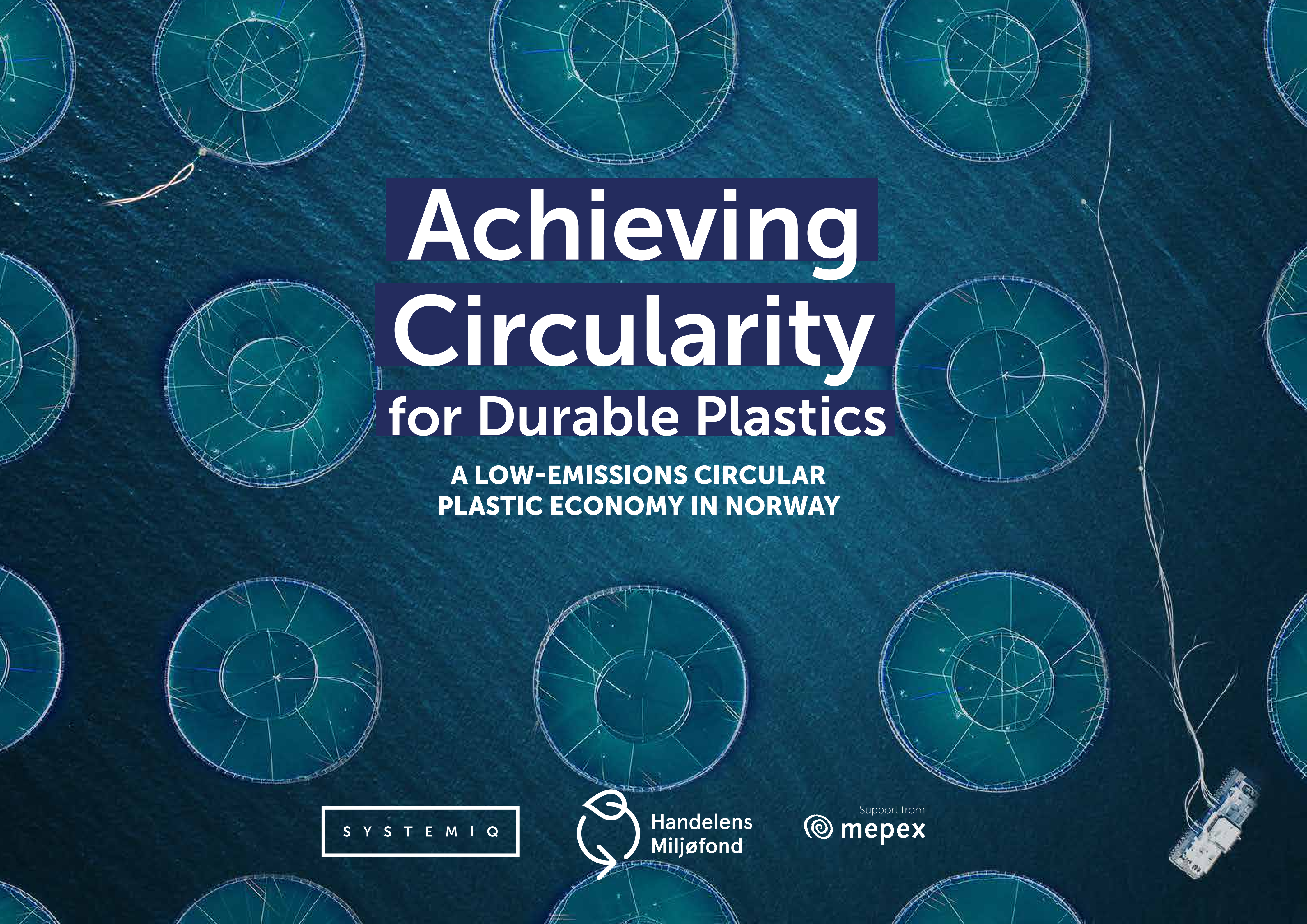

Achieving Circularity for Durable Plastics

A LOW-EMISSIONS CIRCULAR PLASTIC ECONOMY IN NORWAY

SYSTEMIQ

Handelens Miljøfond

Support from mepex

Contents

This report is also available online at www.systemiq.earth

Preface

Reasons for writing this report

The world is facing a critical challenge that requires it to deepen its understanding of the root causes of plastic waste and pollution and define pathways to eliminate plastic pollution at a global scale. By 2024, a global treaty is expected to be negotiated by UN member states that enables a thriving circular plastic economy capable of eradicating plastic pollution.

Norway has the ambition to continue to be a frontrunner on addressing this challenge, and – together with Rwanda – is leading the High Ambition Coalition to End Plastic Pollution, committed to developing a successful global plastic treaty. The goal of this study is to lay out a pathway that can accelerate Norway's own transition towards a low-emissions, zero-waste circular plastic economy by 2040. This is done through an in depth analysis of different sectors of the plastic system and identifying tailored roadmaps with strategies that design out waste and pollution, eliminate unnecessary production and consumption, keep products and materials in the economy, safely collect and dispose of waste that cannot be economically processed, and dramatically reduce greenhouse gas emissions.

This report presents the findings of Part 2 of the 'Achieving Circularity' study. While Part 1 of the study focused on the plastics in consumables and household products, categories with a single use or used for less than a year, this Part 2 focuses on durable plastics in the most important sectors: Construction, Textiles, Electronics & Electricals, Automotive, and Fishing and Aquaculture. These are five very distinct sectors, representing around 46% of total annual plastic demand in Norway today , but only around 25% of total waste, indicating that large quantities of durable plastic are accumulating in the economy. Plastics have been instrumental in the growth of all five sectors, but around 80% of today's system is linear, which means plastic is either incinerated or landfilled at end-of-life, or leaks into nature.

This study aims to build a clear "North Star", linking plastics use, waste and greenhouse gas (GHG) emissions in an integrated way and painting a picture of the most ambitious levels of circularity for individual sectors to aim for.

This data-driven study was prepared in partnership with the Norwegian consultancy Mepex and 12 Norwegian and international experts. It builds on the 'Breaking the Plastic Wave' methodology published by Systemiq and The Pew Charitable Trusts in 2020. Norway is the first country to apply this methodology to durables and our hope and objective is that this report can strengthen collaboration between the different sectors, the petrochemical industry, and the recycling industry. We hope that this study will guide policymakers, industry leaders, investors, and civil society in preparing the most effective initiatives to achieve a highly circular plastic economy that is aligned with national and global net-zero targets.

Cecilie Lind

CEO
Handelens Miljøfond

Yoni Shiran

Partner
Systemiq

About

Handelens Miljøfond

(Norwegian Retailers' Environment Fund)

Handelens Miljøfond is Norway's largest private environmental fund, and Norway's most important measure for complying with the EU Plastic Bags Directive. The fund supports national and international projects that reduce plastic pollution, increase plastic recycling, and reduce the consumption of plastic bags.

The fund's vision is to promote a circular plastic system and a pollution free environment. In 2021, Handelens Miljøfond launched "Achieving Circularity" together with Systemiq and Mepex. Part 1 of this study focused on post-consumer plastic packaging and non-electrical household products.

Learn more at: **www.handelensmiljofond.no**

Systemiq

Systemiq is a B Corp founded in 2016 to drive the Paris Agreement and the Sustainable Development Goals by transforming markets and business models in five key systems: nature and food, materials and circularity, energy, urban areas, and sustainable finance.

In 2020, Systemiq and The Pew Charitable Trusts published "Breaking the Plastic Wave: A Comprehensive Assessment of Pathways Towards Stopping Ocean Plastic Pollution", an evidence-based roadmap that shows how industry and governments can radically reduce ocean plastic pollution by 2040, on which this report is based. The findings of our analysis were published in the peer-reviewed journal, Science.

Learn more at: **www.systemiq.earth**

Mepex

Mepex is a Norwegian independent consultancy firm specialising in waste management, recycling and circular value chains. The aim is to be a catalyst for change, contributing to making the circular economy a reality through resource efficient and climate friendly solutions.

Mepex combines analytical competence with extensive experience in design, construction, and the operation of waste management infrastructure to support authorities, municipalities, organisations, and businesses in formulating strategies and achieving their environmental goals.

Learn more at: **www.mepex.no**

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Endorsements

"Durable plastics are accumulating in the Norwegian economy, and predominantly get incinerated for energy purposes while demand and GHG emissions are growing. This report presents tailored circularity interventions, which if enabled by policy, can accelerate Norway's transition into a low emission society.

Elin Hansen

Head of Circular Economy
ZERO

"Plastic is a fantastic material as its properties provide important possibilities of use. But plastic is also one of the biggest consumers of virgin fossil materials and a significant source of GHG emissions. High use combined with low reuse and recycling rates has created waste problems harming nature and wildlife. It simply cannot continue. Our members in the trade and service industry are committed to reducing the use of all unnecessary plastic and making plastic reusable and easy to recycle. Knowledge and cooperation are key to success. This report is an excellent example of both, and we hope its insights will be used by many.

Tord Dale

Head of Sustainability
Federation of Norwergian Enterprises (Virke)

"Significant amounts of plastic are accumulating in the Norwegian building stock. Given the long lifetimes of plastics in buildings, the failure to implement circular solutions today will result in the Norwegian plastics system being unable to cope with the large volumes of waste for decades to come. Circularity solutions are within reach and this report provides a roadmap to implementation, detailing where the opportunities lie to transform the system.

Guro Hauge

Director Sustainability & Social Policy
The Federation of Norwegian Construction Industries (BNL)

"The textiles industry is working towards higher levels of circularity and reducing emissions throughout its value chains. The "Accelerating Circularity" report helps all stakeholders to better understand opportunities and challenges on this path. I encourage the entire industry to closely collaborate, within the sector and with other actors across the value chain, to truly advance to a sustainable plastics economy.

Linda Refvik

CEO
NF&TA

"It is clear the Norwegian Plastic System has to become more sustainable and less dependent on virgin materials. Circular design and circular business models will be key for companies to succeed in the future, and this report outlines the path to achieve this. I call on the Norwegian Electrical Industry to follow these recommendations.

Frank Jaegtnes

CEO
Elektroforeningen (EFO)

"We need to acknowledge that the seafood industry contributes to a large amount of plastic use and marine plastic pollution - making our industry a significant contributor to marine waste along our shores. NCE Seafood Innovation believes that collaboration and knowledge sharing around industry challenges are essential to address our responsibility and tackle issues effectively. This report provides a solid foundation for action and offers findings and guidance that can help us improve and lead the way to a more circular plastic economy, for both the aquaculture and fishery industry, in Norway. We endorse this contribution.

Nina Stangeland

Managing Director
The Seafood Innovation Cluster

Acknowledgements

Expert Panel

This work was developed together with a panel of 12 Norwegian experts with diverse backgrounds and perspectives.

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Acknowledgements

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Executive Summary

Executive Summary

Norway is globally recognised for its ambition to create a thriving low-emissions circular plastic economy that allows sectors to develop without negative – or, ideally, with positive - impacts on the environment, the economy, and society at large. This is both critically important and extremely challenging as the starting point is a highly linear plastic system that emits large amounts of greenhouse gases (GHGs) during both fossil based plastic manufacturing processes and end-of-life incineration. Without transformative changes, the situation is set to get worse in the next years as the plastic accumulating in the system reaches the end of its lifetime and starts to churn out as waste in higher volumes.

Fortunately, there is growing awareness of the extent of the problem and momentum to act is building in terms of both government policies and industry actions around the world. But initiatives are still primarily at the pilot stage and the major shifts needed are yet to occur. Norway is leading the way in several areas of innovation and is well-positioned to play a pioneering role in the transition to a low-emissions circular plastic system. The country must now make strategic decisions that will determine the speed and direction of this transition for decades to come.

Coupled with Part 1 of the Achieving Circularity study, this report offers a pioneering vision for how to transform the Norwegian plastic system by 2040. It presents tailored circularity strategies for durable plastics across five very distinct sectors: Construction, Textiles, Electronics and Electricals, Automotive, and Fisheries & Aquaculture. To define the most effective upstream and downstream strategies for each sector, as well as the policies and partnerships needed to achieve them, we must first analyse the different uses of plastic across sectors in detail, including applications, functionalities, usage forecasts, impacts, and substitutes. Our analysis aims to deepen understanding of the economic, environmental and social implications of the critical choices facing the plastic industry.

Our central goal is to help decision makers and industry leaders in Norway to identify the best pathway to achieve the low-emissions circular plastic system the country needs by modelling three scenarios. The first is a Baseline or Current Commitments Scenario, presenting what the plastic system will look like in 2040 if nothing changes.

Next is the System Change Scenario, which shows the maximum level of circularity that can be achieved by 2040 by scaling up levers such as better waste collection, product design, new delivery models, and recycling. This offers a high level of circularity, but only addresses half the GHG emissions in the plastic system, leading to the third option, the Net-Zero Scenario. This presents a viable pathway for Norway's plastic system to achieve ~77% circularity and reduce GHG emissions by ~90% by 2040, thus aligning itself with the Paris Agreement.

The fact that Norway imports most of its plastic and plastic products, and exports over a third of its plastic waste, has implications for how to assess both the impacts of its current plastic system and analyse prospective strategies, and is therefore considered across the report's key findings. Issues to be addressed include plastic production emissions not being included in Norway's Nationally Determined Contributions to the Paris Agreement, the majority of jobs being outside Norway, and the need for collaboration with other Nordic countries and the EU to define future plastic solutions. Cooperation will be key, but this report also poses the key question of to what extent Norway can domesticate its own plastic value chain, while also focussing on driving change abroad.

> "There is a viable pathway for durable plastics to achieve circularity levels of over 70%, whilst reducing GHG emissions by 90%"

This data-driven study draws on analysis carried out by researchers, civil society organisations, companies, and government agencies. It has been guided by an independent and diverse Expert Panel with representation from all sectors. The model and scenario analysis from now until 2040 creates a picture of the current issues and what is needed in order to change the system trajectory, which we hope will help sector leaders and government decision makers identify **effective ways to transition towards a highly circular, low-emissions plastic system.**

Key Findings

The 8 key findings of the report[a] are grouped into three sections (which are summarised in the infographic Exhibit 1):

? Where is the system today and what trajectory is itcurrently on?

? How to operationally change the system trajectory?

? What is needed to change the system from a governance, economic, labour and user perspective?

[a] Note to the reader: numbers included in this study are modelled outputs, accurately represented from our model, which could be perceived as false precision. It is important to emphasize these are projections, not forecasts, and therefore there is a margin of error.

? Where is the system today and what trajectory is it currently on?

1

Plastics have been a key enabler of growth in our economy, which together utilised ~380,000 tonnes of plastic in 2020 across the sectors analysed. However, the system is only 21% circular and requires better management to deliver benefits to society and the economy while mitigating negative climate, environmental and social impacts.

Plastic has been an instrumental material to our economy and society by providing, for example, key infrastructure in aquaculture, building blocks of fibres in textiles, insulation in houses, high performance form factors for electronics, and light-weighting of cars. However, these benefits to the economy and society need to be captured while mitigating plastic's negative environmental and climate impacts.

Almost four-fifths of today's plastic system is linear, in which ~96% of GHG emissions are generated from unabated plastic production and end-of-life incineration. This is an inefficient use of both resources and Norway's remaining 1.5-degree carbon budget.

2

The Norwegian plastic system is on an unsustainable trajectory that risks exacerbating today's systemic challenges.

The use of durable plastic (defined here as products with average lifetime of over one year) face additional challenges. It is necessary to address legacy plastics that were designed without circularity in mind, while also designing for end-of-life reuse and recycling technologies and systems operating in the future, that likely do not yet exist. Due to continued increase in demand for plastics and the long lifetimes in these sectors, **~4.9 million tonnes of plastic stock has already accumulated in use in the system.**

Environmental impacts are set to worsen in the coming years as accumulated legacy plastic starts to churn out in higher volumes than today. If nothing changes, yearly waste volumes are forecasted to more than double by 2040, for which the existing waste infrastructure in Norway is not equipped, and over 70% of waste will be incinerated, landfilled or leaked into nature and GHG emissions will increase by an estimated 28%. This will be mainly driven by higher volumes of incineration (94%) and increased demand for virgin plastic (37%) under business-as-usual.

? How to operationally change the system trajectory?

3

Current policy and industry commitments are still not ambitious enough to drive a holistic transformation of the system and to meet the European Green Deal, the Circular Economy Action Plan, and the Paris Accord.

Despite the growing attention that plastics have received in recent years, commitments made vary by sector, but Construction, Automotive, and Waste Electrical and Electronic Equipment (WEEE) are particularly falling short and are currently not on track to meet circularity targets. Of the 16 policy and industry commitments identified, only 2 met the criteria for inclusion in the baseline "Current Commitments" Scenario. If nothing changes beyond these current commitments, the system will be only 31% circular by 2040, a modest improvement on the 21% circularity level today, and achieve only a mere 7% reduction in GHG emissions.

4

Approximately 77% circularity can be achieved in the Norwegian durable plastic system by 2040, which would halve GHG emissions. This System Change Scenario requires a framework of ambitious circularity interventions along the plastic value chain, including the scale-up of 4 elements:

a. **Reduction:** elimination, lifetime extension, and new delivery models enabling the sharing and reutilisation of plastic can avoid up to 26% of demand.

b. **Collection & sorting:** collection for recycling as well as (local) sorting and cleaning capacity should be scaled up across all sectors as this often creates recycling bottlenecks. Extended producer responsibility (EPR) and other policies will be needed to make this economically feasible, including investments into new advanced technologies.

c. **Mechanical recycling:** a combination of design for recycling, stimulating demand for recycled content, and the scaling up of (local/regional) recycling capacity can increase mechanical recycling to ~34% and chemical recycling to 16% of total demand for utility, but is challenging because of complex polymer mixes.

d. **Chemical recycling** can offer the opportunity to boost circularity levels and deliver virgin quality polymers, but must be complementary to the expansion of mechanical recycling and action must be taken to abate GHG emissions from the start.

Unlike for consumables, substitution with other materials, including biodegradables, were not identified at-scale for plastics in durable applications, but this could change in the future.

5

The application of these interventions must be tailored to each sector and, due to longer plastic lifetimes for durables, strategies to turn the system circular will have a significant time lag compared to consumables.

a Construction:

The most impactful lever is maximising on-site sorting of plastic waste to ensure clean material streams and thus a higher chance of material recovery. This should be coupled with the scaling up of sorting and recycling infrastructure in Norway to treat higher volumes of sorted waste.

Reuse and reduction opportunities via innovative building design should also be leveraged to minimise demand from the sector. However, the impact of these levers on waste generation before 2040 is limited given the long in-use lifetimes.

b Textiles:

As a net importer of textiles, Norway has limited control over upstream solutions and therefore close collaboration with the EU to target the production phase and support international rules and standards is key.

This can unlock a well-functioning system if combined with demand side reduction through reuse and repair business models, scaling up collection, sorting and pre-processing, and investing in new recycling technologies.

c WEEE:

While recycling rates are higher compared to most other sectors, the system remains predominantly linear, largely as a result of industrial cables being left in nature, incorrect disposal of WEEE in mixed municipal solid waste, and theft from collection centres.

To achieve higher levels of circularity, leakage of waste must be reduced by maximising formal collection, with a particular focus on collecting and identifying items for reuse.

Furthermore, design for recycling principles must be adopted to reduce and standardise the types of polymers used and enable a more straightforward sorting process.

Finally, investment should be directed at scaling up innovative sorting technologies that yield higher recovery rates.

d Automotive:

Although Norway is a frontrunner in terms of vehicle collection, in the current system 99% of plastics are being disposed of via landfill or incineration. Key levers to achieve circularity include adopting new business models to reduce plastic demand as well as regulation to enable a well-functioning recycling infrastructure.

Collaboration with Nordic countries (especially Sweden) will be key as Norway has no vehicle recycling facilities and volumes are too small to justify the large investments in recycling infrastructure that are required.

e Fisheries & Aquaculture:

Key levers include lifetime extension in aquaculture by using gear in ways that avoid wear and tear and identifying opportunities for using gear for longer, followed by creating closed (local) recycling loops for rigid High Density Polyethylene (HDPE), and expanding the collection and depolymerization of nets.

? What is needed to change the system from a governance, economic, labour and user perspective?

6

Even after the application of these circularity levers, about half the total emissions related to plastic (~700,000 tonnes CO_2eq) still remain in 2040. To establish a trajectory in line with the net-zero pathway, additional technology interventions need to be deployed to abate the emissions from production and incineration. The Net-Zero Scenario shows that combined circularity and supply side abatement technologies can reduce emissions in 2040 by ~90% relative to Current Commitments.

Three key abatement strategies are required to achieve this (on top of the circularity levers included in the System Change Scenario):

i) switching feedstock source from fossil to alternative carbon feedstocks (such as sustainable biomass) and green hydrogen;

ii) using only renewable energy sources; and

iii) putting in place carbon capture utilization & storage (CCUS) in production and incineration facilities.

Norway is already pioneering carbon capture in its incinerators and can seek to roll this technology across is broader portfolio to abate end of life plastics emissions.

7

Building a low-emissions, highly circular system requires an annual incremental investment of NOK ~280 million, which is affordable compared to scaling up a linear, resource inefficient system.

This is driven primarily by scaling up recycling infrastructure, and abating production and end-of-life emissions. A low-emissions circular system can be achieved while sustaining existing system employment levels to 2040 (noting that the majority of jobs today are outside of Norway, and depending on the selected strategy, some could be domesticated).

However, the application of circularity strategies will result in many jobs needing to shift from traditional volume-based production roles to circular economy-focused roles, particularly in recycling. This will require retraining to ensure a just transition.

8

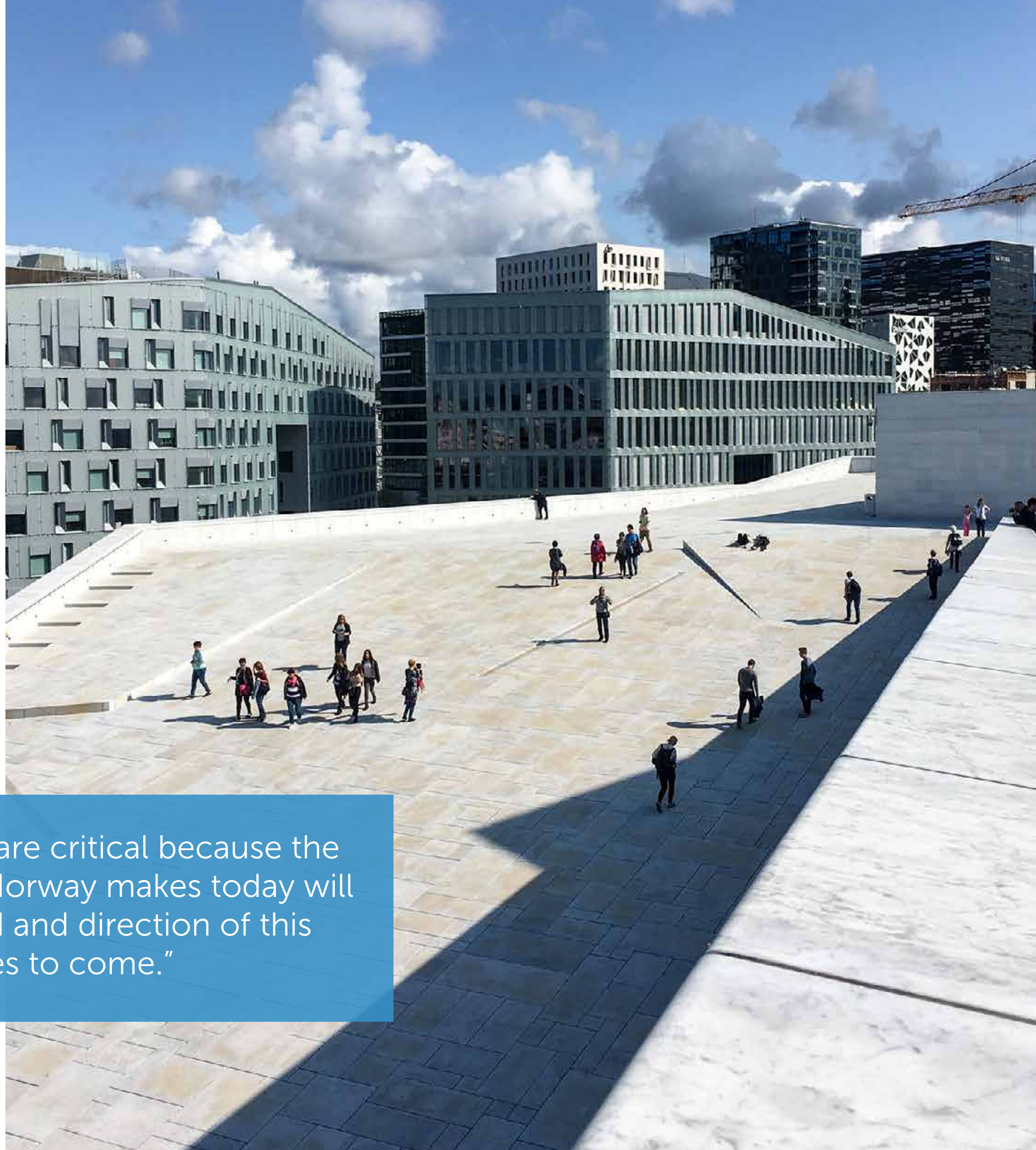
To accelerate the transition to a low-emissions, highly circular plastic economy in Norway, a system vision and strategy needs to be defined, owned and implemented.

Today, different stakeholders in the plastic system are often working in silos and on fragmented solutions, resulting in incompatible strategies and inefficiencies. Norway could consider setting up a multi-stakeholder transformation body to help coordinate the cross-sector cross-value chain transition strategies.

This would guarantee that the system overall balances upstream, downstream and value chain abatement interventions in a way that encourages the most resource- and cost-efficient system transition.

