect the extrusion (reprocessing) of other plastics. This effect, however, is not included in the calculation.

Pigment choices. Packaging with carbon black pigment cannot be detected by near-infrared (NIR) sorting equipment used in most sorting facilities. Calculations assume that packaging with carbon black is collected for recycling at the same average rate as other plastic packaging, then lost into the residual waste stream during sorting. The share of packaging with carbon black follows published estimates at 1.5%-2% of packaging.[117] This lever assumes all carbon black is replaced by other NIR-detectable pigments. It is assumed that opaque PET bottles are not to be recycled, based on recycler input, and for this calculation they have been switched to a recycled alternative (assumed to be 0.25% of the packaging stream[118]). In addition, calculations assume a switch from coloured packaging to clear or light-coloured translucent plastics, with an average 10%-20% increase in price for clear or light-coloured recycled plastic (depending on the type of plastic). Share of coloured plastics (excluding carbon black) in the packaging stream is estimated at 25% based on published information.[119] This improvement lever assumes that three quarters of that segment could be switched.

Additive choices. A small effect of additives in plastics used for packaging is included in this model (in total, about $5 per tonne of mixed plastics packaging collected) to account for discolouration of recycled PET, and density issues causing avoidable losses in the recycling system (e.g., losses in float-sink separation). Calculations assume 2% of the recycled bottle PET is impacted by discolouration and 2% of polyolefins collected for recycling are lost at the reprocessing facility due to density-affecting additives. The effect of additives is a subject for further investigation and could become more significant in higher-quality recycling processes.

Harmonized collection and sorting. Improvements are based on expert input on the effect of harmonizing collection and sorting systems and adopting best practices. Collection and sorting performance are tightly linked, since harmonized collection makes for easier sorting. To avoid double-counting of effects the following assumptions are made:

- Sorting yields for rigid packaging increased to good-practice estimates of 85% (rigids) and 90% (PET bottles).
- Average sorting cost is reduced to proven good-practice example of about $120 per tonne (as already achieved by large-scale sorting facilities in Europe[120]).
- Small increase in recycling yield (two percentage points) to account for improved quality of inputs to reprocessing facilities.
- No change in collection cost is modelled as it is assumed that good-practice cost reductions would be balanced out by additional transport distances (since large sorting facilities would be further apart).
- For the purposes of modelling, it is estimated that good-practice effects (i.e., all assumptions listed above) are achieved in 75% of cases, as not all regions have a high enough population density to allow for large-scale sorting plants, and lower collection and transport costs; and for other, non-technical (e.g., geopolitical) reasons.
- No effect on quality of recycled product is modelled, although this would be expected if the raw material supply to recyclers was improved.

Shift to high-quality recycling for PE and PP. Higher-quality polyolefin recycling would enable significant (about 50%) increases in the average sale price for recycled plastics, offset, however, by higher (by about 15%) recycling costs and reduced (by five percentage points) recycling yields due to more rigorous sorting.[121] It is assumed that 25% of the polyolefin market would move to higher-quality recycling under a good-practice model.

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Disclaimer

This report has been produced by a team from the Ellen MacArthur Foundation, which takes full responsibility for the report's contents and conclusions. While the New Plastics Economy Advisory Board members, participants and experts consulted have provided significant input to the development of this report, their involvement does not necessarily imply endorsement of the report's contents or conclusions.

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Endnotes

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25 Experts indicate there is a risk regarding substances of concern (e.g. pyrolysis produces filtrates containing a range of substances), even though perceived lower than for incineration (e.g. generation of gaseous substances of concern is generally lower). As explained, further detailed research is needed and falls outside the scope of this report.

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27 Lab-scale activities to delaminate multi-layer film indicated that it is possible to separate the layers and remove the ink that was between them (http://cadeldeinking.com/en/).

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71 Numbers in this and following sections have been rounded for ease of communication; this explains small difference between economic benefit of individual levers, and total economic benefit.

72 APR Shrink Label Working Group (2014, http://www.plasticsrecycling.org/resources/reports/sleeve-label-study).

73 Estimate for design-related material losses in plastics packaging recycling stream (from collection to reprocessing) is based on overall average of 38% material loss (from Deloitte, *Increased EU Plastics Recycling Targets: Environmental, Economic and Social Impact Assessment – Final Report* (2015)); recycler feedback and published reports including RRS, *MRF Material Flow Study* (2015); WRAP, *Design of Rigid Packaging for Recycling* (2013).