In order to remain a global leader in the low-emissions, circular plastic space, Norway should apply a combination of ambitious upstream and downstream circularity levers across the different sectors, enabled by a favourable policy, financial and labour environment.

The next three to five years are critical because the strategic decisions Norway makes today will determine the speed and direction of this transition for decades to come.



"The next 3-5 years are critical because the strategic decisions Norway makes today will determine the speed and direction of this transition for decades to come."

The big picture

Plastics have been **indispensable** for the growth of the five sectors, but this has come at a **high cost**

EXHIBIT 1

Today, plastic use across the five sectors (Construction, Textiles, Electronics, Automotive, Fisheries & Aquaculture) **is:**

very linear...

21% reused or recycled

>90% fossil based virgin feedstock

...and high GHG emitters

>60% incinerated

~3%* of total equivalent Norwegian emissions

...and, if **nothing changes** the impact in Norway will worsen by 2040**:

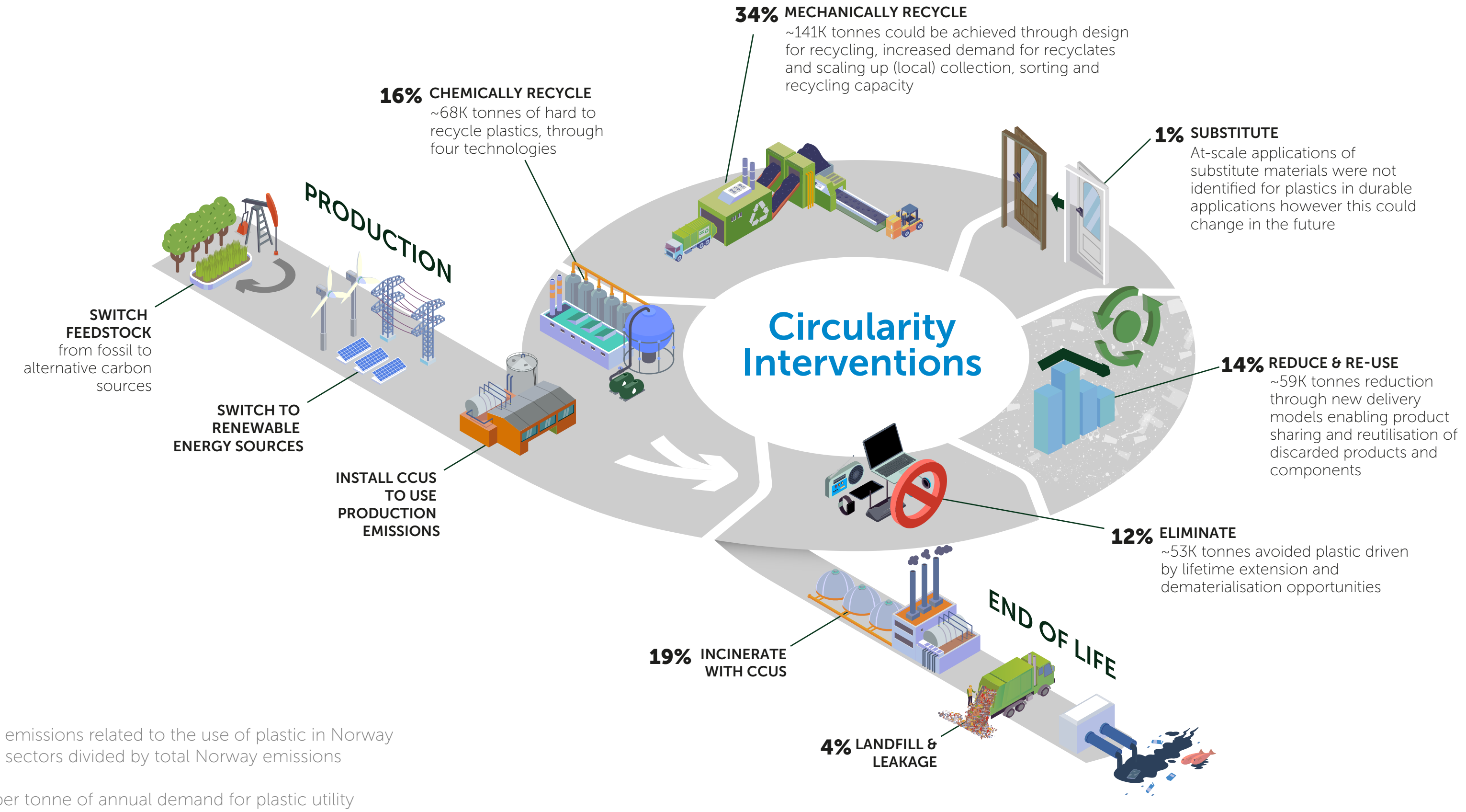
↑113% waste generation

↑37% increase in virgin feedstock production

↑94% incineration

↑28% GHG emissions

77% **circularity** can be achieved under a System Change Net-Zero Scenario...



...while reducing environmental impacts and limited cost for society**

↓89% GHG emissions

↑3% Jobs

↑5% cost p/tonne***

↓30% waste disposal

*total lifecycle emissions related to the use of plastic in Norway across the five sectors divided by total Norway emissions
**vs 2020
***Total cost per tonne of annual demand for plastic utility

Five enabling conditions can accelerate the shift to a low-emissions circular plastic economy:

1 Policies & Financing Model
Set the right standards and incentives for design, use and end-of-life management from both a waste and GHG perspective, whilst enabling a positive business case.

2 Technology & Innovation
Prove sharing and reuse models, invest in advanced sorting technologies, improve (and communicate!) quality of recyclates, consider ramping up chemical recycling domestically, and pioneer low emissions technologies.

3 Cross Value-Chain Collaboration
Guarantee cooperation regarding design, production and end-of-life management from a waste and GHG perspective, mainly with Nordic countries and the EU.

4 Consumer & User Engagement
Ensure industry champions & large users demand sustainable models and designs from manufacturers and emphasise the link between plastics & GHG emissions.

5 Labour Force Reskilling
Enable professionals, including from the oil and gas sector, to focus on sustainable domestic and end-of-life production

The time to act is now

Chapter 1

The current state of play

Understanding the challenges

Plastic has been a key enabler of accelerated growth across all five sectors in scope of this study (Construction, Textiles, Electronics, Automotive, and Fishing and Aquaculture) over the last decades due to its affordability, durability, low weight, high resistance, and potential to mould and shape into any design. At the same time, it is these characteristics that are also creating the environmental and social problems related to the current plastic system, a high greenhouse gas (GHG) emission system that – without the right treatment at end-of-life – also causes plastic pollution that damages the environment and potentially human health[c].

For Norway, the biggest issue is the large amount of GHG emissions generated by the plastic system[d]. Fossil based plastic manufacturing processes and incineration of plastic waste, which is the primary pathway for plastics used in Norway, emit a significant amount of GHGs and this is projected to increase between now and 2040. Domestic plastic pollution also exists but is less significant than in other markets, although Norway does not have full control over the fate of almost 40% of its plastic waste as it is currently exported overseas.

A very diverse set of durable plastic systems

This study includes a varied and complex set of product categories across very different sectors, ranging from consumer electronics like mobile phones, to industrial fishing nets, and fuel tanks in cars (see Exhibit 2). Although solutions should be tailored to meet the unique needs of each of these product applications, they all face similar challenges given that all the product categories in scope are durable, with average lifetimes ranging from 2 years for certain garments to 35 years for plastics in construction.

EXHIBIT 2 **Sectors in scope are very diverse in terms of plastic usage, content and lifetimes**

	Construction	Textiles	Electricals & Electronics	Automotive	Fisheries & Aquaculture
How is plastic used?	Plastic provides a low-cost, versatile, and highly functional material in construction products, e.g. pipes, window profiles, insulation, roofing and flooring.	The majority of fibres in textiles, from clothing to shoes and household textiles are polyester. The use of plastic in textiles enabled the fast fashion trend, making textiles cheaper, lighter and overall more versatile (e.g. stretch, print and colour).	As a versatile and low-cost material for a very diverse sector with products ranging from consumer- facing electronics like mobile phones and TVs, to large industrial cables installed underground.	A lightweight and multifunctional material used throughout the vehicle from bumpers, to seats, to cable insulation, to reduce vehicle weight and thus improve fuel efficiency.	Plastic is the most used material across all gear used due to its low costs and resilience in the marine environment, from the nylon in nets to HDPE in aquaculture farms walkways.
Proportion of plastic in product categories in scope	90%	55%	25%	15%	70%
Average product lifetime	35 Years	4 Years	8 Years	18 Years	9 Years

Mepex Assessment

Key challenges include:

- Inadequate regulation, with plastic not being a priority compared to other materials used in the sector. For example, there are no plastic-specific circularity targets for Automotive and Construction and existing waste targets can be met by focusing on other materials.
- Product design not factoring in end-of-life treatment, resulting in a decline of recyclability and recoverability of materials from mixed material streams in a market with insufficient collection, sorting and recycling infrastructure.
- For some sectors, inefficient use of plastic is exacerbated by the low cost of virgin plastics and the lack of alternative business models to increase utilisation, including better access to collection or incentives to hand in used products (e.g. clothes accumulating in wardrobes after several wears, electronics not handed in, underutilisation of cars).

[c] This is a new field of study that requires more research.
[d] All emissions associated with plastics put on market in Norway are considered in this analysis, even though the majority of emissions are extra-territorial, therefore reducing these emissions will require cooperation with other countries

A greenhouse gas intensive and highly linear starting point

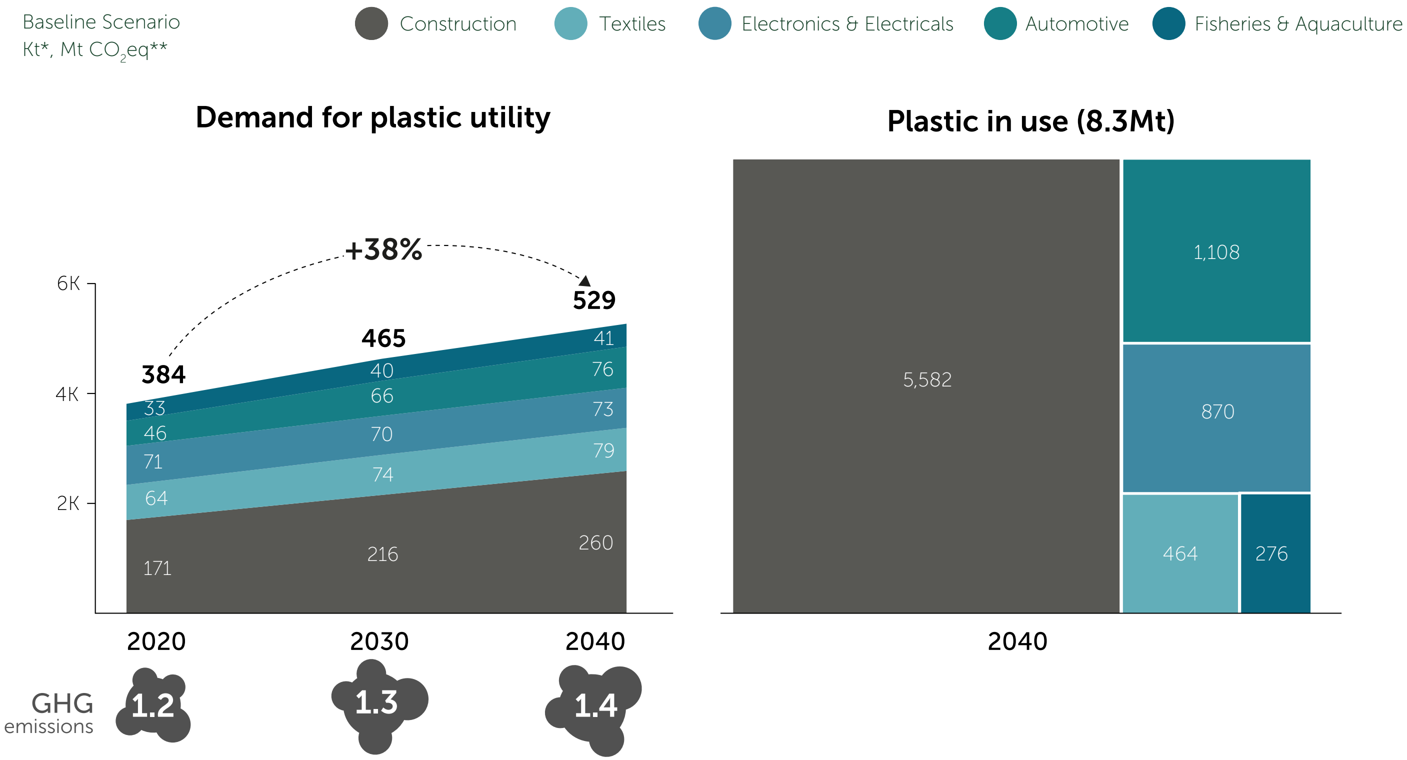
In 2021, the plastics in the five sectors analysed represented about ~46% of total annual demand and ~25% of total annual waste of plastic in Norway.

Annual demand is predicted to grow by ~38% by 2040 and this will lead to an almost 70% increase in the volume of plastic accumulated in the system, rising to ~8,300 tonnes by 2040, representing the lion's share of plastic in stock.

Around 90% of this will be virgin plastics, and combined with increased incineration, will result in an increase of GHG emissions from 1.2 million tonnes of carbon dioxide equivalent (CO_2eq) in 2020 to 1.4 million tonnes of CO_2eq by 2040, instead of the declining emissions pathway needed during this period.

> "A declining emissions pathway is urgently needed to stop the growing GHG emissions in Norway."

EXHIBIT 3 **As demand for plastic utility continues to grow, accumulation of plastic in use will grow to 8.3Mt by 2040**

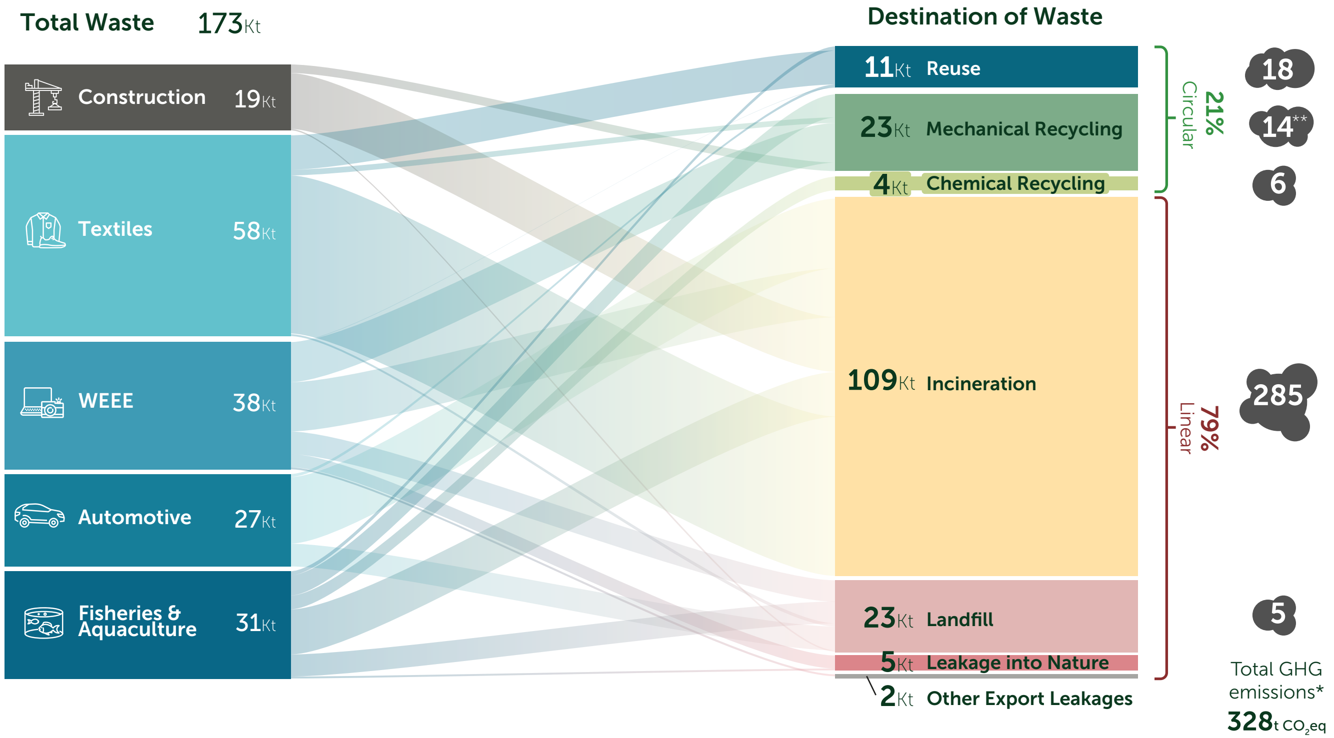


*Kt = thousand tonnes
**$MtCO_2$eq = million tonnes of carbon dioxide equivalent

EXHIBIT 4

Today the most common fate of most domestic and exported plastic waste is incineration, causing significant GHG emissions

Baseline Scenario 2020 – Kt / tCO_2eq



* GHG emissions related to end-of-life, not production
**including collection & sorting emissions

Today, plastics use across the five sectors is still highly linear (~79%), with the predominant pathway being fossil based plastic manufacturing processes with incineration at end-of-life (~63%) (see Exhibit 4). This has significant implications, including:

- Incineration is a highly emissions and resource inefficient destination, which will continue to scale as the plastic system grows. The climate crisis makes the operating model of extraction, production and burning completely untenable. Long-term capex and feedstock lock-ins of incinerators make it more challenging to promote a circular system.
- With durables, especially the ones with very long lifetimes, there is a risk of shifting responsibility for large waste volumes, which are operationally and economically challenging to address, to the next generation.
- Several sectors, notably Waste from Electrical and Electronic Equipment (WEEE) and Fisheries & Aquaculture, have non-trivial plastic leakage into nature[e], but data availability remains a challenge. However, broadly speaking, direct leakage is less of a challenge in the Norwegian system than in some less developed countries.

In terms of circular destinations (i.e. reduction, reuse and recycling), the main solutions currently revolve around recycling (~15%). However, this is predominantly open loop recycling and therefore plastic is not kept in use in the same sector and is not considered recyclable thereafter.

Finally, for both circular and linear end-of-life destinations, the five sectors depend heavily on exports (~36%) – meaning that Norway has less control over the system (e.g. little visibility of reuse of clothes outside the EU) and causing additional adverse impacts (e.g. transportation emissions during export and import).

[e] Leakage refers to plastic waste that ends up in nature. For WEEE, these are cables left underground; for Fishing & Aquaculture, this is gear discarded in water bodies or on land.

EXHIBIT 5

Only two commitments identified met the criteria to be included in the Current Commitment Scenario implying that a significant raise in policy ambition is required across all sectors

Criteria	Identified commitments (total of 16)	Sector	% Circular 2040 Baseline	Current Commitments that fit within the criteria	% Circular - 2040 Current Commitments*	Ambition level of other policies being discussed**
Regulatory commitment	15 Commitments identified which are relevant to these 5 sectors	Construction	12%	**VinylPlus** PVC recycling rates will be increased to meet Norway's share of target	15%	PVC recycling rates increase to meet Norway's share of target. Some other commitments being discussed are very vague and lacking ambition.
		Textiles	24%	Separate collection of textiles by 2025	75%	Additionally, an EPR for textiles might be included in the 2023 revision of the EU Waste Framework Directive
		WEEE	34%	-	34%	Mainly focused on collection rates with no plastic-specific recycling targets, and there is a concern that ambition levels will fail to align with EU regulation.
Industry wide commitment	1 Voluntary commitment identified (for Construction)	Automotive	<1%	-	<1%	No relevant commitments, but more ambitious regulations with material-specific targets are expected e.g., ELV Directive revision
		Fisheries & Aquaculture	35%	-	35%	Ambitious EPR being discussed – implementation to start as of 2024

Ambition Level No Limited Medium High Very high

* Qualitative Assessment of all current commitments identified – not just the ones fitting the criteria

Momentum for change is building but current commitments are falling short

While current commitments to cut plastic waste are building momentum, and more ambitious Norwegian policies are being discussed, they are falling far short of achieving a low-emissions, zero-waste circular plastic economy.

In this study, we identified 16 policies and industry commitments (see Exhibit 5). However, only two of these fit the criteria for inclusion in our Baseline "Current Commitments" Scenario, having been confirmed and with strict concrete targets and roadmaps already in place: the separate collection of textiles by 2025, and the PVC collection targets in construction set by VinylPlus. **If met, these current commitments result in an increase in system circularity of durables from 21% today to 31% by 2040.**

> "Current commitments are falling short to deal with the accelerating rise in waste volumes combined with the escalating GHG emissions"

A qualitative assessment, in which we also consider upcoming regulations and commitments, shows that the regulations being discussed for Fisheries & Aquaculture and Textiles are the most ambitious among the sectors analysed, and include an extended producer responsibility (EPR) framework. In contrast, the Norwegian regulations for the Construction and Automotive sectors are falling short as their current focus is on other materials. However, more ambitious regulations with material-specific targets are expected, for example the End of Life Vehicle Directive revision. Finally, Norway's WEEE regulations are mainly focused on collection rates with no plastic-specific recycling targets and there is a concern that ambition levels will fail to align with EU regulation.

Experts believe that new policies, particularly EPR, will be key to accelerating the transition to circularity.

Scenarios modelled

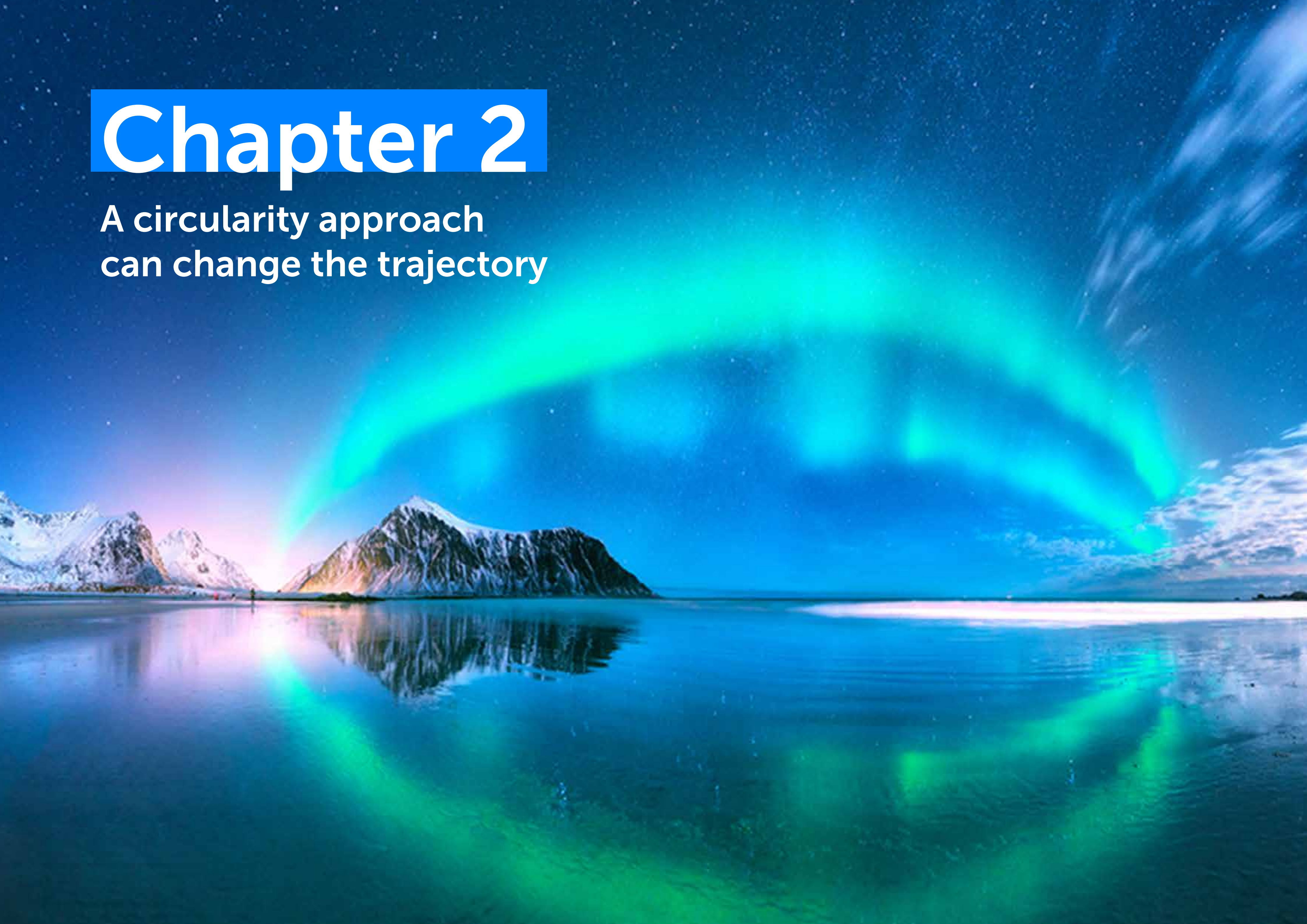
With the **Current Commitments** context as a starting point, we modelled two additional scenarios, and quantified their economic, environmental, and social implications[f]:

- **A System Change Scenario,** in which we applied circularity interventions to analyse what is the most ambitious level of circularity that can be reached by 2040.
- **A Net-Zero Scenario,** in which we applied GHG emissions reduction technologies to the plastics value chain, following the application of circularity interventions.

[f] Microplastics are out of scope for this study.