74 Price difference for coloured versus clear or light-coloured translucent recyclate is dependent on the resin, market and application. Estimated range is based on interviews with recyclers.

75 Ibid.

76 Werner & Mertz website states: "colouring of the plastic is avoided as this is the only way to continue maintaining a recyclate in the technical cycle and make sure the used bottles can serve as raw material source for new bottles". (http://wmprof.com/en/int/news_7/2016/world_innovation__first_pe_bottle_based_on_100___pcr__hdpe/world_innovation__first_pe-bottle_based_on_100___pcr__hdpe.html).

77 WRAP, *Development of NIR Detectable Black Plastic Packaging* (2011).

78 Interviewed recyclers; European PET Bottle Platform, *Design for Recycling Guidelines*; APR, *Design guidelines from the Association of Plastic Recyclers* (2016) mentions negative impact of certain additives on recycling and recyclate quality. (http://www.plasticsrecycling.org/images/pdf/design-guide/Full_APR_Design_Guide.pdf).

79 Interviewed recyclers; APR, *Design guidelines from the Association of Plastic Recyclers* (2016) state: "Of particular concern are additives which cause the rPET to discolor or haze after remelting or solid stating since rPET with poor haze or discoloration is greatly devalued and has limited markets."

80 APR, *Design guidelines from the Association of Plastic Recyclers* (2016) state: "Of particular concern are…dense additives that increase the density of the blend making it sink, thus rendering the package unrecyclable per APR definition."

81 Interviews with European plastics recyclers consistently highlight the challenge of diverse, variable and contaminated source materials.

82 See Appendix for more details.

83 Multi-Material British Columbia, a non-profit organization, is financed by industry to manage residential packaging recycling programmes. For more details, see World Economic Forum, Ellen MacArthur Foundation and McKinsey & Company, *The New Plastics Economy – Rethinking the future of plastics* (2016, http://www.ellenmacarthurfoundation.org/publications).

84 WRAP, *A framework for greater consistency in household recycling in England* (2016, http://www.wrap.org.uk/content/consistency).

85 By way of example, according to experts, only a handful of polyolefin recycling plants have hot-washing processes in place, while this is the standard for high-quality PET recycling. Recently, companies like QCP (http://www.qcpolymers.com) started to deploy these processes for PE and PP as well, aiming to produce high-quality polyolefin recyclates ready for use in packaging again.

86 Werner & Mertz has recently launched a 100% post-consumer recycled HDPE bottle (*Werner & Mertz Professional presents its first PE-bottle based on 100% Post-Consumer-Recycled (PCR) HDPE* (http://wmprof.com/en/int/news_7/2016/world_innovation__first_pe_bottle_based_on_100___pcr__hdpe/world_innovation__first_pe-bottle_based_on_100___pcr__hdpe.html, 2016)); QCP is another example of a recently founded recycling company aiming for high-quality recycling of PE and PP (interviews, http://www.qcpolymers.com).

87 A broad range of interviews with industry experts highlights varied opinions on the potential benefits, feasibility and economic viability of material markers, tracers or watermarks for plastics packaging – highlighting the importance of further work on this topic.

88 Euromonitor International, *Smaller is Better as Global Packaging Growth is Shaped by Variation in Pack Sizes* (http://blog.euromonitor.com/2016/06/smaller-is-better-as-global-packaging-growth-is-shaped-by-variation-in-pack-sizes.html, 2016); The REFLEX Project (http://www.reflexproject.co.uk).

89 Interviews with industry experts highlighted the role of demand from beverage companies in driving higher-quality PET.

90 Law requires mandatory share of recycled content or meeting

one of the other compliance options such as source reduction, refillable packaging or reusable packaging (source: website of California's Department of Resources Recycling and Recovery, http://www.calrecycle.ca.gov/).