Chapter 2

A circularity approach can change the trajectory



Cross Sector Overview

System interventions and aggregate results

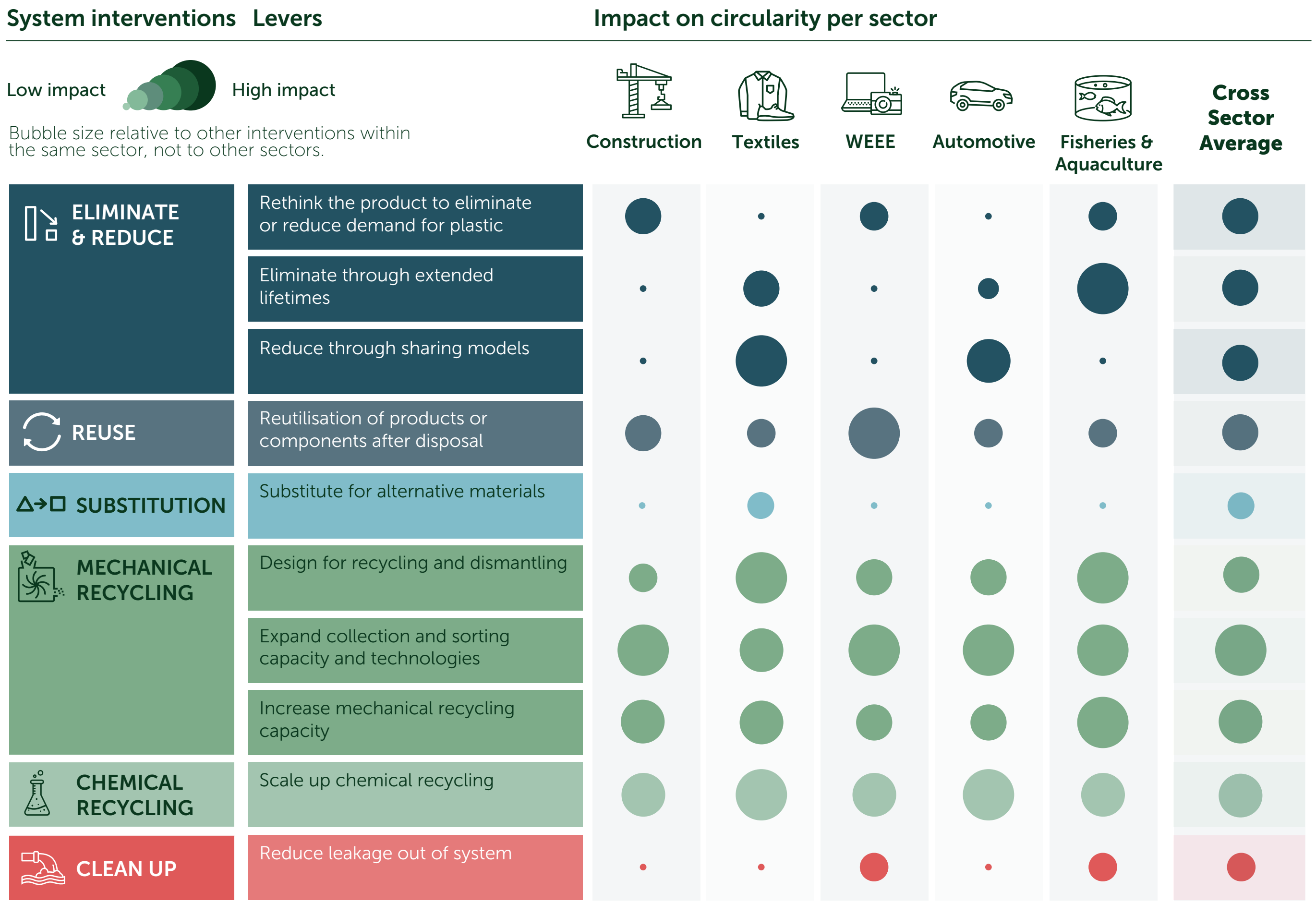
Our System Change Scenario includes five system intervention wedges aimed at reaching higher circularity levels, and models the most important environmental, social and economic implications of applying a different combination of these interventions to each sector, depending on its specific needs and system impacts.

Through the application of ten circularity levers (see Exhibit 6), the five sectors can achieve **~77% circularity** levels by 2040 while **eliminating ~28% of demand for virgin plastic** and **reducing GHG emissions by 38%** (Exhibit 7). This is not in line with Norway's GHG reduction targets, hence the need for the Net-Zero Scenario presented in the next chapter. The predominant circularity pathway is mechanical recycling (~34%), followed by reduction (~20%), chemical recycling (~16%) and reuse/repair (~6%).

Chemical recycling and its application in Norway

Chemical recycling is a nascent technology and the capacities of the different technologies beyond 2030 are highly uncertain.
Allocation assumptions for the Norwegian market overall, and for each sector, were made considering European capacity projections for each technology (pyrolysis, gasification, dissolution, and depolymerisation) and the availability of quality waste streams and polymer types in Norway.

EXHIBIT 6 **System interventions and corresponding levers improve circularity in the sectors with varying levels of applicability**



Although incineration and landfill can be reduced both in proportion and absolute terms by 2040 (except for the Construction sector), these still represent ~18% and ~3% of the end-of-life destinations for plastic (vs ~63% and ~12% in 2020)[9].

Construction remains a challenge as incineration and landfill will increase in absolute volume due to waste volumes increasing by a factor of 7. Another attention point is that there will not be enough recyclate available to satisfy the full voluntary demand for recycled content in either Construction or Fisheries & Aquaculture by 2040, meaning that flows of recycling will balance out based on market supply and demand.

The System Change Scenario reduces the amount of net capex required to build the system by around NOK 700,000 compared to scaling up the linear system infrastructure. Resource efficiency is coupled with capital efficiency as plastic utility is decoupled from plastic volume.

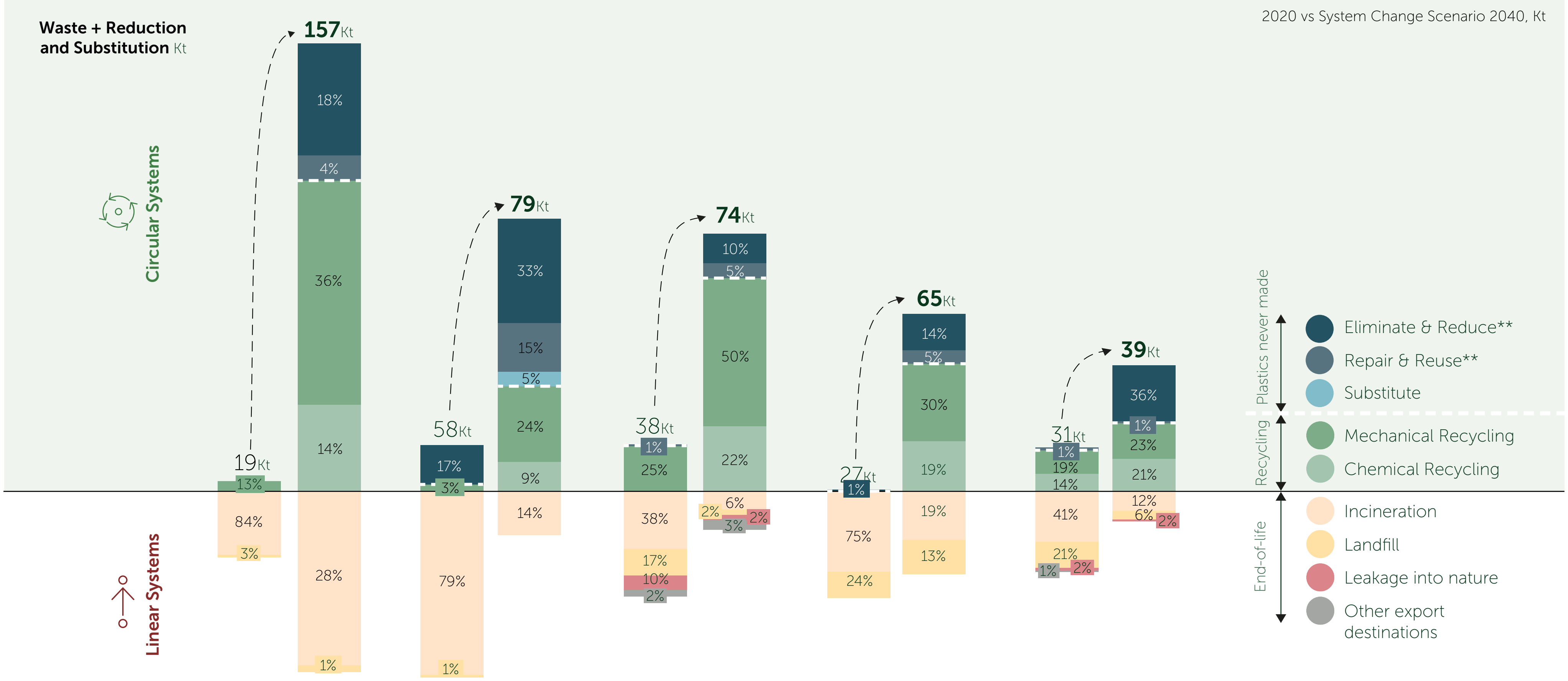
Around 50% of the investment is used to scale recycling, equally divided between mechanical and chemical, while 35% is used to scale up production capabilities and another ~10% to scale up incineration. Total jobs in the plastic system remain the same between the System Change Scenario in 2040 and the Baseline Scenario in 2020.

"A System Change Scenario can change the trajectory, reducing GHG emissions by 38% compared to 2020, while reducing the amount of net capex."

[9] Proportion of annual demand for plastic utility corrected for net addition to stock.

EXHIBIT 7

In a System Change Scenario circularity can increase from 21% to 77% and incineration can be significantly reduced, except for Construction



	Construction 2020	Construction 2040	Textiles 2020	Textiles 2040	WEEE 2020	WEEE 2040	Automotive 2020	Automotive 2040	Fisheries & Aquaculture 2020	Fisheries & Aquaculture 2040	Cross Sector Totals 2020	Cross Sector Totals 2040 System Change Scenario
% Circular*	13%	71%	20%	85%	31%	87%	1%	68%	35%	81%	21%	77%
GHG Emissions $KtCO_2eq$	371	402	279	62	204	75	163	111	138	52	1,128	700
Waste + Reduction and Substitution* **											175Kt	421Kt

*Circularity as a % of annual demand for plastic utility corrected for net addition to stock
**Reduction: elimination through dematerialisation & lifetime extension, and reduction through new delivery models enabling access. Reuse: reutilisation of products or components after disposal
***Waste includes: repair & reuse, recycling, incineration, landfill, leakage and other expert destinations

Construction

Scope

23%
Pipes
All piping

20%
Insulation
Insulation for buildings, bridges, tunnels etc, but excludes road insulation

2%
Roof Products
SBS modified bitumen, PE roofs

15%
Flooring, other
Flooring, roller shutters, films, sheets

3%
Windows & door profiles

37% Out of scope
District piping, running tracks, rubber asphalt

Summary

The use of plastic products in buildings and construction has grown rapidly over recent decades. Coupled with the long lifetimes of products, this has resulted in a significant accumulation of plastic in the Norwegian building stock, meaning that a large wave of plastic waste will emerge in coming years as in-stock volumes reach the end of their lifetimes and churn out as waste. By 2040, it is expected that the Norwegian construction sector will generate ~130,000 tonnes of plastic waste, representing an almost seven-fold increase relative to the 19,000 tonnes of waste generated in 2020.

The current waste-management system is ill-prepared to cope with these volumes, which could risk a significant increase in disposal, particularly incineration. To achieve higher levers of circularity, the most impactful lever is maximising on-site sorting of plastic waste to ensure clean material streams and thus a higher chance of material recovery. This should be coupled with the scaling up of sorting and recycling infrastructure to allow it to treat higher volumes of sorted waste.

Reuse and reduction opportunities via innovative building design should also be leveraged to minimise demand from the sector. However, these levers will have a limited impact on waste generation before 2040 given the long in-use lifetimes. Policy will need to play a pivotal role to guarantee the focus and speed required, and to prevent further urban sprawl due to Norway's low population density.

By applying these circularity levers the system can move from 13% to 71%[h] circularity by 2040, while the proportion of plastic demand met by virgin production can be reduced to 67% by 2040, down from 82% today. However, even with the ambitious deployment of circularity solutions, GHG emissions related to plastics in this sector are set to grow by 8% (from 371,000 tonnes of CO_2eq in 2020, to 402,000 tonnes of CO_2eq by 2040) in the System Change Scenario (Exhibit 8). This is much lower than the estimated 92% emissions growth (to 713,000 tonnes of CO_2eq by 2040) in the Baseline Scenario.

[h] Circularity as a % of annual demand for plastic utility corrected for net addition to stock

EXHIBIT 8

Potential outcomes of implementing a System Change Scenario

		FROM 2020	TO System Change 2040	
A MORE SUSTAINABLE AND CIRCULAR CONSTRUCTION INDUSTRY	**Floor space** per capita	62.5 m²	50 m²	-20%
	Mass of plastic	23.5 kg/m²	23.5 kg/m²	0%
	Virgin plastic production	140 Kt	152 Kt	+8%
	Recycling (Mechanical & Chemical)	3 Kt	78 Kt	+2,500%
	Incineration, landfill & leakage	17 Kt	46 Kt	+171%
	Circularity*	13 %	71 %	+446%
	GHG Emissions per tonne of demand for plastic utility	2.2 tCO_2eq	1.5 tCO_2eq	-29%
WITH LIMITED TRADE OFF FOR SOCIETY	**Cost** per tonne of demand for plastic utility	14,000NOK	17,000NOK	+26%
	Jobs per Kt of demand for plastic utility**	0.4	5.2	+1166%

* Circularity as a % of annual demand for plastic utility corrected for net addition to stock
** Excluding production as majority takes place outside Norway

Key stats

171Kt
Volume put on market 2020

35Yr
Average Lifetime

Most common Polymers in use

~32% **EPS** Expanded Polystyrene

~23% **PVC** Polyvinyl chloride

~21% **PE** PolyEthylene

Baseline:
Norway unprepared to cope with the upcoming wave of plastic waste

The construction sector represents the second largest end use market for plastics in Norway after packaging (171,000 tonnes in 2020), yet this sector is currently the smallest source of plastic waste (19,000 tonnes in 2020) out of the five sectors considered in this report due to long lifetimes of construction products.

Plastic demand in the Norwegian construction sector has grown significantly in recent decades, driven predominantly by increased plastic usage per square metre to around 12-21 kg/m², [1] as well as by population growth and increasing floor space per capita[2]. This trend has also been seen globally, with plastic consumption from the sector growing at an average rate of 4.3% per year over the last two decades.[3] In Norway, a growing trend towards the import of low-cost products has contributed to rising consumption of plastics and led to the substitution of other materials (e.g. timber, aluminium, and mineral wool) with plastics.

The rapid growth in plastic demand from the sector, coupled with long product lifetimes, has resulted in a large accumulation of in-stock plastic, reaching an estimated 2.7 million tonnes by 2020. We can therefore expect a large wave of plastic waste from the construction sector over the coming decades.

Current demand volumes are almost 9 times higher than waste volumes[i], which means we expect an estimated 7-fold increase in waste volumes by 2040 as the large in-stock volumes begin to churn out as waste. Norway's current waste collection, sorting and recycling infrastructure are entirely underprepared to cope with these volumes of waste. Under current policy and environmental conditions, this could lead to a large increase in disposal, particularly incineration, leading to unacceptable levels of GHG emissions.

Plastic accounts for less than 1% of construction and demolition waste. Its low volume, coupled with the economic and logistical challenges associated with the separate collection of plastic waste has limited on-site sorting of plastics to date.

This is the main barrier to circularity today, with only 13% of plastics currently recycled from building and construction. Construction plastics are often embedded in the building, for example behind walls and under floors and roofs, and firmly attached, such as to flooring using adhesives, or to windows that need to be dismantled separately. This poses a challenge to on-site sorting and often results in the use of destructive demolition techniques that do not allow for the recovery of clean plastic waste streams. In addition, there is a lack of economic incentives for plastics recovery, given the low value of secondary plastics relative to building materials such as steel and timber, as well as high labour costs. This has led to a preference for speed of demolition over plastic recovery that limits system circularity.

In addition to the economic and logistical challenges associated with the recovery of plastics from construction and demolition, another key barrier to circularity is the presence of legacy additives and substances of concern that were used prominently in many building products in the past but are now regulated against. Plastics containing these substances cannot be recycled and put back on the market.

There is currently limited policy focus on construction plastics but movements in other sectors signal growing momentum towards more stringent policy.

There are no mandatory requirements for separate collection or recycling of plastics from construction and demolition in Norway and, given the low costs of disposal and incineration, no economic incentives. Voluntary initiatives exist, such as the Nordic Swan Ecolabel, which sets standards on building materials, best practices on demolition, on-site sorting, etc., but, given the lack of policy mandate and the poor economics, these initiatives are poorly subscribed to. While the Waste Framework Directive mandates that 70% of construction and demolition waste must be recycled or reused, the relatively low volumes of plastic waste mean that it is not typically a target material for achieving this mandate. However, there are positive signals indicating that the EU, via the Circular Economy Action Plan, and Norway, via its national plastic strategy, are likely to propose new requirements for plastics recovery from construction and demolition in the near future.[5]

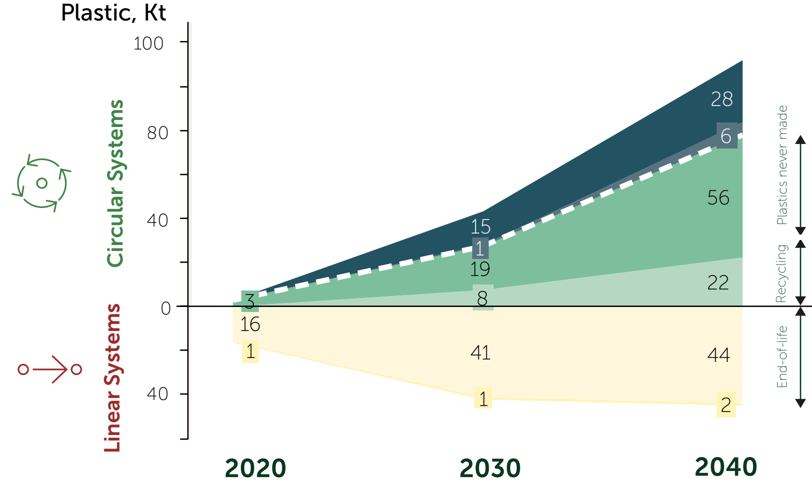
[i] Although it is very likely that the proportion of plastic in mixed waste is underestimated, and it is likely higher than the 5% estimated in a 2015 report.[4]

Achieving Circularity:
Innovative building design and reuse, coupled with on-site sorting can change the system

A level of 71% circularity can be achieved by 2040 (57% without chemical recycling), mainly by maximising the on-site sorting of plastic waste to ensure a clean material stream, and thus a higher probability of material recovery in downstream sorting and recycling stages. Additionally, sorting and recycling infrastructure should be scaled rapidly, both in Norway and the wider region, to treat the much higher volumes of sorted waste, as well as to cope with rapid growth in plastic waste. Reuse and reduction opportunities via innovative building design should also be leveraged to minimise demand from the sector. These levers can eliminate around 11% of plastic demand by 2040.[6]

EXHIBIT 9 **Through the application of circularity levers the Construction sector can reach 71% circularity by 2040**

As % of total demand for utility (with deduction of stock)



	2040 System Change Scenario	2040 Current Commitment Scenario
Eliminate & Reduce	18%	0%
Repair & Reuse	4%	0%
Substitute	0%	0%
Mechanical Recycling	35%	13%
Chemical Recycling	14%	0%
Incineration	28%	84%
Landfill	1%	3%
Leakage into nature	0%	0%

	2020	2030	2040
Circularity	13%	51%	71%
Total utility demand*	19 Kt	86 Kt	157 Kt
Total waste	19 Kt	71 Kt	130 Kt
GHG Emissions	371 $KtCO_{2eq}$	470 $KtCO_{2eq}$	402 $KtCO_{2eq}$

* corrected for net addition to stock

Downstream levers are most important in the near-term. These rely on a rapid expansion of sorting and recycling capacity in Norway. Sorting capacity is required to increase by 13-fold by 2040, rising from 4,000 tonnes to 44,000 tonnes. Similarly, mechanical recycling capacity is required to scale to support the 16-fold growth in recycling feedstock (56,000 tonnes by 2040) from the construction sector.

The single most impactful lever to increase circularity is maximising on-site sorting of plastics to enable separate collection.

It is widely documented that separate collection and sorting of construction products on site leads to cleaner, uncontaminated materials. This is clearly exhibited by the success of existing separate collection schemes in the industry, for example under the VinylPlus framework.

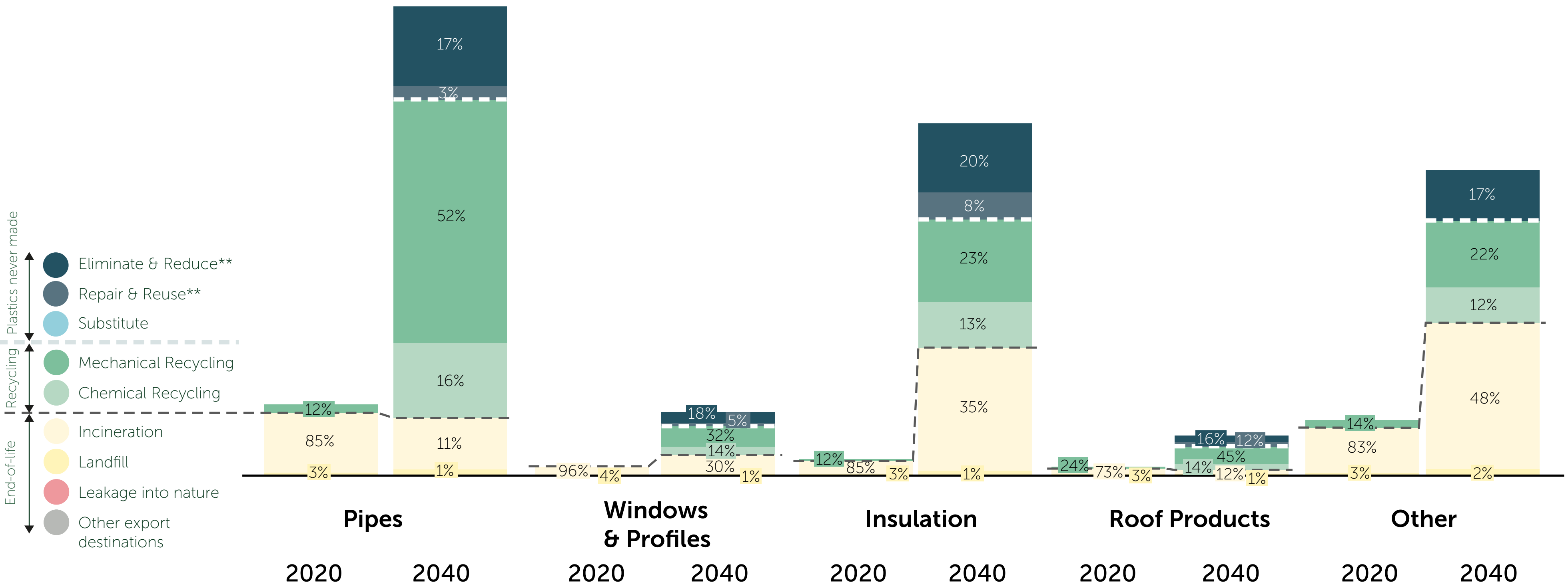
According to a report by Plastics Europe[7], separately collected plastic waste is ten times more likely to be recycled than mixed waste. This is particularly relevant in the construction sector where the concentration of plastics in mixed construction and demolition waste (consisting of rubble, bricks, etc.) is extremely diluted.

Due to the current logistical and practical challenges associated with on-site sorting, maximising the separate collection of plastic waste requires better data on two fronts:

- More data is required on what materials are contained within buildings, for example through the use of digital building passports that log the composition of the building and the components/materials used, or through pre-demolition audits. While there is a mandatory requirement to carry out these audits in many EU member states, including Norway, this is rarely enforced.
- Monitoring schemes that increase understanding of what collection rates are today are needed in order to allow for benchmarking exercises and set industry wide targets. A number of effective schemes have already proven that increased collection of plastics leads to higher recycling rates (e.g. Europe-wide schemes that are part of VinylPlus such as Recovinyl, REWINDO in Germany, etc.).

EXHIBIT 10 **The highest impact levers for the Construction sector are Mechanical and Chemical Recycling**

2020 vs 2040 System Change Scenario



	Pipes 2020	Pipes 2040	Windows & Profiles 2020	Windows & Profiles 2040	Insulation 2020	Insulation 2040	Roof Products 2020	Roof Products 2040	Other 2020	Other 2040
Total demand for utility*	9 Kt	60 Kt	1 Kt	8 Kt	2 Kt	45 Kt	1 Kt	5 Kt	7 Kt	39 Kt
% Circular	12%	88%	0%	69%	12%	64%	24%	88%	14%	50%

* Corrected for net addition to stock
**Reduction: elimination through dematerialization & lifetime extension, and reduction through new delivery models enabling access.
Reuse: reutilization of products or components after disposal

Policy will have an important role to play, for example by setting material-specific collection rates, and by mandating and enforcing the use of building passports. Finally, economic incentives need to be put in place to enable greater focus on on-site sorting. Essentially, the cost of unsorted waste must increase to above that of on-site sorting and disposal rates must increase to incentivise on-site sorting. Other circularity levers are important but will be ultimately futile without increased on-site sorting.

Under a fully optimised system, with on-site sorting in place, mechanical recycling could account for 43% of total plastic waste generated by the building and construction sector in Norway by 2040.

This can only be achieved if separate collection becomes common practice. An improvement in sorting and recycling yields, through the upgrading of current technologies (e.g. to robotic sorting), can allow for some incremental improvements in recycling rates. As demonstrated by Finland-based ZenRobotics, robotic sorting has significant potential for sorting large and heavy plastic fractions. Commercial plants already using these technologies have achieved sorting losses as low as 10%. In addition, robots enable uninterrupted sorting and 24/7 operations, increasing the capital efficiency of sorting plants. The adoption of these technologies would also make decentralised operations possible, reducing transport costs and increasing the likelihood of sorting in more remote areas.

Building out mechanical recycling capacity in Norway relies on significant investment in the sector but potential will be limited in the short term due to the technical challenges associated with dealing with waste from volumes put on the market decades ago. Many polymers that are now emerging as waste contain legacy additives (e.g. PVC contains the heavy metals cadmium and lead) that are now heavily regulated against. By 2040, the majority of plastic waste containing legacy additives should have churned out of the system.

Design for recycling and dismantling, through standardising component design, polymer types and colouring, easier material separation, and avoiding additive content – particularly additives with a high potential for being regulated – will improve the business case for mechanical recycling in the future.

Stimulating the use of recycled content is also key. Construction is particularly well suited to leverage low-quality, low-cost recycled content as there are no food-grade and aesthetic requirements. A good example of this is Statsbygg, the Norwegian government's building commissioner, property manager and developer, encouraging the use of recycled content and already using 20 tonnes of recycled plastic in three different projects.

Chemical recycling is particularly relevant for plastic waste from the construction sector due to the legacy additive content.

This waste is not suitable for mechanical recycling and is therefore typically disposed of; however, chemical recycling technologies can filter out additives to recover pure monomers, although this still requires sorting and cleaning prior to recycling. This analysis estimates that only a limited amount of construction waste can be chemically recycled before 2030 (~8,000 tonnes), but that this can grow to around 22,000 tonnes by 2040, covering ~14% of the circularity solution for construction in Norway. However, there is a high level of uncertainty around the future of chemical recycling and its costs. Wherever possible, all other circularity levers should be prioritised first.

It is important to begin implementing upstream levers – such as design for recycling, modular building design, and component standardisation – this decade, but they will have limited impact before 2040 due to long in-use lifetimes. A crucial demand reduction lever is the shift towards the renovation and refurbishment of buildings, instead of new builds, which thus reduces both the plastic waste generated by the sector and the demand for new components. However, the reuse potential of plastic components is limited to certain applications where modularity and standardisation are feasible. For this to work, modular design, standardisation, non-destructive demolition practices, and the scaling of takeback schemes need to be implemented. There are already good examples of small schemes trying to scale takeback opportunities, including Bewi and Vartdal Plast AS for EPS insulation, Tarkett for PVC flooring, Interface AS for old floor tiles, and Protan for roofing materials.

Additionally, designing buildings and components for deconstruction to preserve the structural integrity of plastics as far as possible and enable clean, non-destructive dismantling will be key.

Norway has significant potential to use buildings more intensively through efficient, more compact design, enabling an 11% reduction in floor space per capita, and an 11% reduction in plastic demand relative to the Baseline Scenario in 2040.[7] This involves the scaling of sharing models and the use of flexible, multi-purpose building designs. One approach that is gaining traction is through well-known services such as Airbnb and co-working communities. Working from home flexibility enables the reduction in office space, and there are many co-benefits to more compact living, including reduced energy requirements for heating and lighting.

Limited potential for substitution has been identified in this study. This is due to the many use-phase benefits that plastic delivers in the construction sector, its low relative cost, and the limited number of suitable substitute materials. Timber is already widely used in Norway for flooring, structures and coverings, profiles, etc., and it is assumed that there is limited opportunity to increase this further, particularly given the cost-sensitive nature of the sector.

EXHIBIT 11 **Key recommendations per actor**

Value chain actors

Manufacturers

1. Design for recycling, including component standardsation
2. Closed loop supply chain partnerships and use recycled content
3. Set up take -back schemes

Architects

1. Shift to renovation vs new build projects
2. Efficient and modular design considering end-of-life
3. Material substitution
4. Input to digital building passports

Demolition industry

1. Prepare for on-site sorting of plastics
2. Liaise with innovators such as ZenRobotics
3. Support take-back schemes

Recyclers

1. Scale up sorting and recycling capacity; invest in advanced technologies
2. Sort for and scale chemical recycling

Policy

Regulators

1. Introduce plastic on-site sorting and recycling targets, specific targets when dismantling or rehab of construction projects, and implement monitoring schemes to guarantee compliance of on-site sorting
2. Establish EPR regulation, with specific requirements on take-back of left over and residual stock
3. Increase public procurement targets for circular buildings

Finance

Investors

1. Inclusion of circular economy targets in financing criteria
2. Preferred rates for circular business model enablers

Recommendations

The Construction sector should prioritise three main actions :

- Encourage renovation over new build and shift to more compact and efficient living.
- Introduce ambitious, dedicated policies for plastic waste in Construction & Demolition, focusing on requirements for on-site sorting.
- Prepare for on-site sorting of plastics and scale up waste management systems.

Textiles

Scope

37%
Clothing
All clothes, including sports clothes and professional clothes

22%
Shoes
All shoes

13%
Outdoor life
Tents, mosquito netting, parasols, umbrellas, life jackets, awnings, sails, air mattresses

17%
Textile storage & packaging
Bags and boxes for packaging and storage made of textiles

9%
Household textiles
Bedding, blankets, tablecloth, napkins, towels, curtains, bed covers

2%
Accessories
Hats, gloves, mittens, ties, other

Out of scope
Pet equipment, Toys, Garden, Big carpets, Furniture textiles, Mattresses, Geotextiles

Summary

Plastic has become central to the fashion, industrial apparel, household textiles and outdoor life industries. Today, Norwegians consume ~13kg of plastic in textiles per person per year and, in 2020, Norway had ~670,000 tonnes of textiles in use[j], of which ~55% was plastic.[8,9]

A combination of increased consumption, lower usage per item, and the prominent use of less recyclable multi-fibred or multi-layered garments (a third of all textile waste is unsuitable for fibre to fibre recycling)[10] has led to the textiles sector becoming the second largest generator of plastic waste annually, after packaging.

Initial steps have been taken to create a more circular system, from the industry developing design principles to pilots testing how all discarded textiles can be collected by 2025. But although momentum is building, additional supply side regulations (such as the EU's objective to introduce mandatory performance requirements for textile products by 2024) and an EPR policy (currently being discussed in Norway) will be needed to accelerate the transition.

As Norway is a net importer of textiles, with less than 5% local production, the country has limited control over upstream solutions. Close collaboration with the EU, targeting the production phase and supporting international rules and standards, is therefore vital. In combination with demand side reduction through reuse and repair business models, and downstream levers, this can unlock a well-functioning circular system.

Our analysis shows that, by applying circularity strategies, annual virgin plastic consumption can be reduced by ~34,000 tonnes (74%), and a transition from 20% to 86% circularity[k] can be achieved by 2040. GHG emissions related to plastics in textiles can be reduced from ~200,000 tonnes of CO_2eq by 2040.

EXHIBIT 12

Potential outcomes of implementing a System Change Scenario

		FROM 2020	TO System Change 2040	
A MORE SUSTAINABLE AND CIRCULAR TEXTILE INDUSTRY	Average consumption per capita	13 Kg	12 Kg	-8%
	Virgin plastic production	54 Kt	18 Kt	-67%
	Recycling (Mechanical & Chemical)	2 Kt	26 Kt	+1,200%
	Incineration, landfill & leakage	46 Kt	12 Kt	-74%
	Circularity*	20 %	86 %	+330%
	GHG Emissions per tonne of demand for plastic utility	4.4 tCO_2eq	1.0 tCO_2eq	-77%
WITH NO TRADE OFF FOR SOCIETY	**Cost** per tonne of demand for plastic utility	15,000NOK	10,000NOK	-33%
	Jobs per Kt of demand for plastic utility**	3.5	10.8	+209%

* Circularity as a % of annual demand for plastic utility corrected for net addition to stock
** Excluding production as majority takes place outside Norway

Key stats

64Kt
Volume put on market 2020

2-6 Yr
Average Lifetime

Most common Polymers in use

~**83**%
PET (Polyester)

~**8**%
PA Polyamide Nylon

~**4**%
PP Polypropylene

[j] Textiles in scope are: clothing, shoes, accessories, outdoor life, packaging, and selected household textiles.
[k] Circularity as a % of annual demand for plastic utility corrected for net addition to stock.

Baseline:
A linear system highly dependent on exports

Although there are some signs that consumers in Norway are becoming more conscious about their consumption, fast fashion remains prevalent and annual utility demand across all product categories is expected to grow by 24% by 2040 compared to 2020.[12]

Product categories in scope are highly linear, with ~80% of total plastic waste currently incinerated and a small proportion landfilled.

In terms of circularity, ~17% of total waste is reused. Around half of this is exported to other countries in Europe, 34% is exported to Africa, and 17% to Asia[13]. This strategy has been important to Norway as today's textile collection points, managed by NGOs, have built supporting infrastructure that will further improve circularity in the future. Besides reuse, a small proportion (~3%) of total textile waste is exported to be recycled outside of Norway.

Norway has set targets to significantly increase dedicated textile collection by 2025, in line with the EU Waste Framework Directive.

The Norwegian Fashion & Textile Agenda (NF&TA) is testing several pilot systems aimed at a collection rate of 80% of textile waste by 2025, compared to the ~23%[11] collection rate today. This is a key starting point to achieve higher levels of circularity.

However, Norway runs the risk of losing valuable, carefully collected secondary materials to other markets unless advanced local sorting, pre-processing and recycling facilities are developed.

A sector specific EPR regulation and a system for eco-modulated fees will make a significant difference.

Even though no details have yet been communicated, initial EPR policies for textiles are expected to be included in the 2023 revision of the Waste Framework Directive. These are expected to include design guidelines from 2024, and policies to prohibit the incineration of overstock, and recycling and/or repair and reuse targets, by early 2025.

~80% of total plastic waste from textiles is currently incinerated

Key barriers to circularity that EPR and other policies will need to tackle include:

- **Fast fashion credo,** including high turnover rates of seasonal collections and overproduction to reduce cost per item. Today, the overproduction and overstock volumes and mishandling of unsold commerce is underreported. This is amplified by a tax system that disadvantages recycling (additional taxes and administrative costs) over the incineration of unsold textiles.
- **Taxes on repair and resell services**, including administrative work involved.
- **Lack of trustworthy information** about the textile products, their components, and their environmental footprint[14].
- **Textile quality and recyclability:** sorting and recycling centres have noted a decreasing textile quality– limiting lifetimes and contributing to a decline in recyclability and recoverability – caused by an increase in multi-fibred and multi-layered textiles which are unsuitable for sorting and recycling, as well as fibre shedding during washing and drying and general wear and tear.
- **No at-scale technologies for fibre to fibre recycling:** while fibre-to-fibre recycling is currently being tested (e.g. depolymerization of PET), it is far from being implemented at a commercial scale and is inhibited by low textile quality and recyclability, and the complexity of different fibres.
- **Low economic value of secondary materials** due to the mixed fibre composition and limited availability of quality recyclates.
- **The need for pre-processing and sorting:** currently the collection and sorting value chain are highly fragmented with high inconsistencies and low sorting accuracy[14].

Achieving Circularity:
Sharing, repairing and recycling

Through the application of circularity strategies circularity levels could increase up to 86% by 2040 (Exhibit 13). Improving overall textile quality and reducing the complexity of fibre composition through design guidelines and regulations will be essential enablers for all circularity measures.

There are two key upstream levers:

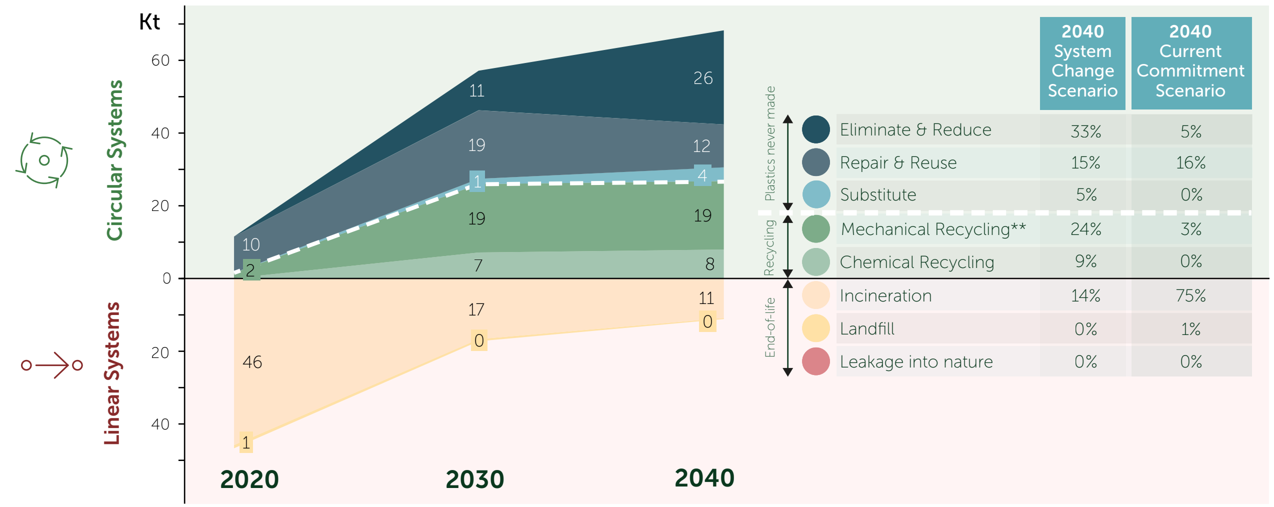
Firstly, facilitating and encouraging sharing and reuse business models, like rental, second-hand and repair, could reduce 20% of virgin plastic demand by 2040 and extend the average lifetime of textiles by 1.7 times, based on average length of second-hand ownership[14].

Globally, ~48% of GenZ [I] and Millennials and ~35% of GenX are willing to buy second-hand, with a ~1/3 intention-action gap[14]. In their 2030 vision, the EU strategy for sustainable and circular textiles emphasises the importance of making profitable reuse, rental and repair services widely available. Guidelines like the eco-design directive for durability, repairability and recycling, and a possible ban on the destruction of unsold textiles, will be critical enablers to turn this strategy into a reality. In Norway, sharing, resale and reuse models are starting to gain traction, with local examples including tise.com, finn.no, fjong.no, and levd.no for kids.

[I] Generation Z (or Gen Z),is the demographic cohort succeeding Millennials and Gen X. Gen Z is the first social generation to have grown up with access to the Internet and portable digital technology

EXHIBIT 13 **Through the application of circularity levers the Textiles sector can reach 86% circularity by 2040**

As % of total demand for utility (with deduction of stock)



	2020	2030	2040
Circularity	20%	77%	86%
Total utility demand*	58 Kt	74 Kt	79 Kt
Total waste	58 Kt	64 Kt	53 Kt
GHG Emissions	279 $KtCO_2eq$	141 $KtCO_2eq$	62 $KtCO_2eq$

* corrected for net addition to stock
** higher uncertainty as fibre-to-fibre recycling of polyester does not exist yet at scale

Another lever is the introduction of fewer and smarter seasonal collections (i.e. moving from fast to slow fashion), multi-functional garments, and reducing overproduction. This has the potential to reduce demand for virgin plastic by 10% in 2040.

Today's fast fashion credo dictates at least four seasonal collections, with short turnover periods and frequent rotations of what is on display. The EU Strategy for Sustainable and Circular Textiles states in its 2030 vision that fast fashion needs to be out[14]. Some large industry players are working towards fewer seasonal collections with less distinct colours and patterns, which is expected decrease overall demand and overproduction. Smarter seasonal collections, preceded by a test phase using e-testing or pre-ordering are expected to further reduce unnecessary production due to better design and fit. However, as not all brands will be willing to make these changes voluntarily, effective policies will be key, including to financially disincentivise overproduction. A local example of a company already applying this is Moiré.

Accurately quantifying overstock/overproduction in Norway is difficult, due to underreporting and mishandling. As a reference, globally ~40% of garments are sold at markdown price due to overproduction. Fewer seasonal collections and investments in new technologies for demand forecasting and stock management have the potential to reduce industry wide overproduction, in combination with economic or regulatory incentives. France is currently the only European country with regulation in place to ban the destruction of unsold fashion by 2023[14]. This needs to be a clear objective in the EPR for textiles.

Besides these upstream levers, there are two key downstream levers.

Firstly, the scaling up of collection, sorting, and pre-processing infrastructure. Under the EU Waste Framework Directive, Norway must work toward increasing the dedicated collection of textiles by 2025 and is currently testing the best way to achieve this. However, without improved downstream measures like sorting, pre-processing, and recycling facilities, Norway runs the risk of mismanaging these carefully collected textiles.

By establishing higher collection rates, more textiles will be available for reuse and recycling domestically. This development is expected to reduce the share of collected and subsequentially exported textiles in Norway in 2040 to a quarter of the 2020 export levels.

To enable reuse and recycling, the development and implementation of automatic sorting technologies like NIRS scanning, that detect materials as well as fibre composition, fibre quality and colours in waste streams, is essential[14]. Sorting needs to be accompanied by pre-processing to handle the removal of zippers, buttons, etc., which can be integrated into sorting or recycling facilities. Pre-processing remains costly and complex, but this can be tackled with regulatory incentives and should be addressed in the EPR for textiles.
Regulatory incentives, like prohibiting the export of unsorted textile waste outside of the EU, as well as increasing requirements for sorting accuracy to meet recycling rates, will drive the consolidation of the fragmented sorting landscape and increase the share of textiles available for reuse and recycling to 78% of total waste by 2040.

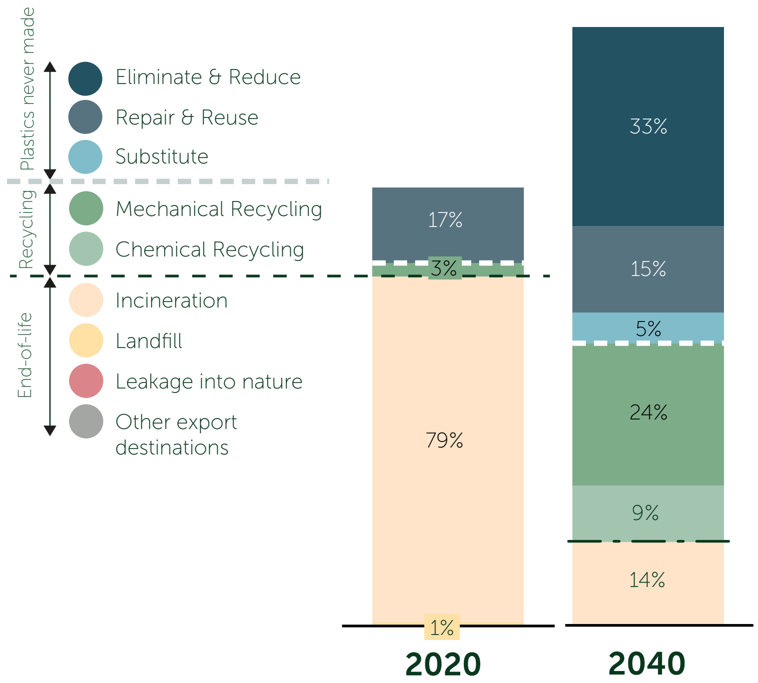
The second key downstream lever is recycling, both domestically and in close collaboration with other Nordic countries, which has the potential to represent 33% of total circularity by 2040. The proportion of closed loop recycling (i.e. fibre-to-fibre) is highly dependent on new technologies (e.g. PET depolymerisation) and design for recycling.

Currently, only ~3% of total waste is recycled through open loop recycling into non- woven products, which mainly takes place outside of Norway.

Beyond collection, sorting, and preprocessing, the main enablers to reach higher recycling rates are new recycling technologies (e.g. PET depolymerization) and design for recycling that reduces complexity and standardises fibre composition.

EXHIBIT 14 **The highest impact lever for the Textiles sector is Reduction driven by opportunities for new business models, including sharing**

2020 vs 2040 System Change Scenario



	2020	2040
Total demand for utility*	58 Kt	79 Kt
% Circular	20%	86%

* corrected for net addition to stock

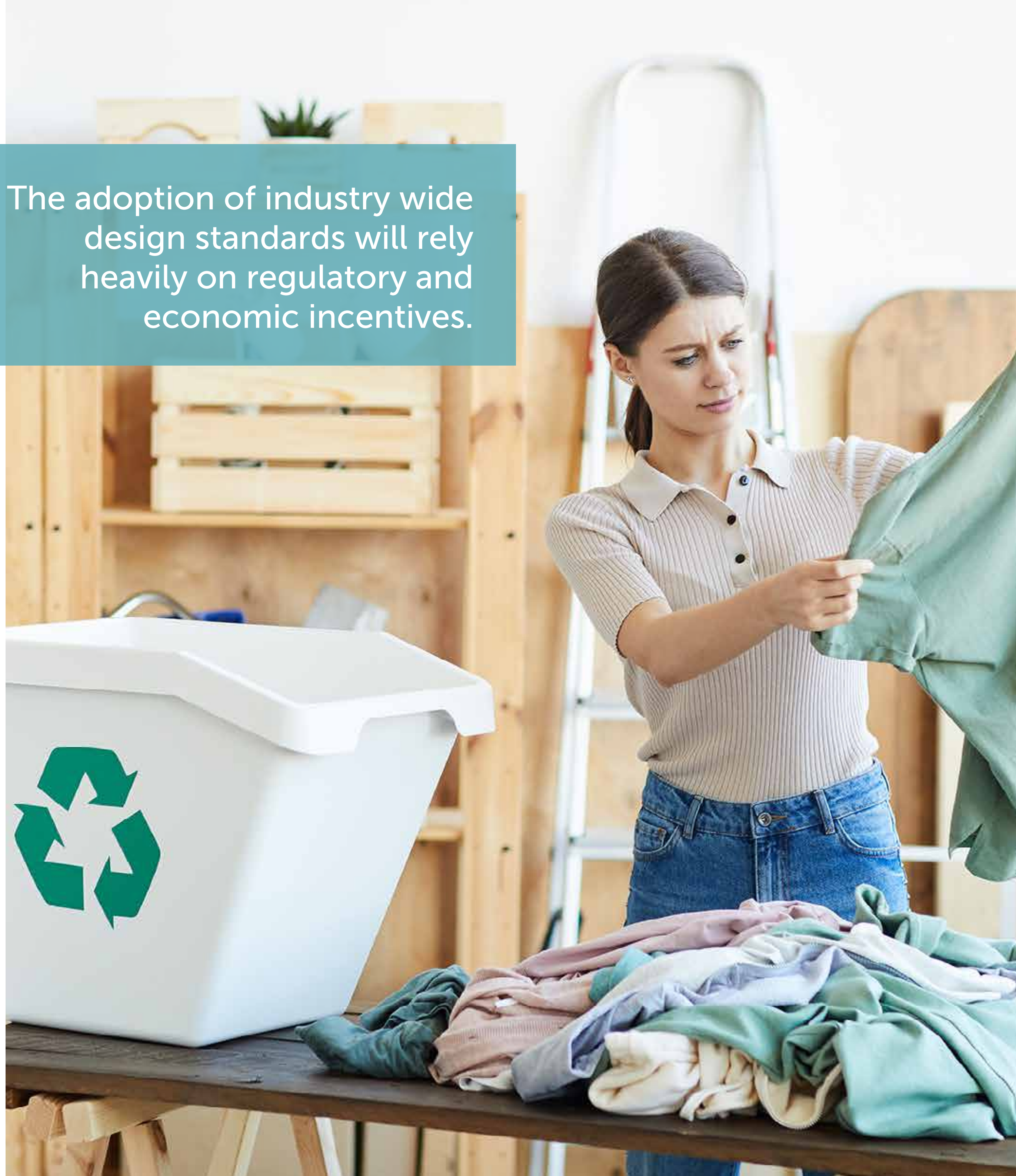
Fibre-to-fibre recycling of polyester (PET) does not yet exist at scale, but several technologies are currently being piloted, including in Norway and Sweden. Today, recycling is limited almost exclusively to the downcycling of polyester, and this is expected to remain the case for mechanical recycling.

In terms of design for recycling, the adoption of design guidelines will be key. As properties of polymers deteriorate during washing and drying, as well as due to wear and tear, feedstock is often inadequate for recycling. The adoption of industry wide design standards will rely heavily on regulatory and economic incentives. Although design guidelines to increase recyclability and recoverability of textiles are being broadly discussed today, their application is still in pilot stages and will need to be addressed in the EPR for textiles[14].

While there is some opportunity to use recyclate from other sectors to produce recycled fibres, particularly consumable applications (e.g. rPET – plastic from bottles), this is also limited in terms of quality of the supply. Additionally, the expected increase in closed loop recycling of consumables by 2040 will limit access to recylates from this sector.

The EU Strategy for Sustainable and Circular Textiles prioritises fibre-to-fibre recycling rather than bottle-to-fibre, as the quality of recylates determines future recoverability and recycling rates. However, as mentioned above, at scale closed loop recycling technologies are not yet available. Therefore, it is important that circularity strategies and future regulations for textiles target mandatory closed loop recycling rates to limit downcycling within the sector.

The adoption of industry wide design standards will rely heavily on regulatory and economic incentives.



Finally, chemical recycling is expected to play an increasingly significant yet complementary role to mechanical recycling. In our analysis, chemical recycling was found to be the most likely route to fibre-to-fibre recycling of polyester at scale. Chemical fibre-to-fibre recycling rates are expected to increase from virtually zero today, to ~8,000 tonnes of total waste by 2040, and then recirculate as recyclates back into the sector.

The volume of textile waste streams in Norway are big enough to justify domestic recycling, and is expected to be sufficient to operate domestic recycling hubs, given economic viability. However, collaboration with other Nordic countries to develop competitive sorting and recycling hubs could be more economically efficient and allow for knowledge sharing.

It is important to highlight that there are ongoing discussions about what is considered waste in the textile sector. The EU currently has regulations in place to regulate exports to non-OECD countries, and there are efforts to close the gap on missing recycling capacity in Europe, e.g. through the Horizon Europe programme.