91 Interview with Container Recycling Institute.

92 QCP is an example of a recently founded recycling company aiming for high-quality recycling of PE and PP (interviews, http://www.qcpolymers.com); Werner & Mertz has recently launched a 100% post-consumer recycled HDPE bottle (*Werner & Mertz Professional presents its first PE-bottle based on 100% Post-Consumer-Recycled (PCR) HDPE* (http://wmprof.com/en/int/news_7/2016/world_innovation__first_pe_bottle_based_on_100___pcr__hdpe/world_innovation__first_pe-bottle_based_on_100___pcr__hdpe.html, 2016)); Several companies, including Unilever, IKEA, Walmart and Colgate, announced recycled content targets for their packaging, which will likely require significant high-quality recycled PE and PP.

93 http://www.oceanconservancy.org/our-work/trash-free-seas-alliance

94 For example, in the Philippines, waste-pickers collected up to 90% of certain types of plastic bottles with high after-use value. Low-value plastic items, in contrast, are neglected; collection rates are close to 0%. Source: The Ocean Conservancy and McKinsey Center for Business and the Environment, *Stemming The Tide: Land-based strategies for a plastic-free ocean* (2015).

95 WRAP, *WRAP Plastics Compositional Analysis at MRFs* (2015).

96 Denkstatt, *Criteria for eco-efficient (sustainable) plastic recycling and waste management: Fact based findings from 20 years of Denkstatt studies, Background report for associated presentation* (2014).

97 Eco-emballages, *Amélioration de la recyclabilité des emballages en plastique autres que bouteilles et flacons* (2013).

98 Flexible Packaging Association, *Flexible Packaging Industry Segment Profile Analysis* (2013).

99 Smithers Pira, *The Future of Global Rigid Plastic Packaging to 2020* (2015).

100 Smithers Pira, *The Future of Global Flexible Packaging to 2018* (2013).

101 Historical exchange rates from www.usforex.com

102 Euromonitor International, Data exported on September 29th, 2016.

103 WRAP, *Plastic packaging composition 2011* (2013).

104 Denkstatt, *Criteria for eco-efficient (sustainable) plastic recycling and waste management – Fact based findings from 20 years of Denkstatt studies, Background report for associated presentation* (2014).

105 US International Trade Commission, *Polyethylene Retail Carrier Bags from*

Indonesia, Taiwan, and Vietnam (2009); Conserving Now, *Plastic Bag Consumption Facts* (https://conservingnow.com/plastic-bag-consumption-facts/).

106 European Commission, *Impact Assessment for a proposal for a directive of the European Parliament and of the Council amending Directive 94/62/EC on packaging and packaging waste to reduce the consumption of lightweight plastic carrier bags* (2013).

107 SeatlePi, *Plastic left holding the bag as environmental plague* (2004).

108 Zero Waste Scotland, *Carrier Bag Charge "one year on" report* (2015).

109 Smithers Pira, *Demand for PET Packaging Material to reach $60 billion by 2019* (http://www.smitherspira.com/news/2014/april/demand-for-pet-packaging-material-in-2019, 2014).

110 Reloop, *Beverage Sales By Container Type, Germany 2000-2015* (http://reloopplatform.eu/beverage-sales-by-container-type-in-austria-4/)

111 World Urbanization Prospects – 2011 Revision.

112 Deloitte, *Increased EU Plastics Recycling Targets: Environmental, Economic and Social Impact Assessment – Final Report* (2015).

113 Deloitte, *Increased EU Plastics Recycling Targets: Environmental, Economic and Social Impact Assessment – Final Report* (2015). The approximate 40% often includes the easiest to recycle items; for example, Belgium only collecting bottles, many regions not collecting household flexible packaging. Sources: Fostplus website (www.fostplus.be); summary of plastic film collection in Europe studies by WRAP (WRAP, *Film reprocessing technologies and collection schemes* (2012)).

114 Source for the disposal cost: Deloitte, *Increased EU Plastics Recycling Targets: Environmental, Economic and Social Impact Assessment – Final Report* (2015). The collection cost for residual waste is based on an analysis of EU datasets and expert interviews.

115 EPA, *US collection-for-recycling volumes from Environmental Protection Agency Report* (2013); *Japan from Packaging Waste Management Institute Report* (2014); EU-28 from Plastic Recyclers Europe/Deloitte report (2015); APC, *Australia from Packaging Covenant Report* (2014-2015); other collection volumes are extrapolated from web research and population data.