EXHIBIT 15

Key recommendations per actor

Value chain actors

Manufacturers	Retailers	Consumers	Recyclers
1. Implement circular design standards, including design for recycling and improvement of textile quality 2. Material innovation 3. Multi-functional garments 4. Smarter and fewer seasonal collections	1. Incentivise rental, sharing, repair, and resell models 2. Smarter and fewer seasonal collections	1. Switch to rental, sharing, and resell models 2. Carefully handle, wash and dry to extend lifetime	1. Establish a competitive sorting/recycling hub in Norway in collaboration with other Nordic countries 2. Partner and share sorting and recycling technologies and innovations

Policy

Regulators

1. Ensure implementation of the separate textile collection mandate by 2025
2. Define clear EPR policies, including design and end-of-life guidelines, and the appointment of a sorting and pre-processing partner
3. Enforce improvement of textile quality and reduced complexity of fibre composition through design guidelines regulations
4. Influence the EU to introducing regulations to increase transparency and reporting of, and limit overproduction
5. Remove taxes on repair and resell services

Finance

Investors

1. Inclusion of circular economy targets in financing criteria
2. Preferred rates for circular business model enablers

Recommendations

Three main actions can move the needle towards circularity

- Application of circular design principles.
- Implementation and scale up of new rental, resale and repair business models that ensure each owner extends the use-phase.
- Establishment of a competitive sorting and recycling hub, either in Norway or in collaboration with other Nordic countries.

Electricals & Electronics

Scope

43%
Small Equipment
Includes small IT and telecoms, lamps, small products with outer measurements below 50cm

35%
Large equipment
Includes large products with outer measurement above 50 cm, and all large industrial equipment

18%
Industrial cables
Large insulated electrical conductors or large cables of a similar nature

4%
Screens & displays
Includes all screens and monitors with a surface area of more than 100 cm2

Summary

Global demand for electrical and electronic equipment (EEE) has risen rapidly over the last century and Norway is no exception, with a 15% growth in demand in the last decade alone. Given the sector's dependency on plastics, this has led to rapid growth in plastic consumption and waste generation, making Waste from Electrical and Electronic Equipment (WEEE) the 4th largest source of plastic waste in Norway.

While WEEE recycling rates are high compared to most other sectors, the system remains predominantly linear, with over 20% of WEEE unaccounted for at end-of-life[15]. WEEE is also responsible for the largest share of plastic left in nature as a result of industrial cables often being left underground. Currently, ~30% of WEEE plastics is recycled annually through a well-functioning network of WEEE collection centres and recycling facilities. However, less than 1% of WEEE is recovered for reuse, despite significant potential for repair and refurbishment.

To achieve higher levels of circularity, leakage of waste must be reduced by maximising formal collection, with a particular focus on reuse; adopting design for recycling principles to reduce and standardise the types of polymers and simplify the sorting process; and directing investment towards scaling innovative sorting technologies that yield higher recovery rates.

Through the application of these levers, this sector can reach ~87% circularity[m] by 2040, and reduce virgin plastic consumption by ~39,000 tonnes (58%). At the same time, these circularity levers can reduce annual GHG emissions related to plastics in the sector by 63%, from 202,000 tonnes of CO_2eq today to 75,000 tonnes by 2040 (Exhibit 16).

[m] Circularity as a % of annual demand for plastic utility corrected for net addition to stock

EXHIBIT 16

Potential outcomes of implementing a System Change Scenario

		FROM 2020	TO System Change 2040	
A MORE SUSTAINABLE AND CIRCULAR ELECTRICALS & ELECTRONICS INDUSTRY	**Plastic consumption** per capita	13 Kg	11 Kg	-19%
	Virgin plastic production	67 Kt	28 Kt	-58%
	Recycling (Mechanical & Chemical)	11 Kt	53 Kt	+380%
	Incineration, landfill & leakage	25 Kt	7 Kt	-70%
	Circularity*	31 %	87 %	+278%
	GHG Emissions per tonne of demand for plastic utility	2.9 tCO_2eq	1.0 tCO_2eq	-64%
WITH NO TRADE OFF FOR SOCIETY	**Cost** per tonne of demand for plastic utility	19,000NOK	18,000NOK	-7%
	Jobs per Kt of demand for plastic utility**	5.7	10.8	+89%

* Circularity as a % of annual demand for plastic utility corrected for net addition to stock
** Excluding production as majority takes place outside Norway

Key stats

71Kt
Volume put on market 2020

5-15 Yr
Average Lifetime

Most common Polymers in use

~**38**% PP Polypropylene

~**18**% PS PolyStyrene

~**14**% PE PolyEthylene

~**11**% ABS Acrylonitrile Butadiene Styrene

Baseline: Lack of control at end-of-life

The EEE sector is highly diverse, with products ranging from consumer-facing electronics like mobile phones and TVs, to large industrial cables installed underground. The challenges faced are unique to each product category and solutions must be tailored to meet the specific needs of different product groups.

This sector is the 3rd largest consumer of plastics in Norway, at ~71,000 tonnes in 2020, and is the 4th largest source of plastic waste, accounting for ~38,000 tonnes of waste.

The concomitant development of the EEE and plastics sectors has led to plastics becoming ubiquitous in the sector, which is heavily dependent on this cheap, versatile material. The rapid growth in global demand for consumer electronics since the mid-20th century, coupled with the rapid turnover of EEE components (lifetimes range from 2 to 15 years), has led to the rapid growth of WEEE plastics.

Norway, like most European countries, suffers from a lack of control over WEEE at end-of-life.

The inappropriate handling and treatment of WEEE represents a serious environmental, social, and economic threat. There have been a number of regulatory attempts to alleviate these challenges, including the European WEEE Directive, introduced in 2003 and revised in 2012 with the aim of maximising the recovery of valuable resources through reuse and recycling, and reducing environmental impacts caused by inappropriate treatment, littering and leakage into nature.

The Directive requires each country to collect 85% of waste generated at dedicated collection facilities (or 65% of put on market volumes). According to a recent study by the United Nations Institute for Training and Research (UNITAR)[16], Norway separately collects around 70%-80% of its WEEE . It is therefore non-compliant[n] with the Directive, but is nevertheless one of the leading European countries in terms of WEEE collection. However, this means that 20%-30% of WEEE is not collected via the formal system, representing a leakage in the system and reducing the probability of material recovery. The main reasons for leakage are:

- Norway having a large informal sector, which accounts for around 20% of the leakage, involving the theft of WEEE from collection points which is then typically exported illegally, predominantly to Eastern European and African countries[15].
- Industrial cables remaining uncollected at end-of-life due to the high costs of recovery.
- Incorrect disposal of WEEE in mixed waste, which significantly reduces the chance of recovery.

It is also likely that collection rates are even lower than estimated in this study given that the data on theft is highly uncertain and could be significantly underestimated, particularly for higher value small items such as mobile phones, which also typically have the highest of plastic content.

Despite its comparatively well-established collection network, the Norwegian EEE plastic system is 69% linear with less than 1% of WEEE reused and 30% of WEEE plastics recycled annually.

Following collection and sorting, WEEE undergoes

disassembly and depollution share, shredding and mechanical sorting in specialised treatment facilities. Recycling of WEEE plastics is a well-established part of the treatment process, with sink-float tanks used to separate and sort polymers and to remove and selectively treat plastics containing brominated flame retardants listed under the European POP (persistent organic pollutant) and REACH legislation which cannot be put back on the market. There is also no recycling of certain polymers, such as PVC, due to additive content and/or a lack of market for recyclates. This leads to average yields of around 60%-70%[17].

Repair and reuse of EEE is currently an underutilised opportunity. Today, many goods are discarded despite being fully operative or easily reusable if fixed. There is also no system in place to identify and recover reusable products once they are collected as WEEE. Therefore, there is great potential for scaling the secondhand market in Norway by creating demand for secondhand products and establishing a collection system able to separate reusable goods.

[n] However, it should be noted that Norway's WEEE directive covers a wider scope compared to the rest of the EU, including large industrial cables and large industrial equipment. Excluding these categories would mean that Norway is compliant with the directive, achieving collection rates of 85%-91% of total WEEE generated.

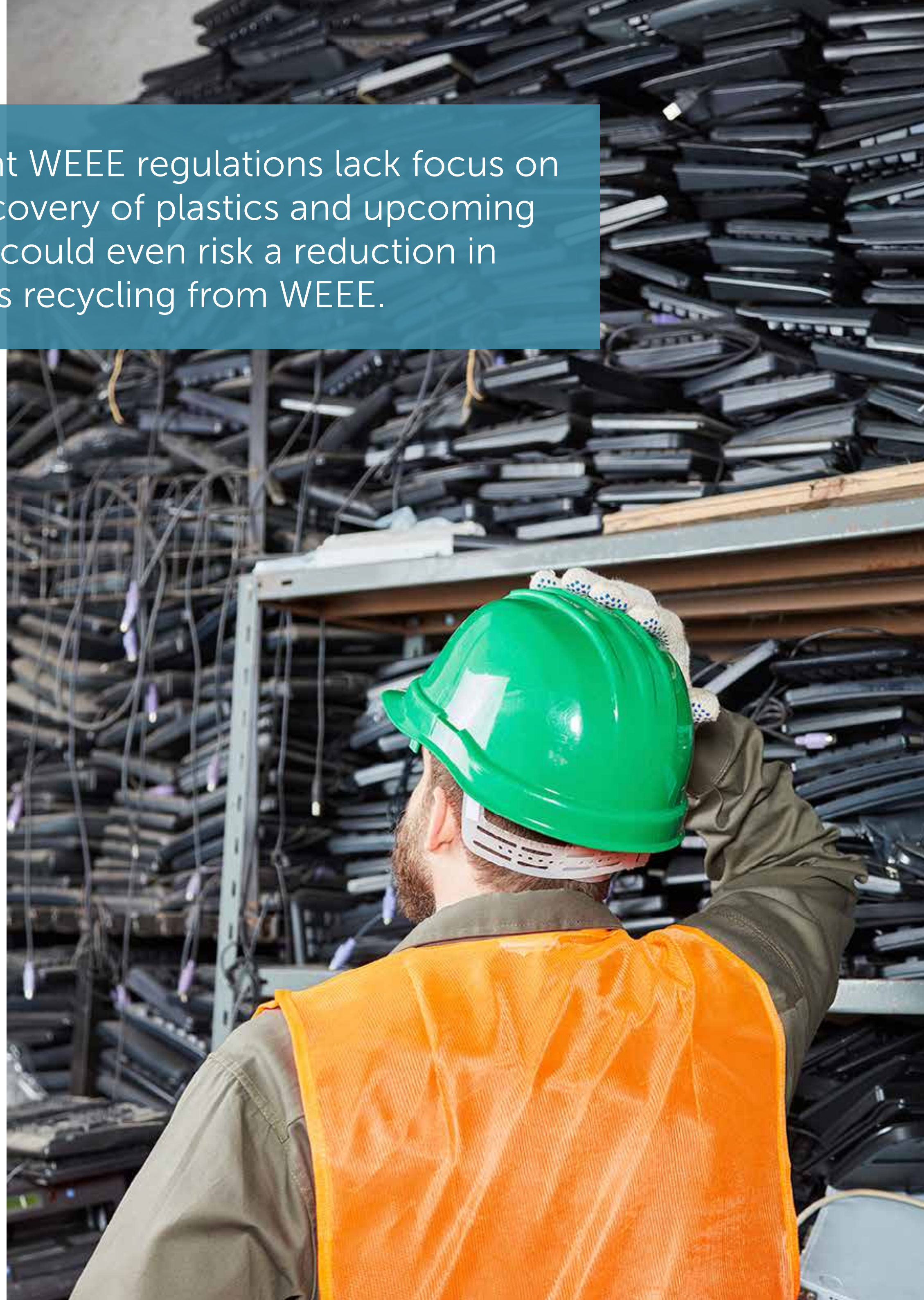
Current WEEE regulations lack focus on the recovery of plastics and upcoming policy could even risk a reduction in plastics recycling from WEEE.

The WEEE Directive focuses primarily on collection and overall material recycling rates but lacks focus on the recycling, reuse or recovery of plastics from WEEE. There is even a risk that upcoming policy will have adverse effects on plastics recycling from WEEE due to more stringent constraints on POPs, which could be detrimental to WEEE plastics recycling. Furthermore, there have been signals indicating the potential removal of large industrial equipment and large industrial cables from the Norwegian WEEE Directive as these are not included in the EU WEEE Directive.

Other key circularity barriers beyond the lack of regulation, the technical challenges associated with POPs, and the lack of control over WEEE include:

- A lack of design for recycling of EEE, specifically with regards to plastics.
    - Many polymers are still being used which are not recoverable by current sorting techniques due to overlapping densities with polymers containing substances of concern.
    - The use of additives and composite materials that alter the densities of polymers, making sorting challenging.
    - The high level of heterogeneity of WEEE plastics, with a varying composition of polymers from sample to sample raising the cost of recovery and lowering the yields achieved.
- Relatively low costs of disposal compared to the costs of mechanical sorting and recycling, creating incentives to landfill or incinerate the plastic components rather than recycle them.
- Low quality of recyclates leading to downcycling, mainly for lower value applications such as outdoor furniture and plant pots[17].

Current WEEE regulations lack focus on the recovery of plastics and upcoming policy could even risk a reduction in plastics recycling from WEEE.



Achieving Circularity:
Stimulate reuse, standard designs, and design for recycling

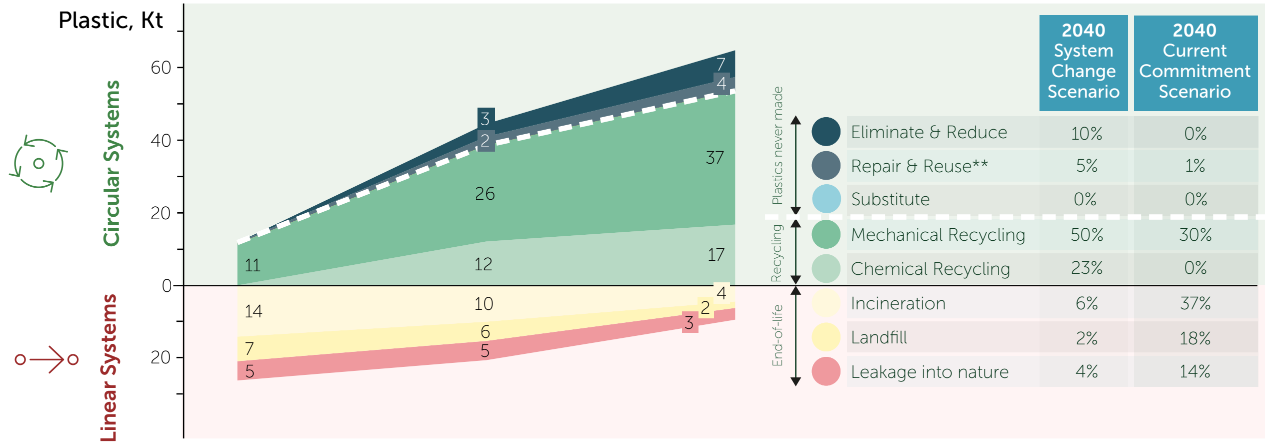
Through the combined deployment of circularity levers, circularity levels could increase to 87% by 2040 (63% without chemical recycling), and the reliance on virgin production could be reduced to 43% of total demand, down from 95% in 2020.

The most important upstream lever for increasing circularity is applying design for recycling principles.

Many Original Equipment Manufacturers (OEMs) are committing to ambitious targets for recycled content, meaning that there is significant potential to create closed loops in the sector and short loop plastics from products back including to the same producers . Examples of companies that have set such targets include Phillips, which aims to reach 7,600 tonnes of recycled content by 2025, as well as Apple, Sony, LG and Logitech.

EXHIBIT 17 **Through the application of circularity levers the Electronics & Electricals sector can reach 87% circularity by 2040**

As % of total demand for utility (with deduction of stock)



	2020	2030	2040
Circularity	31%	69%	87%
Total utility demand*	38 Kt	65 Kt	74 Kt
Total waste	38 Kt	62 Kt	75 Kt
GHG Emissions	202 $KtCO_{2eq}$	137 $KtCO_{2eq}$	75 $KtCO_{2eq}$

* corrected for net addition to stock
**This only includes repair and reuse of products handed in at waste collection centres, it does not include the secondary market.

An estimated 80% of the environmental impact of a product is determined at the design stage[18]. Adopting design for recycling principles is therefore key both to ensuring recyclability and to meeting the feedstock requirements needed to scale recyclate markets and meet the industry's recycled content targets.

Design for recycling of plastics in EEE involves simplifying and standardising the polymer mix, shifting to polymers which are more commonly recycled by WEEE recyclers, and avoiding the use of additives (particularly those which have a high chance of being regulated in the future) or hazardous substances[18]. On a higher level, design for recycling of EEE also requires the long-term standardisation and stabilisation of product design to prevent users having to retire and replace functioning products before their end-of-life. Steps towards standardisation are already being taken, with Norway following the EU's decision to standardise the plug type for eight product categories by the end of 2024.

The potential for reduction of plastics in EEE is limited to around 12% relative to the baseline demand projection for all categories except industrial cables[19].

Dematerialisation strategies in EEE are multifaceted and current trends already indicate a movement towards, for example, more compact devices, an increased use of cloud computing, and device consolidation where a single device could be used to provide many services. By leveraging these shifts, it is estimated that 10% of plastics in current consumer-facing EEE can be eliminated.

There are five major downstream levers that should be prioritised in the short term to ensure higher rates of mechanical recycling.

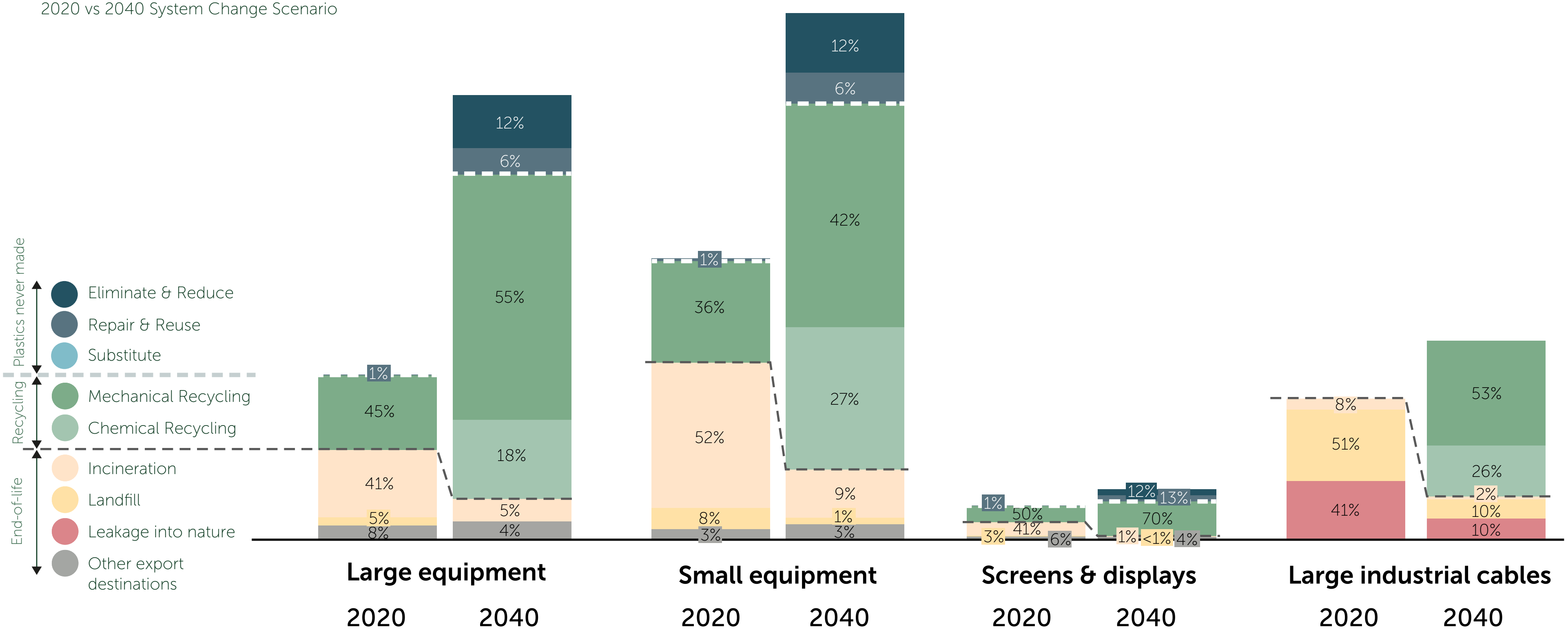
Maximising formal collection of WEEE should be the first priority. It is the most impactful lever in the short term and is critical for gaining greater control over WEEE and avoiding adverse environmental impacts, particularly in other countries.

The Norwegian system currently faces three main collection challenges: theft at collection points, incorrect disposal in mixed waste, and industrial cables being left underground and never recovered. Overcoming these challenges, particularly theft at collection points, requires much more stringent enforcement of existing policy.

Incorrect disposal has declined as a result of information campaigns from the PROs (Producer Responsibility Organisations) and the introduction of take back schemes in Norway. While this has been particularly effective for higher value items, progress has stagnated recently and incorrect disposal rates have plateaued, with lower value items still being incorrectly disposed of. Financial incentives and disincentives, particularly deposit return schemes and fines, can reduce incorrect disposal to much lower levels. In fact, by leveraging these opportunities, incorrect disposal could be minimised to 2% by 2040.

EXHIBIT 18 **The highest impact levers for the Electronics & Electricals sector are Mechanical and Chemical Recycling**

2020 vs 2040 System Change Scenario



	Large equipment 2020	Large equipment 2040	Small equipment 2020	Small equipment 2040	Screens & displays 2020	Screens & displays 2040	Large industrial cables 2020	Large industrial cables 2040
Total demand for utility*	10 Kt	27 Kt	17 Kt	32 Kt	2 Kt	3 Kt	9 Kt	12 Kt
% Circular	46%	91%	37%	87%	50%	95%	0%	79%

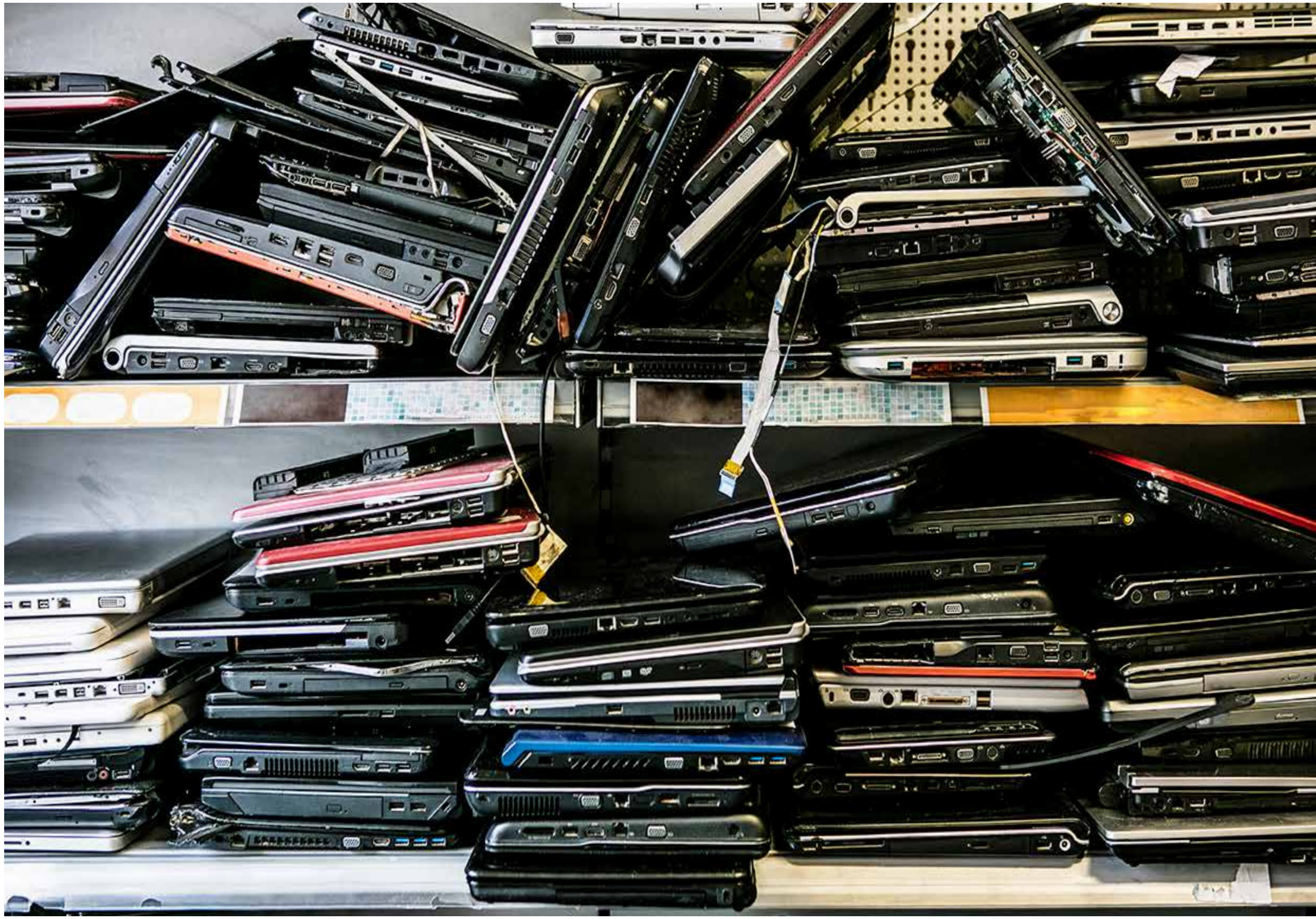
* corrected for net addition to stock

There is existing policy in Norway mandating that old cables are removed, but extracting them is a costly process. Through better enforcement of this policy, removal rates could increase from around 60% to 90% by 2040. However, it is important to consider that it is not always technically feasible to remove old cables, nor always better from an environmental perspective.

Reuse is a very underutilised opportunity; many products are discarded prematurely, indicating significant potential for reuse. However, most reuse is likely to occur abroad.

There is significant opportunity for collected WEEE products to be refurbished and resold for further use, but there are two major challenges. Firstly, the lack of demand for second-hand products in Norway, both for lower value products due to the low cost of replacing items with new products, as well as for higher value products where there is not the same level of guarantees as there are for new products. Secondly, on the supply-side, there is a lack of focus at collection points on identifying items that could be refurbished and reused.

Reuse initiatives are beginning to emerge in Norway, particularly involving B2B companies taking in used PCs, for example 3step IT. Norway is setting itself up to be a leader in this space, with the establishment of Ombrukt AS (a subsidiary of the Consumer Electronic Trade Foundation) to establish an approval scheme for the reuse of consumer electronics being a key example. After associated companies sort, test, clean, and if necessary, repair products at approved repair centres, they are registered in a Nordic database for reused products and sold in the market by approved Ombrukt-partners. All the products are sold with a warranty to provide extra security for consumers[20].



Furthermore, to stimulate reuse, some stores like Power and Elkjøp have introduced take back schemes, offering consumers a small sum in return to spend on their own products in the store. This means the stores manage the economics of collection and reuse, not the EPR systems. WEEE reuse also has the potential to employ 10 times more people per tonne of material processed than recycling activities[21].

Adoption of advanced sorting technologies is required to help overcome current technical challenges. Many plastics –such as PA, PMMA, and PC – are lost under today's technologies, which rely on material density to distinguish plastics, as they have the same density ranges as plastics with brominated flame retardants. Innovations are required to increase recovery of these polymers, many of which are already underway but require the right resources (time, know-how, capital) and the formation of alliances with both producers and recyclers.

Good examples of such alliances is the work delivered by the Poly-CE project, which resulted in guidelines for and from recycling[18], and the ongoing NONTox project. Such innovation processes typically take five years or more.

Another example of innovative technologies being tested and scaled is the sorting line provided by Belgian company, Advanced Design of Recycling Machines (AD REM), and German company Hamos, which has already been deployed in the UK and Japan. The process involves two float-sink tank stages, to recover the polyolefins, as well as electrostatic separation to separate the PS and ABS. Investment in scaling these advanced technologies as well as in further R&D is critical and should be supported by policy, for example by setting recycled content targets and material-specific recycling rates.

Mechanical recycling capacity should be expanded to support the 220% growth in recycling needed to cope with the much larger volumes of waste. However, many facilities in Norway typically operate at only 60%-70% capacity due to unfavourable economics. With higher recyclate prices, and greater demand for recyclates, recyclers will be incentivised to maximise their capacity utilisation factor. In addition, extra capacity must be built, either within Norway or in collaboration with neighbouring countries, to meet the 36,000 tonnes of mechanical recycling required for WEEE plastics by 2040.

Finally, chemical recycling should tackle plastics which are unsuitable for mechanical recycling, particularly those which contain brominated flame retardants, as well as plastics from old industrial cables. While chemical recycling is a nascent technology, requiring more research, it is expected to play an important role for WEEE plastics under the System Change Scenario, with 23% (~17,000 tonnes) of demand for utility chemically recycled by 2040 and recirculated back into the system.

Recommendations

The Electronics & Electricals sector should prioritise four main actions:

- Standardised design for recycling principles, including recycled content targets.
- Implementation and scale up of rental and second-hand business models.
- Introduction of regulatory requirements to control the whereabouts of WEEE at end-of-life, including the separation of functional products at collection points to enable reuse.
- Scale up of advanced sorting technologies.

EXHIBIT 19 **Key recommendations per actor**

Value chain actors

Producers
1. Design for recycling
2. Material innovation
3. Use recycled content, preferably from closed loop schemes

Retailers
1. Offer second-hand and rental models
2. Increased security to avoid theft

Consumers/Users
1. Switch to second-hand and rental models
2. Return no longer used items so they can be repaired/refurbished
3. Consider collection at end-of-life (industrial cables)

Recyclers
1. Invest in advanced sorting technologies
2. Close collaboration with producers and retail to guarantee collection of WEEE

Policy

Regulators
1. Introduce design for recycling standards
2. Control the end-of-life of WEEE for plastics, including collection via the piloting of deposit return schemes
3. Mandatory requirement to identify and separate functional products at collection points, to enable reuse
4. Targets for recycling for specific types of plastic
5. Enforce the EU's establishment of a "right to repair" in Norway

Finance

Investors
1. Inclusion of circular economy targets in financing criteria
2. Preferred rates for circular business model enablers

Automotive

Scope

10%
Large parts, other
Bumpers, fuel tanks, dashboards

65%
Other Polymers
Car body parts, headlight lenses, instrument panel, seats

25%
Other Polyolefins
Cable insulation, interior trims

69%
Cars & Vans

20%
Out of Scope
Tyres

11%
Out of Scope
Trucks, buses and other vehicles

Summary

Plastics have been a key enabler of more affordable, durable, and fuel-efficient vehicles due to their low density. However, their rapidly increasing use in the sector has resulted in a large accumulation of in-use plastic stock, and ultimately a decline in the recyclability of vehicles.

While Norway is considered a frontrunner in terms of vehicle collection at Authorised Treatment Facilities, the current system is still highly linear, with 99% of plastics being disposed of either via landfill or, more commonly, incineration. A key barrier to circularity is the lack of regulation focusing on the management of plastics, as the recycling targets of the current End-of-Life Vehicle (ELV) Directive can be almost entirely met without any plastics recycling.

The automotive plastic system is complex and will require the introduction and adoption of new business models to reduce demand (e.g. through shared mobility solutions), the adoption of design for recycling principles to reduce the number of types of polymers, and regulation to enable a well-functioning recycling infrastructure.

For all solutions, collaboration with Nordic countries (especially Sweden) will be key as Norway has no vehicle manufacturing facilities and the volumes are too small to justify the large investments in recycling infrastructure that are required. Our analysis shows that the sector can move from 1% to 68% circularity by 2040°, and virgin plastic demand could be reduced by 9,000 tonnes (~21%). In addition, ambitious application of these circularity levers alone could reduce the GHG emissions related to plastics in the automotive sector by 32% from 163,000 tonnes of CO_2eq in 2020 to 111,000 tonnes of CO_2eq by 2040.

° Circularity as a % of annual demand for plastic utility corrected for net addition to stock

EXHIBIT 20

Potential outcomes of implementing a System Change Scenario

		FROM 2020	TO System Change 2040	
A MORE SUSTAINABLE AND CIRCULAR AUTOMOTIVE INDUSTRY	**Vehicles per capita**	0.62	0.61	-2%
	Mass of plastic in average car Kg / vehicle	246 Kt	280 Kt	+14%
	Virgin plastic production	45 Kt	35 Kt	-21%
	Recycling (Mechanical & Chemical)	~0 Kt	32 Kt	NA
	Incineration, landfill & leakage	27 Kt	21 Kt	-23%
	Circularity*	1 %	68 %	+6400%
	GHG Emissions per tonne of demand for plastic utility	3.6 tCO_2eq	1.5 tCO_2eq	-59%
WITH NO TRADE OFF FOR SOCIETY	**Cost** per tonne of demand for plastic utility	16,000NOK	15,000NOK	-5%
	Jobs per Kt of demand for plastic utility**	0.2	8.3	+5120%

* Circularity as a % of annual demand for plastic utility corrected for net addition to stock
** Excluding production as majority takes place outside Norway

Key stats

- **46Kt** Volume put on market 2020
- **18Yrs** Average Lifetime

Most common Polymers in use

- ~**25**% **PP** Polypropylene
- ~**12**% **PA** Polyamide Nylon
- ~**10**% **PE** PolyEthylene

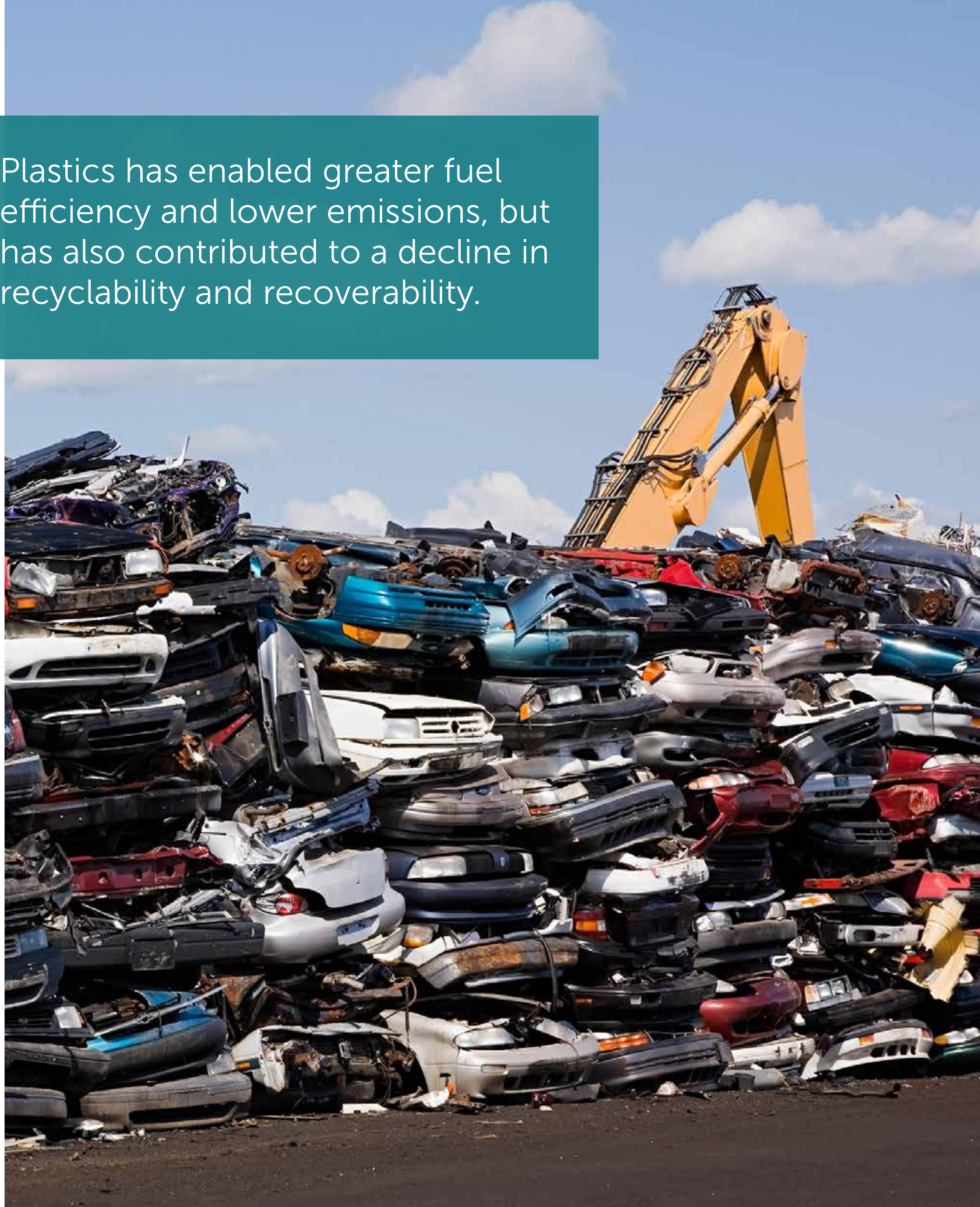
Baseline:
Plastics in stock are accumulating in a highly linear system

As the population of Norway has become wealthier, the number of vehicles per capita has increased from ~0.42 in 1990 to ~0.62 today (compared to 0.56 on average in the EU)[22] and this is expected to stabilise at ~0.68 vehicles per person by 2040.

At the same time, plastic content in vehicles globally has increased from ~160 kg/vehicle in 1990 to ~250 kg/vehicle today, an almost 60% increase. The use of plastics in vehicles has a number of advantages, namely its low density, fuel efficiency, low cost, durability, and safety benefits[23]. It is expected that plastic content will reach ~280 kg/vehicle by 2040, particularly with the trend towards larger cars and the rise of electric vehicles (EVs), due to their weight sensitivity and lower requirements for heat resistance. As a result of these trends, plastic has accumulated in the Norwegian vehicle stock, reaching an estimated 740,000 tonnes in 2020.

The rise of plastics has enabled greater levels of fuel efficiency and thus lower use-phase emissions, but it has also contributed to a decline in the recyclability and recoverability of materials from vehicles, essentially shifting the environmental burden from the use-phase to end-of-life.

Plastics have typically been used to substitute steel components in vehicles, which immediately reduces the probability of recovering the materials given the higher recycling rate of steel and the ease of separating steel



Plastics has enabled greater fuel efficiency and lower emissions, but has also contributed to a decline in recyclability and recoverability.

from shredder residue relative to plastics. In addition, there has been a rise in the number of different polymers used, particularly engineering plastics, as well as greater use of composites and multi-material components, making mechanical recycling of automotive plastics extremely challenging. These design trends have led to a significant reduction in the recyclability of vehicles.

Although Norway is a frontrunner in the management of End-of-Life Vehicles (ELVs), the current system is still highly linear, with only 1% of plastic being dismantled (mainly bumpers) and reused or recycled. The remaining 99% is incinerated or landfilled.

A well-established ELV return system, introduced in the late 1970s, coupled with a successful scrap deposit system, has allowed Norway to successfully manage the whereabouts of ELVs, which has proven to be a challenge in the rest of Europe. However, beyond collection, Norway lacks the infrastructure required to close the material loops.

Norway has access to post-shredder technologies (PSTs) to recover metals, but there are no advanced PSTs in the region for recovering plastics from shredder residue. As a result, today only a marginal amount of plastic from Norwegian ELVs is being recycled by companies like Stena and Norsk Gjenvinning. The application of advanced PSTs, while commercially available and continuously innovating, is not common practice given the lack of economic or regulatory incentives in most countries.

Current regulation lacks focus on plastics, but this is expected to change soon through the Revision of the End of Life Vehicle Directive, which is expected to include material-specific recycled content and recycling targets[24]. This step change in regulatory ambition is critical for driving investment in the infrastructure needed to recover automotive plastics at end-of-life. However, even with the current non-material-specific ELVD targets, the rapidly increasing share of plastics in vehicles means that there is a real risk of non-compliance unless some plastics are recycled.

As well as the lack of effective regulation and infrastructure, there are a number of other important barriers to circularity of automotive plastics, including the lack of design for recycling of automotive plastics to combat the rise in the use of complex composites and additives and the number of polymers; a lack of economic incentive to dismantle vehicles and recycle plastics given the high labour costs, high transport costs, and low resale value relative to low costs of disposal; and, given the industry's high quality requirements and emphasis on aesthetics, the low uptake of recycled content.

Tyres

Tyres are not included in our modelling of the automotive sector, given their vastly different pathways and treatment routes, but they are important to consider due to the high volumes of plastic waste generated and high GHG emissions produced during their incineration, which is the dominant pathway for end-of-life tyres.

Tyres still contribute a large volume of waste in Norway, reaching 60,000 tonnes in 2020, of which around 46% (~28,000 tonnes) is plastic. Most of this plastic waste (92%) is currently incinerated, while only 8% is reused or recycled. Chemical recycling is expected to play a significant role in the treatment of tyres, and a number of pilot and small-scale plants are already emerging. For example, in Norway, Enviro Systems have developed a local plant which recycles tyres via pyrolysis.

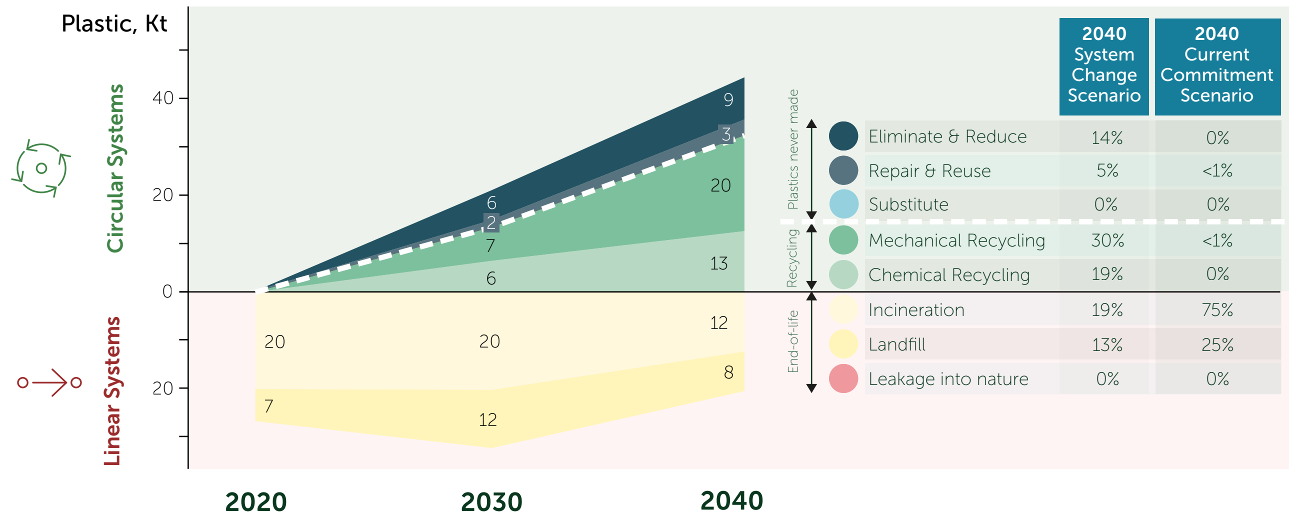
As stated in Chapter 1, microplastics are out of scope of this study.

Achieving Circularity:
Shared mobility solutions and scaling up advanced post-shredder technologies can change the trajectory

The automotive sector in Norway must pursue the ambitious deployment of circularity levers to reduce dependency on virgin fossil-based plastics and achieve a more circular system. Reduction in plastic consumption via the adoption of shared mobility solutions, as well as modal shifts, could eliminate 12% of plastic demand by 2040. Additionally, circularity levels of 68% can be reached by 2040. This relies almost entirely on downstream levers in the short term as the long lifetimes of vehicles in Norway (~18 years) means that the impact of design levers implemented over the next decade on waste generation is limited.

EXHIBIT 21 **Through the application of circularity levers the Automotive sector can reach 68% circularity by 2040**

As % of total demand for utility (with deduction of stock)



	2020	2030	2040
Circularity	1%	40%	68%
Total utility demand*	27 Kt	54 Kt	65 Kt
Total waste	27 Kt	47 Kt	56 Kt
GHG Emissions	163 $KtCO_{2eq}$	159 $KtCO_{2eq}$	111 $KtCO_{2eq}$

* corrected for net addition to stock

Shared mobility solutions and modal shifts have significant potential to scale in Norway, reducing vehicle demand per capita and thus demand for plastics. This is particularly true for cities like Oslo where there is evidence of these models already starting to take off. In smaller towns and more rural areas, there is less potential for these models. This change is not happening because of plastic, but plastic reduction is a co-benefit of this change.

Today, the average car is parked for at least 95% of its lifetime[25], which is an extremely inefficient use of valuable resources. Shared mobility solutions such as Getaround and Bilkollektivet have the potential to change this, and the predicted rise in autonomous vehicles are likely to accelerate this trend. By introducing shared mobility models and incentivising modal shift, the vehicle stock could be reduced by 11% in 2040, relative to the baseline, resulting in a 12% reduction in demand for plastics.

Design for recycling is critical for the automotive sector but the impact on recycling rates before 2040 is likely to be low. This involves the simplification and standardisation of polymer types and the reduction of composites and multi-material components.

Widespread adoption of design for recycling of vehicle components could reduce losses from mechanical recycling to a minimum of 15%, down from 30% today.[26, 27] The trend towards reinforced plastics containing fillers and additives has made plastic vehicle components virtually impossible to mechanically recycle. By shifting to mono-material components, avoiding the use of paint, using fewer and standardised polymer types, and, where possible, avoiding the combination of different polymers altogether, much higher yields may be achieved in mechanical recycling and thus higher quality recyclates, driving a greater share of closed loop recycling.

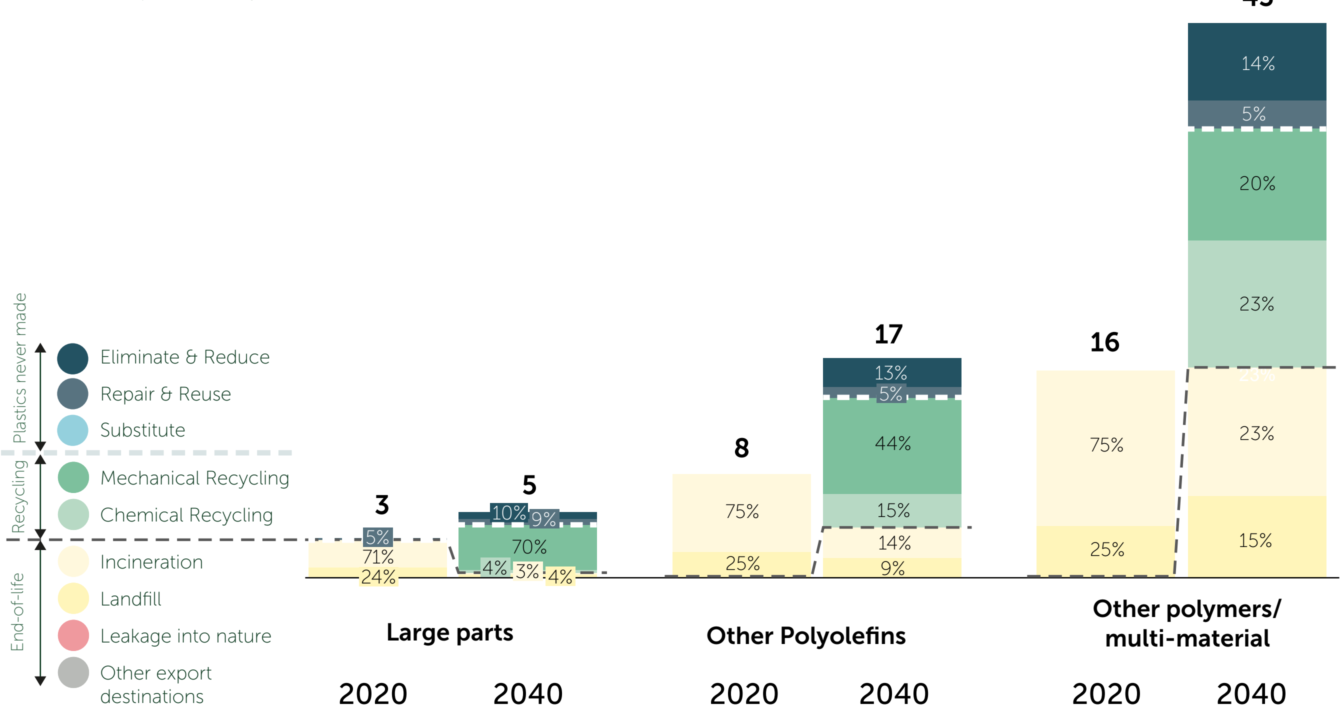
Design for recycling in the automotive industry is already emerging, with some companies developing self-reinforced PP components that have the same or superior mechanical properties but allow for a straightforward recycling process.

Adoption of design for recycling relies strongly on the formulation of industry-wide standards, which must be strictly adhered to. While industry has a key role to play in developing and enforcing these standards, policy support is required as the automotive industry is highly cost driven and to date has been optimising design for cost. The revised ELV Directive is expected to introduce material-specific recycling rates because the existing targets, which apply to all materials generally, have had little impact on plastics recycling given their relatively low share of total vehicle weight. This will place pressure on OEMs to make recyclability of components a key criterion of their design.

In addition, the revision of the ELV Directive is likely to introduce mandatory recycled content requirements, a crucial requirement to minimise downcycling. Many OEMs are also setting their own recycled content targets (e.g. Volvo, with a 25% by 2025 recycled content target), and early adoption of design for recycling will be essential to secure a reliable future supply of high-quality recyclates.

EXHIBIT 22 **The highest impact levers for the Automotive sector are Mechanical and Chemical Recycling**

2020 vs 2040 System Change Scenario



	Large parts 2020	Large parts 2040	Other Polyolefins 2020	Other Polyolefins 2040	Other polymers/ multi-material 2020	Other polymers/ multi-material 2040
Total Demand for utility*	3 Kt	5 Kt	8 Kt	17 Kt	16 Kt	43 Kt
% Circular	5%	93%	0%	77%	0%	62%

* corrected for net addition to stock

There is some potential for overall plastic demand reduction in the sector through the reuse of refurbished plastic components, but this is likely to be minimal and limited to repair only.

Given the time and labour-intensive nature of the process, dismantling rates remain low in Norway. But best practice examples in other countries, such as France, suggest that there is room for improvement, and there is already evidence of this happening in Norway, driven by the large cost differentials between new and used parts for the repair of vehicles.

By 2040, it is estimated that demand could be reduced by 4% relative to the baseline as a result of component reuse. The potential for reuse of plastic components is very much dependent on having modular, standardised vehicle designs, using non-destructive dismantling processes, and on the existence of re-sale channels for used parts, which are currently low but scaling in Norway. However, this is likely to be limited to replacing broken parts on cars in use, or insurance vehicles, rather than on new cars. It would also require technical specifications to remain static over the lifespan of the vehicle, or to become more flexible for certain components, particularly for non-safety critical components. Given these challenges, the potential for reuse is likely to remain low.

Driven by the desire to minimise vehicle weight and thus fuel consumption, the automotive sector has worked hard to optimise the use of plastics in vehicles. Further reduction of plastic content may be possible through future innovation[28, 29], but is likely to be minimal, particularly with the rise in EVs, which are expected to see greater use of plastics to reduce overall vehicle weight in order to improve range.