116 Examples: RRF, MRF Material Flow Study (2015) (http://www.plasticsrecycling.org/images/pdf/resources/MRF-material-flow-study-FINAL.pdf); Container Recycling Institute, Bottled Up (2013) (http://www.container-recycling.org/index.php/publications/2013-bottled-up-report; Material loss of 38% from collection to recycled plastic production is based on Deloitte, *Increased EU Plastics Recycling Targets: Environmental, Economic and Social Impact Assessment – Final Report* (2015).

117 WRAP, *Development of NIR Detectable Black Plastic Packaging* (2011).

118 Cotrep, *The impact of the increase in white opaque PET on the recycling of PET packaging* (http://www.cotrep.fr/fileadmin/contribution/mediatheque/avis-generaux/anglais/packaging-and-additives/20131205-Note_introductive_PET_opaque_EN_publi%C3%A9e.pdf, 2013)

119 WRAP, *Plastics Compositional Analysis at MRFs* (2015); WRAP, *Design of Rigid Packaging for Recycling* (2013); WRAP, *Development of NIR detectable black plastic packaging* (2011); Cotrep, *Preliminary note on the impact of the increase in white opaque PET on the recycling of PET packaging* (2013).

120 Expert interviews.

121 Estimates for price, cost and yield impacts of higher-quality polyolefin recycling processes are from industry interviews.

About the Ellen MacArthur Foundation

The Ellen MacArthur Foundation was established in 2010 with the aim of accelerating the transition to the circular economy. Since its creation the charity has emerged as a global thought leader, establishing the circular economy on the agenda of decision makers across business, government and academia. With the support of its Core Philanthropic Funder, SUN, and Knowledge Partners (Arup, IDEO, and SYSTEMIQ), the Foundation's work focuses on five interlinking areas:

Education

Inspiring learners to re-think the future through the circular economy framework

The Foundation has created global teaching, learning and training platforms built around the circular economy framework, encompassing both formal and informal education. With an emphasis on online learning, the Foundation provides cutting edge insights and content to support circular economy education, and the systems thinking required to accelerate a transition.

Our formal education work includes Higher Education programmes with partners in Europe, the U.S., India, China and South America, international curriculum development with schools and colleges, and corporate capacity building. Our informal education work includes the global, online Disruptive Innovation Festival.

Business and Government

Catalysing circular innovation and creating the conditions for it to reach scale

Since its launch, the Foundation has emphasised the real-world relevance of the circular economy framework, recognising that business innovation sits at the heart of economic transitions. The Foundation works with its Global Partners (Cisco, Google, H&M, Intesa Sanpaolo, NIKE Inc., Philips, Renault, and Unilever) to develop scalable circular business initiatives and to address challenges to implementing them.

The Circular Economy 100 programme brings together industry leading corporations, emerging innovators, affiliate networks, government authorities, regions and cities, to build circular capacity, address common barriers to progress, understand the necessary enabling conditions, and pilot circular practices, in a collaborative, pre-competitive environment.

Insight and Analysis

Providing robust evidence about the benefits and implications of the transition

The Foundation works to quantify the economic potential of the circular model and develop approaches for capturing this value. Our insight and analysis feeds into a growing body of economic reports highlighting the rationale for an accelerated transition towards the circular economy, and exploring the potential benefits across stakeholders and sectors.

The circular economy is an evolving framework, and the Foundation continues to widen its understanding by working with international experts, key thinkers and leading academics.

Systemic Initiatives

Transforming key material flows to scale the circular economy globally

Taking a global, cross-sectoral approach to material flows, the Foundation is bringing together organisations from across value chains to tackle systemic stalemates that organisations cannot overcome in isolation. Plastics was identified through initial work by the Foundation with the World Economic Forum and McKinsey & Company as one of the value chains most representative of the current linear model, and is therefore the focus of the Foundation's first Systemic Initiative. Applying the principles of the circular economy, the New Plastics Economy initiative, launched in May 2016, brings together key stakeholders to re-think and re-design the future of plastics, starting with packaging.

Communications

Engaging a global audience around the circular economy

The Foundation communicates cutting edge ideas and insight through its circular economy research reports, case studies and books. It uses relevant digital media to reach audiences who can accelerate the transition, globally. The Foundation aggregates, curates, and makes knowledge accessible through Circulate, an online information source dedicated to providing the latest news and unique insight on the circular economy and related subjects.

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