Downstream levers are likely to have the most significant impact up to 2040. The key downstream levers in the automotive sector are the scaling up of advanced post-shredder technologies and chemical recycling.

Increasing recycling rates of automotive plastics relies predominantly on the scaling and improvement of advanced PSTs in Norway, as the dismantling of plastic components is limited due to economic and logistical challenges.

For this reason, most recyclers favour advanced PST over dismantling[30] as, given the plastic quantities to be recovered, they are seen as more economically efficient. However, the dismantling of large components does have value in terms of enabling a cleaner stream of plastics and therefore should be pursued as far as the economics allow. Given the significant investment required, widespread adoption of advanced PSTs in Norway relies on an improvement in the economics of recycling engineering plastics – including higher disposal costs and plastic recyclate prices, as well as strong policy incentives, which are expected to be introduced in the upcoming revision of the ELV Directive and, to some extent, by large industry players in the region such as Volvo who have started to show interest in closed loop recycling schemes. At the same time, alternative disposal routes (i.e. landfilling and incineration) must become less attractive economically or be strictly limited by regulation. Given the volumes required to justify investment into these technologies, collaboration between Norway and neighbouring countries is critical.

Chemical recycling will also have a major role to play in the automotive sector, particularly in recycling plastics that are not recovered via advanced PSTs or that are not suitable for mechanical recycling. While mechanical recycling is preferable to chemical recycling from a resource efficiency, energy and GHG emissions perspective, the challenges associated with sorting plastics from shredder residue limits its scalability. Even if all potential levers are utilised to their maximum potential and best practice is adopted across Europe, it is estimated only 35% of total plastic waste from ELVs in Norway would be mechanically recycled, producing ~20,000 tonnes of recyclate.

Mechanical recycling of technical plastics and plastic composites is technically challenging as the properties of polymers in ELVs deteriorate during the use-phase due to UV exposure, wear and tear, etc., resulting in low quality recyclates. In addition, plastic components in vehicles typically have very strict specifications and require virgin quality material, particularly for safety-critical parts and exterior components that affect the aesthetics of the vehicle. Therefore, the potential for closed-loop mechanical recycling is limited. While there is some opportunity to use mechanical recyclate from other sectors, particularly consumable applications, this is also limited in terms of both the quantity and quality of the supply. Given these technical challenges, and the suitability of the shredder light fraction to thermal treatment, we expect chemical recycling to play an increasingly significant – though still complementary – role in this sector. In the System Change Scenario, ~22% of plastic waste, equal to ~13,000 tonnes is chemically recycled and recirculated back into the plastic system by 2040.

EXHIBIT 23 **Key recommendations per actor**

Value chain actors

Manufacturers (Cars & parts)
1. Design for recycling
2. Material innovation
3. Form closed loop supply chain partnerships with recyclers

Dealers & Platforms
1. Offer rental and sharing models

Consumers
1. Switch to rental and sharing models
2. Switch to alternative models of transport
3. Opt for refurbished parts instead of new

Recyclers
1. Scale advanced post-shredder technologies

Policy

Regulators
1. ELV directive:
   - Material-specific recycling and recycled content targets
   - Yield requirements for shredder facilities and dismantling requirements for ATFs
2. Strengthen the EPR: through inclusion of design for recycling

Finance

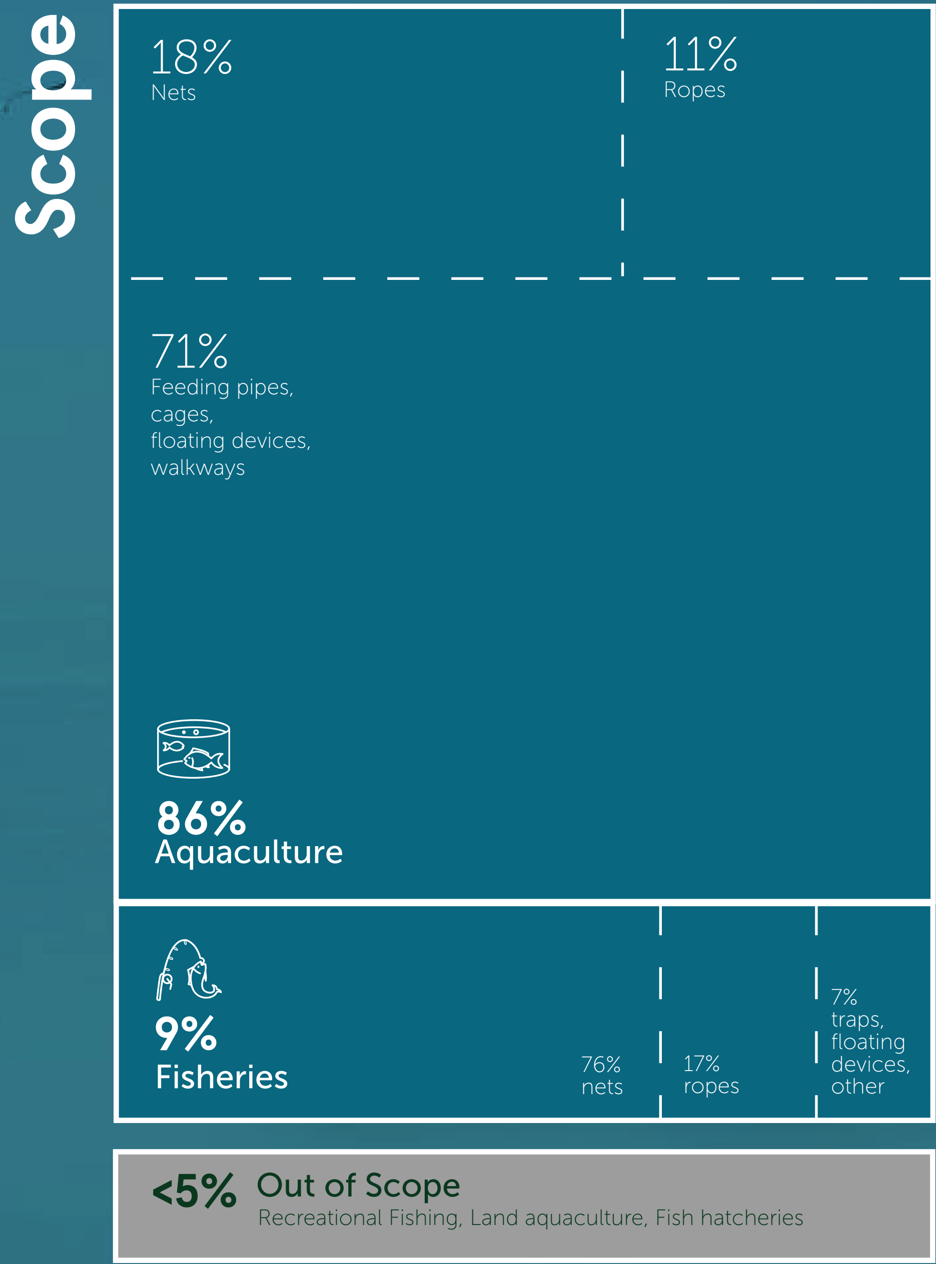
Investors
1. Inclusion of circular economy targets in financing criteria
2. Preferred rates for circular business model enablers

Recommendations

The Automotive sector should prioritise four main actions:

- Accelerating the implementation of new business models by shifting economic incentives (e.g. VAT, parking fees), with a particular focus particularly focusing on shared mobility solutions, as well as shifts towards other modes of transport including buses, e-scooters, cycling, etc.
- Policy interventions, particularly the revision of the ELV Directive to include material-specific recycling targets, combined with a requirement for the simplification and standardisation of polymer types and the reduction of composites and multi-material components.
- The scaling of advanced PSTs to enable local mechanical and chemical recycling.
- For all these interventions, collaboration with other Nordic countries (especially Sweden) will be key as Norway has no car manufacturers and waste volumes are relatively small.

Fisheries & Aquaculture



Summary

Norway's fishing industry is a major sector in the country's economy and is relied on internationally, as Norway is the second largest global exporter of seafood (by value).

Plastic has been a key enabler for the industry's growth, thanks to its low cost, malleability, resilience, and durability. But its negative impacts are less well known, including its leakage into nature, which has a greater direct effect on marine life than plastic leakage by other sectors through entanglement during 'ghost fishing', smothering, and other threats. In Norway, both fisheries and aquaculture firms have started to recognise the importance of moving towards a more circular plastic system and momentum is building. Research and pilots are already taking place both upstream and downstream but a robust EPR policy, constructed in collaboration with all actors in the value chain, will be key to accelerating the transition to a more circular system.

Our analysis shows that the demand for virgin plastics in fisheries and aquaculture can be reduced by ~16,000 tonnes (~48%), and the sector shift from 35% to 81% circularity[p], by 2040. As a result, total yearly GHG emissions related to this sector decrease from ~114,000 tonnes of CO_2eq to ~51,000 tonnes of CO_2eq by 2040 (Exhibit 24).

EXHIBIT 24

Potential outcomes of implementing a System Change Scenario

		FROM 2020	TO System Change 2040	
A MORE SUSTAINABLE AND CIRCULAR FISHING & AQUACULTURE INDUSTRY	**Kg of plastic weight needed per tonne of fish**	115 Kg	106 Kg	-8%
	Virgin plastic production	33 Kt	17 Kt	-48%
	Recycling (Mechanical & Chemical)	10 Kt	17 Kt	+70%
	Incineration, landfill & leakage	21 Kt	7 Kt	-67%
	Circularity*	35 %	81 %	+131%
	GHG Emissions per tonne of demand for plastic utility	3.5 tCO_2eq	1.2 tCO_2eq	-66%
WITH LIMITED TRADE OFF FOR SOCIETY	**Cost** per tonne of demand for plastic utility	25,000NOK	18,000NOK	-28%
	Jobs per Kt of demand for plastic utility**	13.1	12.5	-5%

* Circularity as a % of annual demand for plastic utility corrected for net addition to stock
** Excluding production as majority takes place outside Norway

Key stats

- **33**Kt — Volume put on market 2020
- **4**Yr — Fisheries Average Lifetime
- **10**Yr — Aquaculture Average Lifetime

Most common Polymers in use

- ~**64**% — **PE** PolyEthylene
- ~**19**% — **Nylon 46**
- ~**14**% — **PP** Polypropylene

[p] Circularity as a % of annual demand for plastic utility corrected for net addition to stock

Baseline:
Momentum is building for a more circular system

While plastic demand per tonne of fish caught has been stabilising for both fisheries and aquaculture, annual demand for plastics utility is still increasing (expected to rise by ~27% between 2020 and 2040), driven by production growth[31].

Plastic makes up ~70% of the weight of all gear used (45% for fisheries, 73% for aquaculture)[11]. Fishing capacity has already gone through a restructuring phase and gear has now stabilised at ~9 kg of plastic/tonne of fish. In aquaculture, efficiency of plastic use is expected to show a slight improvement, driven by the move to larger offshore farms and the use of closed cages on onshore farms, before stabilising at ~117 kg of plastic/tonne of fish by 2030, highlighting the fact that aquaculture is far more plastic intensive than fishing.

Even though Norway is a frontrunner in plastic management in this sector, and there are many promising circularity pilot projects ongoing, the current system is still highly linear, with 66% of plastic waste currently incinerated, landfilled or leaked into nature.

Today, ~42% of total waste is incinerated, ~21% landfilled, and ~2% leaks into nature[q]. Only ~33% of total waste is currently recycled, though this has been increasing over the last years. The majority of this recycled material flows to other sectors, but a small proportion of components are reused after gear has been discarded (~2%). However, it is important to note there is a strong culture of repair (the highest across all five sectors), and a significant amount of repair and reuse takes place before the gear is discarded, especially for nets, which are very expensive. Over 60% of nets get repaired at least once a year.

[q] This is a highly uncertain and much debated figure; the majority are small low weight items like rope cuts, as large gear is more easily recoverable.

There is a strong culture of repair with over 60% of nets getting repaired at least once a year.

"The EPR for Fishing Gear can become a game changer if implemented correctly, and set a global example"

Most aquaculture firms and fisheries have a high awareness of plastic pollution and have put different management practices in place. Recognition of the need to reduce the demand for plastic in the first place has also been growing and many aquaculture companies now measure their plastic footprint and have defined an initial circularity roadmap.

It is important to highlight that data accuracy for fisheries is higher than for aquaculture based on deep academic research and field interviews[33]. Although the data for aquaculture has a higher level of uncertainty and more research needs to be done, good data is available on recycling numbers.

Current commitments are building momentum and more ambitious policies are on the horizon, specifically a new EPR regulation which could make a significant difference if designed and implemented well. Convenient access to zero-cost disposal is key. Several policies are being discussed in Norway, including Marpol Annex V, the EPR regulation, and the European Directive on Port Reception Facilities that requires waste from ships to be landed and adequately managed in ports. Collection facilities are already being put in place in ports, and a direct fee for handing in waste is being changed to an indirect fee (i.e. the waste handling fee will apply to ships regardless of whether they deliver waste or not), thus removing an incentive for littering. However, it will be a challenge to implement this across all ports and aquaculture farms considering the sheer number of eligible locations in Norway.

According to experts, other key enablers for circularity include design for both longer lifetimes and recycling, research and awareness building on how to better use equipment, making it economically viable to scale up infrastructure and ensure the latest technologies are available (from local sorting, to cleaning and recycling), and making the price of recycled plastic more competitive compared to virgin plastic.

An EPR for Fishing Gear will be introduced by the 31st of December 2024 and could be a game changer if implemented correctly, influencing everything from fishing gear design to end-of-life infrastructure, and delivering the financial resources for the transition[33].

Achieving Circularity:
A well-defined and implemented EPR and better information sharing can enable a circular system

Through the combined deployment of upstream and downstream levers, circularity could increase to 81% by 2040 (see Exhibits 25 and 26), and the reliance on virgin plastics could be reduced to 55%, down from 100% in 2020, although having access to enough recycled material could be a barrier. This sector does not have a silver bullet solution. To achieve higher levels of circularity, reuse and recycling should be maximised through better design and scaling up of local sorting, cleaning and recycling infrastructure.

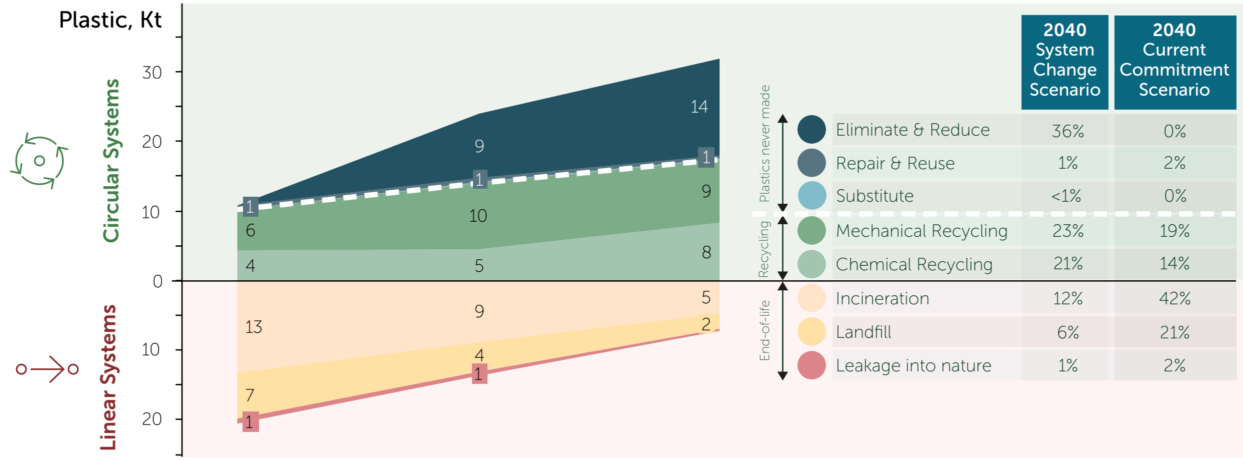
The key upstream lever is reduction, especially through lifetime extension in aquaculture (see Exhibit 26). Better gear design and (re)usage practices can reduce plastic demand by ~36% in 2040 (a cumulative reduction of ~135,000 tonnes between 2025 and 2040).

In our research, opportunities for lifetime extension were identified in both fisheries and aquaculture. However, given that ~90% of the plastic in this sector is in use in aquaculture equipment, where ~13x times more plastics are needed to produce a tonne of fish compared to the fisheries sector, the impact of applying these practices in aquaculture is many times greater.

Lifetime extension is a combination of better design and usage, and in many aquaculture farms initial pilots are already underway to improve both. In terms of design, a good example are the floating collars in aquaculture farms, which represent over 50% of all plastic in stock. Research is ongoing to improve their design by allowing for reuse. Initial results from ScaleAQ show that most

EXHIBIT 25 **Through the application of circularity levers the Fisheries & Aquaculture sector can reach 81% circularity by 2040**

As % of total demand for utility (with deduction of stock)



	2020	2030	2040
Circularity	35%	64%	81%
Total utility demand*	31 Kt	37 Kt	39 Kt
Total waste	31 Kt	29 Kt	25 Kt
GHG Emissions	138 $KtCO_2eq$	83 $KtCO_2eq$	52 $KtCO_2eq$

* corrected for net addition to stock

floating collars can be repaired and recertified, extending their lifetimes by at least 9 years, although it is believed this can even extend to an additional 20 years. In terms of usage, a good example in aquaculture are feeding pipes. Through changing pressure from compressed air to water, and using them underwater, instead of on the water surface, wear and tear reduces significantly and average lifetimes can be expanded from one to approximately four years or longer. In fisheries, a good case can be made for trawl nets, which could be used for longer if they are lifted instead of swept over the seabed, which is also less harmful for the seafloor habitat.

Although Norway is leading the way in terms of design standards, there is still significant room for improvement. For the practices described above, the EPR regulation currently being discussed will be a key enabler. Beyond design, the regulation should consider usage practices and prohibit the discarding of gear that is still of good enough quality through the implementation of recertification processes. Today, too much gear is still being discarded before the end of its lifetime (this happens more often in aquaculture than fisheries, where expensive nets are repaired until this is no longer possible) because it is cheaper to discard elements than reuse them. This particularly tends to happen when a farm is expanding.

Besides the upstream levers, there are three major downstream levers that should be developed.

Firstly, maximising collection, cleaning and pre-sorting facilities in ports or near aquaculture farms could enable up to 90% of waste to flow to formal sorting facilities.

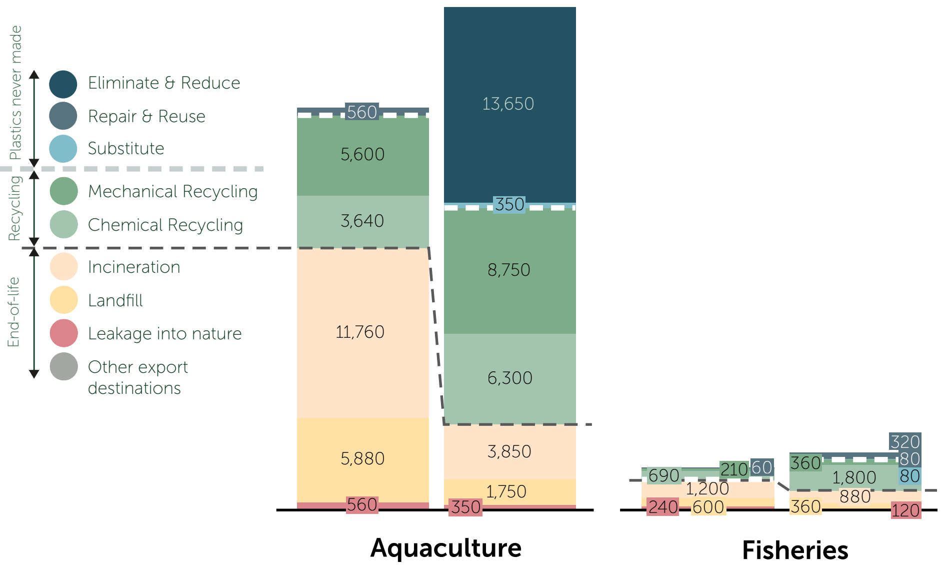
Today, almost 50% of collected waste ends up in residual waste without being checked for recyclable materials, often due to a lack of cleaning and pre-sorting capacity at the port or near the aquaculture farm. Financing through the EPR scheme will be key to enabling the scale up of these facilities and creating a viable business model. A good example of improving local infrastructure are the local collection and recycling hubs currently being planned by Marine Recycling Cluster[34]. Some of these initiatives are focused on creating end-to-end loops, others on precycling before selling to recyclers. Another example is Grieg Seafood, which is working on a closed loop recycling scheme for ropes with its rope suppliers and Quantafuel. In Canada, there are also examples of pilot projects coordinated by Ocean Legacy implementing recycling facilities in ports capable of sorting/cleaning and recycling different types of gear.

Secondly, local mechanical recycling in Norway could be expanded to recycle ~36% of total waste volumes domestically by 2040.

The main opportunity is for rigid High Density Polyethylene (HDPE) gear from aquaculture. This high value material is in high demand but the majority is currently exported to larger European players (e.g. Plastix). Supported by financing from EPR regulations, the local industry could become more competitive and expand its capacity further.

EXHIBIT 26 **The highest impact lever for the Fisheries & Aquaculture sector is Reduction due to lifetime extension opportunities**

2020 vs 2040 System Change Scenario



	Aquaculture 2020	Aquaculture 2040	Fisheries 2020	Fisheries 2040
Total demand for utility*	28 Kt	35 Kt	3 Kt	4 Kt
% Circular	35%	83%	31%	67%

* corrected for net addition to stock
** Reduction: elimination through dematerialisation & lifetime extension, and reduction through new delivery models enabling access.
Reuse: reutilisation of products or components after disposal

The main local recyclers include Noprec / Oceanize, Brontes, and Quantafuel Kristiansund. Today, local capacity is ~6,000-10,000 tonnes and this is expected to double over the next couple of years .

Design for recycling and promoting an increased uptake of recycled content by the industry are other key enablers for growing the local mechanical recycling industry. The Akva Group, in partnership with Plasto and Oceanize, is on track to achieve its mission to develop the first aquaculture farm using 100% recycled content and has already made good progress[35]. Similarly, ScaleAQ together with Hallingplast are developing equipment made of recycled material[36, 37].

It is estimated that ~45% of input can be recycled content by 2040. Better information sharing will be key to accelerating the uptake of recycled content. For example, a digitised information system that can track quality and control is critical for the market development of recycled plastics.

Thirdly, chemical recycling will remain a key solution for nets and capacity should be expanded.

Hard to recycle nets make up >70% of the total plastic waste in fisheries, and >25% in aquaculture[11]. Even though improvements can be made in terms of design for recycling, the mixed polymer design combined with unrecyclable materials and the condition of the nets at end-of-life will keep this a particularity difficult type of gear to recycle[38]. However, Aquafil has a patented technology to process nets into Econyl yarn via a depolymerisation process and has created a positive market value. It is likely that chemical recycling of nets will continue to take place outside of Norway considering the investment required.

Zero leakage will remain difficult to achieve.

Along with post-consumer packaging, gear related to the fishing and aquaculture industry is the most significant source of marine litter found on beaches in Norway (18-90% of weight depending on the area)[39]. In terms of impact, it has even higher negative effects, due to ghost fishing and smothering. It is very difficult to trace either the origin of the gear or the year of loss. Although Norway is a frontrunner in terms of good management practices to avoid leakage into the ocean, and is able to recover the majority of large gear lost, small items that are lost or discarded remain a big challenge. This also makes clean-ups particularly difficult and expensive.

Some experts believe biodegradable materials would be more effective than retrieval programmes, although most experts agree their use will remain very limited and the overall effect on circularity will be negligible. Further research and development into biodegradable materials for fishing gear is needed to understand technical feasibility. Dsolve is a good example of a Norwegian collaborative research programme on a mission to develop new biodegradable polymers for the marine environment[40].

EXHIBIT 27 **Key recommendations per actor – Fisheries & Aquaculture**

Value chain actors

Manufacturers	Aquaculture Farms	Fisheries	Recyclers
1. Gear design and innovation 2. Usage guidelines to reduce wear & tear 3. Connect with research programmes on material innovation 4. Take-back and reuse schemes	1. Track plastic footprint and implement circularity strategy 2. Pilot closed loop cycles 3. Gear reuse & recertification 4. Continue record management and training programmess on losses	1. Gear reuse and recertification 2. Continue record, management and training programmess on losses (including technology to track lost nets) 3. Incentivise correct disposal	1. Scale up collection infrastructure in ports near aquaculture farms 2. Closed loop recycling partnerships with aquaculture farms/fisheries

Policy

Regulators

1. Prepare an ambitious EPR policy (to be in place by end of December 2024), considering development of local infrastructure for easier to recycle plastics, and closer partnerships for harder to recycle gear (e.g. nets)
2. Disincentivise use of low-cost virgin plastic, e.g. through the application of a plastic tax

Finance

Investors

1. Inclusion of circular economy targets in financing criteria
2. Preferred rates for circular business model enablers

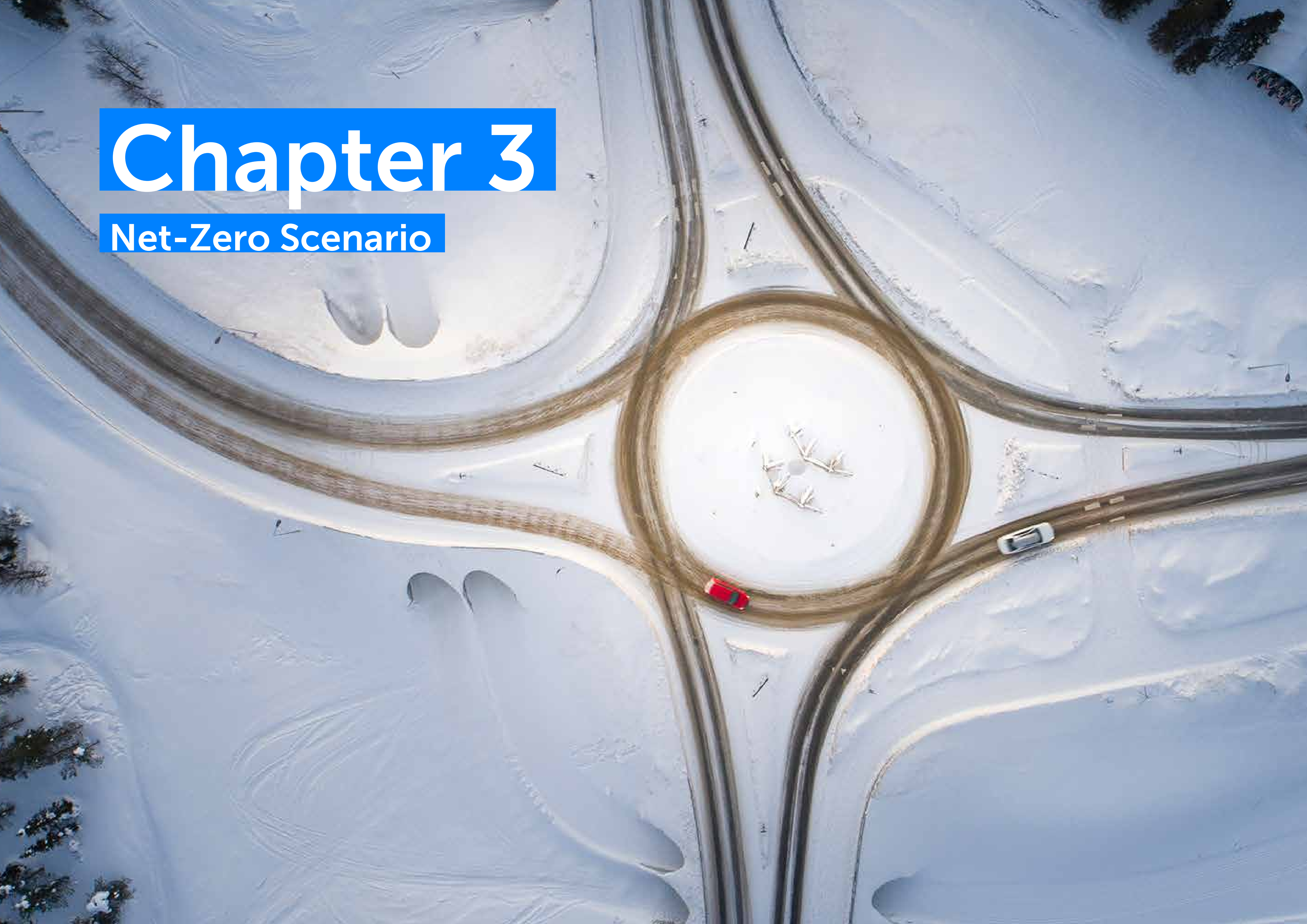
Recommendations

The Fisheries and Aquactulture sector should prioritise three main actions:

- Introducing an ambitious EPR policy built together with main players to accelerate action and finance the transition.
- Accelerating the implementation of circular strategies by aquaculture farms and fisheries, including reuse and recertification, creation of closed loops, use of recycled content, and continued focus on usage optimisation.
- Using information flows and product/material tracking to guarantee documentation on risk analysis for recycled products.

Chapter 3

Net-Zero Scenario



Net-Zero Scenario

The circularity levers described in the previous chapter can drive a ~38% reduction in GHG emissions compared to 2020 by 2040, but this still leaves ~700,000 tonnes of system emissions remaining in 2040. As a result, supply side abatement levers and technologies are required to mitigate residual system emissions and put the Norwegian plastic system on a net-zero trajectory.

Our analysis considers all emissions associated with plastics put in the market in Norway. Because the majority of emissions are generated in production and at end-of-life, the bulk of emissions considered are international. Therefore, reducing these emissions will require regional cooperation with other countries, mainly by switching feedstock source and energy source and capturing residual production emissions.

Additionally, incineration emissions can be abated domestically and regionally through the application of carbon capture and storage (CCS). This can reduce system emissions by 570,000 tonnes, leaving approximately 130,000 tonnes of emissions from the Norwegian plastic system by 2040, a 90% reduction compared to the baseline scenario and putting the system on a trajectory to reach net-zero by the early 2040s.

Circularity levers can get the system half way to net-zero by 2040

Circularity has the potential to remove about half of the emissions from the plastic system in scope by 2040, and lead to a net 38% reduction vs 2020 emissions.

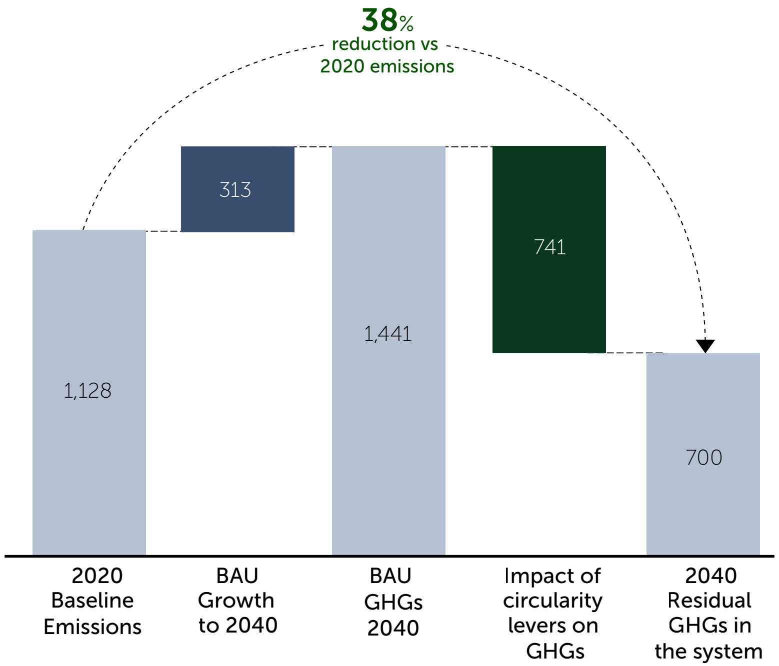
Circularity is the fastest, most economic, most environmentally friendly and resource efficient way to abate the Norwegian plastic system and should be prioritised and optimised for its range of broader social, economic and environmental benefits beyond GHG reduction.

However, due to long lifetimes of some durable plastic categories (i.e. construction and automotive), 8 million tonnes of plastic will also reside in in-use stock in 2040 that – unless either downstream system circularity is increased or incineration emissions are abated – will result in ~26 million tonnes of CO_2eq in additional emissions when it reaches end-of-life and is (mostly) incinerated with energy recovery. This is equivalent to over half of Norway's total annual emissions today.

In addition, significant emissions (~700,000 tonnes of CO_2eq) from production and end-of-life continue to be produced by the highly circular system in 2040 (see Exhibit 28).

EXHIBIT 28 **Circularity reduces GHG emissions by 38% vs 2020, leaving 700kt of emissions p.a. in the Norwegian system by 2040, predominantly from Production and Incineration**

2020-2040 GHGs from Plastic used in the five sectors in scope, Kt CO_{2eq}



Therefore, significant supply side emissions reduction strategies and technologies are required to abate the cumulative 21 million tonnes of CO_2eq that will still be emitted by the plastic system between now and 2040, even if circularity levers are applied.

> "Circularity levers can produce **only** ~38% reduction in GHG emissions compared to 2020. Therefore **supply side emissions reduction strategies and technologies** are required to put the Norwegian plastic system on a net-zero trajectory'

Approach to abating the post-circularity emissions in the Norwegian plastic system

Norway has committed to a 55% reduction in GHGs compared to 1990s levels by 2030 and a 90-95% reduction by 2050 (not net-zero), as per its Nationally Defined Commitments (NDC) submission to the UNFCCC[41] in alignment with the Paris Agreement. Its net-zero transition is rated as "Almost Sufficient" on Climate Action Tracker[42], with national emissions projected to be 41 million tonnes of CO_2eq by 2030, 21% below 1990s levels. However, further policy interventions and transition efforts will be required to hit its Nationally Determined Commitments.

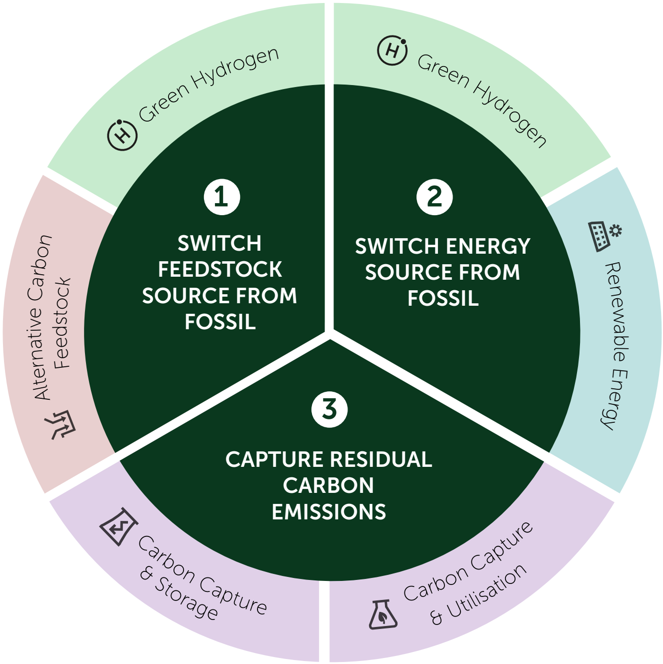
In addition to circularity, three main supply-side technology strategies can be combined to abate emissions along the plastics value chain (see Exhibit 29):

Switching feedstock: Moving from almost exclusively fossil carbon to use around 80% non-fossil carbon sources.

Switching energy source: Electrifying processes where possible and use of green hydrogen for some high temperature heat. Most energy will be required for the synthesis of green hydrogen as feedstock, with only 10-15% of electricity used directly.

Capturing emissions: Capturing CO_2 emissions from production processes or waste incineration and either utilising them (carbon capture and utilisation – CCU) to produce methanol or permanently storing them under the ground (carbon capture and storage – CCS).

EXHIBIT 29 **Three supply-side strategies to abate residual emissions along the value chain**



"Norway's net-zero transition is rated as "**Almost Sufficient**" on the Climate Action Tracker. Further policy interventions and transition efforts will be required to hit its UNFCCC Nationally Determined Commitments."

Production abatement in the Net-Zero Scenario

Approach to production abatement:

Norway imports as much primary plastics as it exports[r] and is a net importer of non-primary plastics. Given the net trade balance and abatement of the Rafnes stream cracker being out of scope of this analysis, we have assumed all plastics used in Norway (in scope for this project) have a pan-EU origin. Thus, we have leveraged the detailed pan-European chemicals and plastics net-zero pathways generated in **Planet Positive Chemicals** (PPC) report to inform the Net-Zero Scenario. Due to Norway's status as a highly developed economy with sovereign wealth, strong governance, net-zero policy ambition, and leadership in sector transition, we have selected the most ambitious, fastest abatement scenario discussed within the analysis as the most appropriate level of ambition.

The Net-Zero Scenario[s] assumes a world that is moving the chemicals and plastics industry towards net-zero at the fastest techno-economic rates practical[t]. After 2030, no more plants using fossil as either feedstocks or fuels are constructed, assuming that the world is intensifying its transition efforts, increasing stranded asset risks, and policy/societal pressures on the plastics industry regarding licence to operate. The model assesses around 50 technologies across 10 different basic chemicals that form the basis of most plastics.

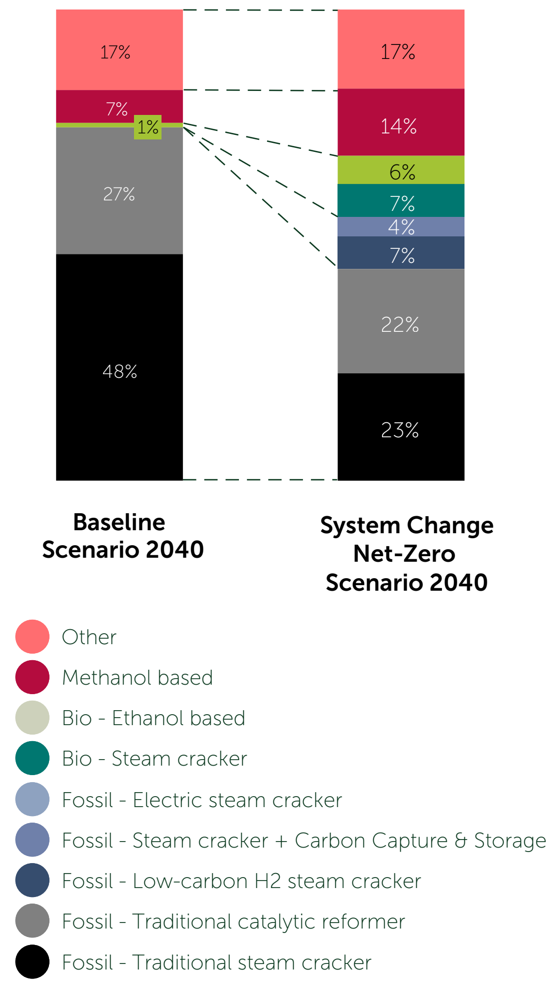
In this Net Zero Scenario, the highest scope 1-3 GHG abating technologies available at a given time are constructed, even if they are more expensive compared to alternative available technologies. This strongly favours technologies that use carbon feedstock originating from atmospheric sources for production, namely biomass or direct air capture. The outcome of this scenario is represented in Exhibit 30, showing the production technology mix in 2040 between the Current Commitments Scenario and the Net-Zero Scenario.

Steam crackers are central to chemicals production today, responsible for around 50% production volume in 2020 (excluding ammonia). They will continue to play a critical role in the future for olefins (ethylene and propylene for PP and PE production, as well as butadiene) production, but abatement via retrofitting of Carbon Capture & Storage (CCS), low-carbon hydrogen, and alternative feedstocks (bio-oil and pyrolysis-oil) will be employed in roughly equal shares. Bioethanol and green methanol will become critical feedstocks for olefins production. Both these feedstocks can be produced from sustainable carbon sources and can be transported via ship.

To bring about the implementation of this production abatement strategy, Norway needs to support the abatement of European plastics production via international policy action, cross-border financing, and commercial off taker agreements, in essence committing to pay for the green-premium on low-emissions plastics production. Furthermore, it may consider promoting greenfield low-emissions production in countries with abundant, affordable renewable energy sources thus low-cost green hydrogen for feedstock[u], frequently found in the Global South.

EXHIBIT 30 **Production technology mix**

% of chemicals produced



[r] More precisely, it has a trade balance of primary plastics balanced primary forms, net importer of plastic in non-primary forms, net exporter of chemical products. https://www.ssb.no/en/utenriksokonomi/utenrikshandel/statistikk/utenrikshandel-med-varer

[s] Referred to in the report as No new Fossil production capacity installation After 2030 – NFAX

[t] The Net-Zero Scenario leverages an agent-based model used for the Planet Positive Chemicals report by Systemiq (Sept. 2022) that evaluates each plastics and chemicals production plant globally each year vs. the expected global demand, to assess whether it should be retrofitted, retired or new greenfield plants should be constructed.

[u] As well as a non-fossil carbon source

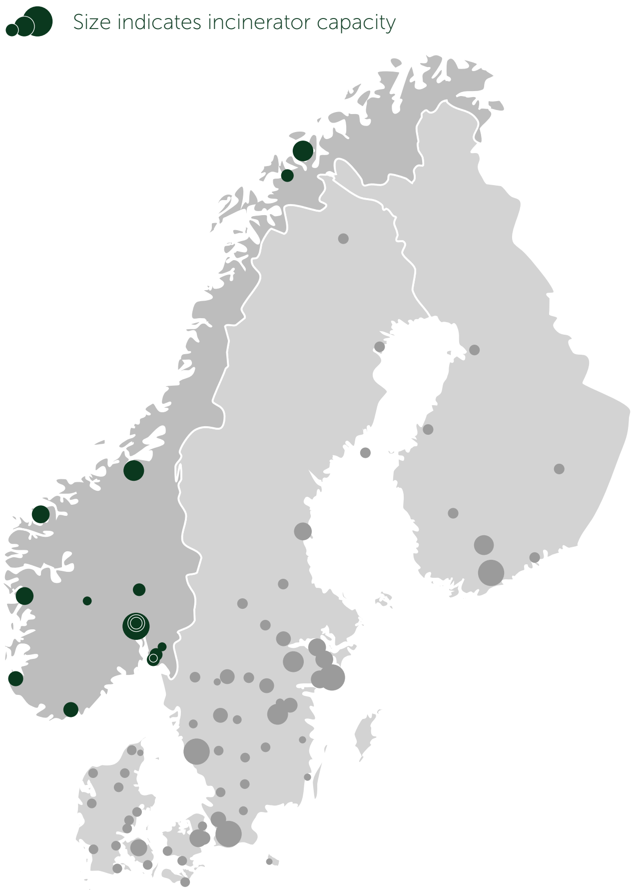
End-of-life Abatement in the Net-Zero Scenario

Incineration is the predominant end-of-life destination in the Norwegian market. Even following the implementation of high levels of circularity, incineration volumes are only reduced by 30%, to 77,000 tonnes by 2040, while still generating 210,000 tonnes of emissions. The most capex efficient route to abatement will likely be to retrofit the regional incinerator portfolio with CCS.

As the map in Exhibit 31 shows, the incinerator portfolio capacity across Norway and Sweden is dense and situated at points of waste generation close to urban populations. Therefore, the capacity is geographically concentrated in the south of Norway and Sweden within a 500 km radius. This makes CO_2 transport to the point of storage less of a logistical and regulatory barrier, given that most incinerators are close to the coastline, making rollout of an interconnected pipeline network on-land coupled with shipping captured CO_2 emissions a possible route, although not without significant challenges. Notably, circularity levers reduce the disposal volumes such that there is no need to export waste for incineration (where there are no technical barriers), allowing Norway to rely on its existing domestic incinerator capacity.

Norway is pioneering a game-changing end-of-life abatement technology at the Klemetsrud Incinerator and Longship / Northern Lights CCS project. This aims to demonstrate at industrial scale, for the first time, a commercial model by which plastic waste systems globally could be abated in future.

EXHIBIT 31 **Overview of incinerator portfolio**



Source: CEWEP

Hafslund Oslo Celsio

Carbon capture - the next step in responsible end treatment of waste

The Celsio plant will be the world's first waste to energy plant with carbon capture as part of a full value chain with transport and permanent storage. From 2026 Celsio will be capturing and liquefying 400,000 metric tonnes CO_2 per year. The liquid CO_2 will be transported by non-emission trucks from the plant to an intermediate storage facility at port, where Northern Lights JV, Equionor, Shell and Total Energies, will collect and transport the CO_2 by specially designed tankers to a receiving terminal on the west coast of Norway. From the terminal Northern Lights will inject the CO_2 into a geological storage reservoir, 100 km out in the North sea and 2600 meters below the seabed. This strategy allows the CO_2 to be permanently stored and prevented from re-entering the atmosphere. In full operation, Celsio will have overcome two major technical barriers facing the abatement of plastic waste incineration:

i) carbon capture on an incinerator's exhaust pipe, and
ii) transport and sequestration of the CO_2.

Following two successful pilots using amine-based capture technology, this project has demonstrated it is possible to capture more than 95 % of CO_2 in the flue gas and have full control of the amine process.

The total cost of the project is NOK 9,1 billion, including 10 years of operation (noting the premium associated with pioneering this innovation), with 100% funding secured since June 2022.

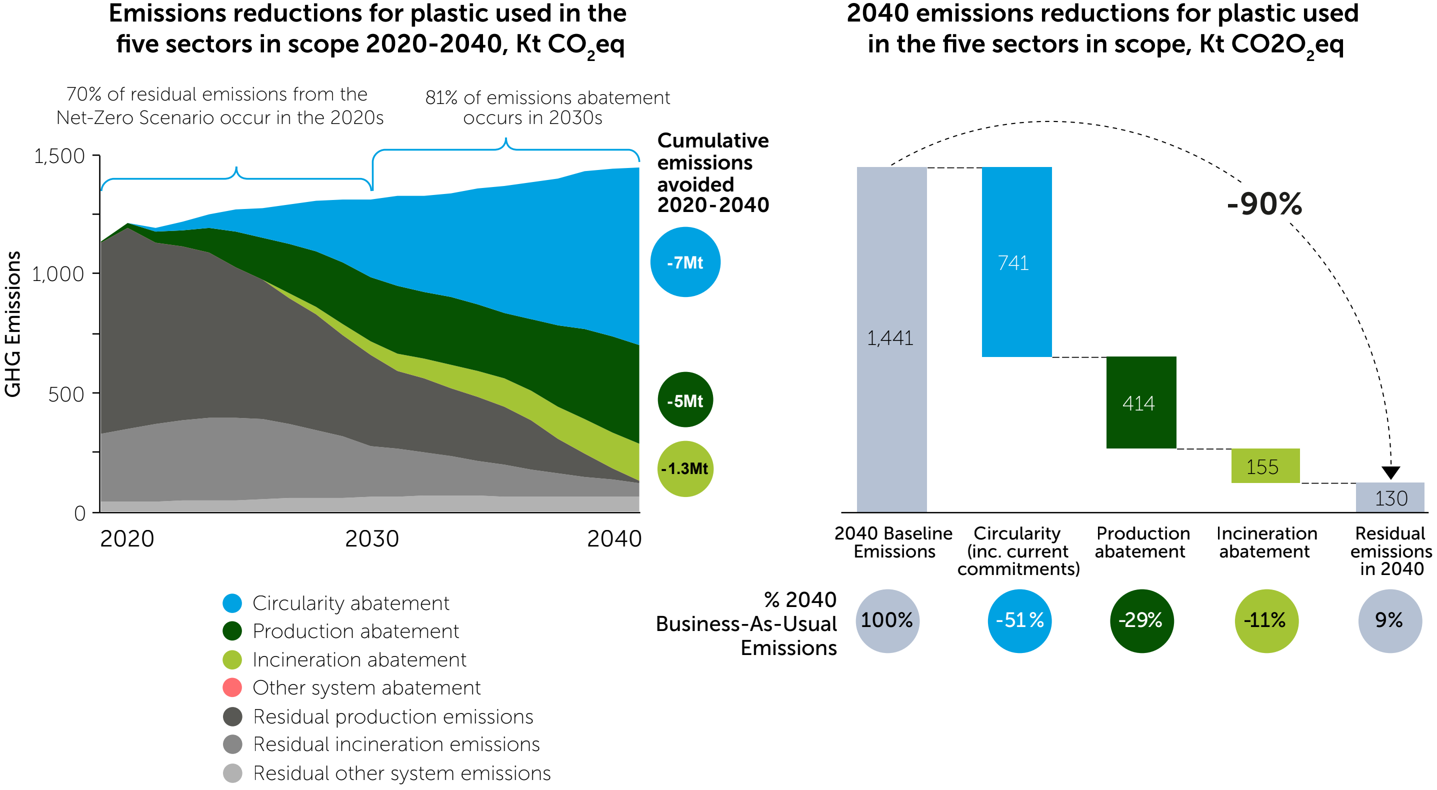
Carbon negativity has been cited as part of the project's ambition, given that ~200,000 tonnes of emissions to be sequestered are from municipal waste of biogenic origin (not referring to its plastic waste feedstock today, which is of fossil origin).

The use of biogenic and direct air captured feedstocks in the future system for virgin plastic production, as assumed in the Net-Zero Scenario, make this project a possible early demonstrator of the Norwegian plastic system's potential to pass through net-zero and become carbon negative. This could make the Norwegian plastic system a climate solution after 2043, contributing back to the carbon budget while still providing plastic utility to the Norwegian economy in a dual value proposition to society and the planet.

Circularity is still essential to avoid high dependency on CCS rollout for incinerators given its lack of commercial of scale today, as if CCS fails to scale then end-of-life emissions would more than double by 2040. Given the advanced Technology Readiness Level (TRL8-9) of this end-of-life solution, it has been assumed that CCS is subsequently rolled out to the incinerator portfolio across the region progressively over the timeseries, aligned with the production abatement trajectory.

Subsequently, 90% of emissions can be removed from the Norwegian Plastics System through current commitments, circularity and supply side abatement technologies by 2040 (see Exhibit 32), placing it on a trajectory to net-zero by 2043.

EXHIBIT 32 **Circularity and Supply Side Abatement Technologies can reduce GHG Emissions in the Norwegian Plastics System by 90% by 2040**



In addition to this approach to end of life abatement, minimising export of waste is a "no-regret" move to avoid greenfield growth of waste management infrastructure internationally. Waste transport abroad is problematic as it orientates towards locations where it is most economical to depose of, usually with the weakest control and capability to process it[43].

Furthermore, value chain control and transparency diminishes as soon as the waste leaves the country. The Basel Convention is now seeking to restrict the transport of lower-quality plastic waste outside of OECD countries. This supports a trend towards the domestication of waste to avoid passing responsibility for its generation onto other countries, thus increasing domestic pressure to drive higher levels of system circularity.

Recommendations

- Create an enabling international policy environment for low emission production: policy makers should evaluate the strategic, economic, social and environmental advantages of supporting international abated production via trade policy and off-taker agreements, both in regionally and as a development approach in the Global South.
- Abate end-of-life emissions: Implement a programme to apply carbon capture to all incinerators in the region as soon as economically and politically possible, likely for storage. Conduct further assessment into the potential for CCU and the treatment of waste carbon as a scarce resource.

"Exporting waste is problematic as it orientates towards locations where it is most economical to depose of, usually with the weakest control and capability to process it."

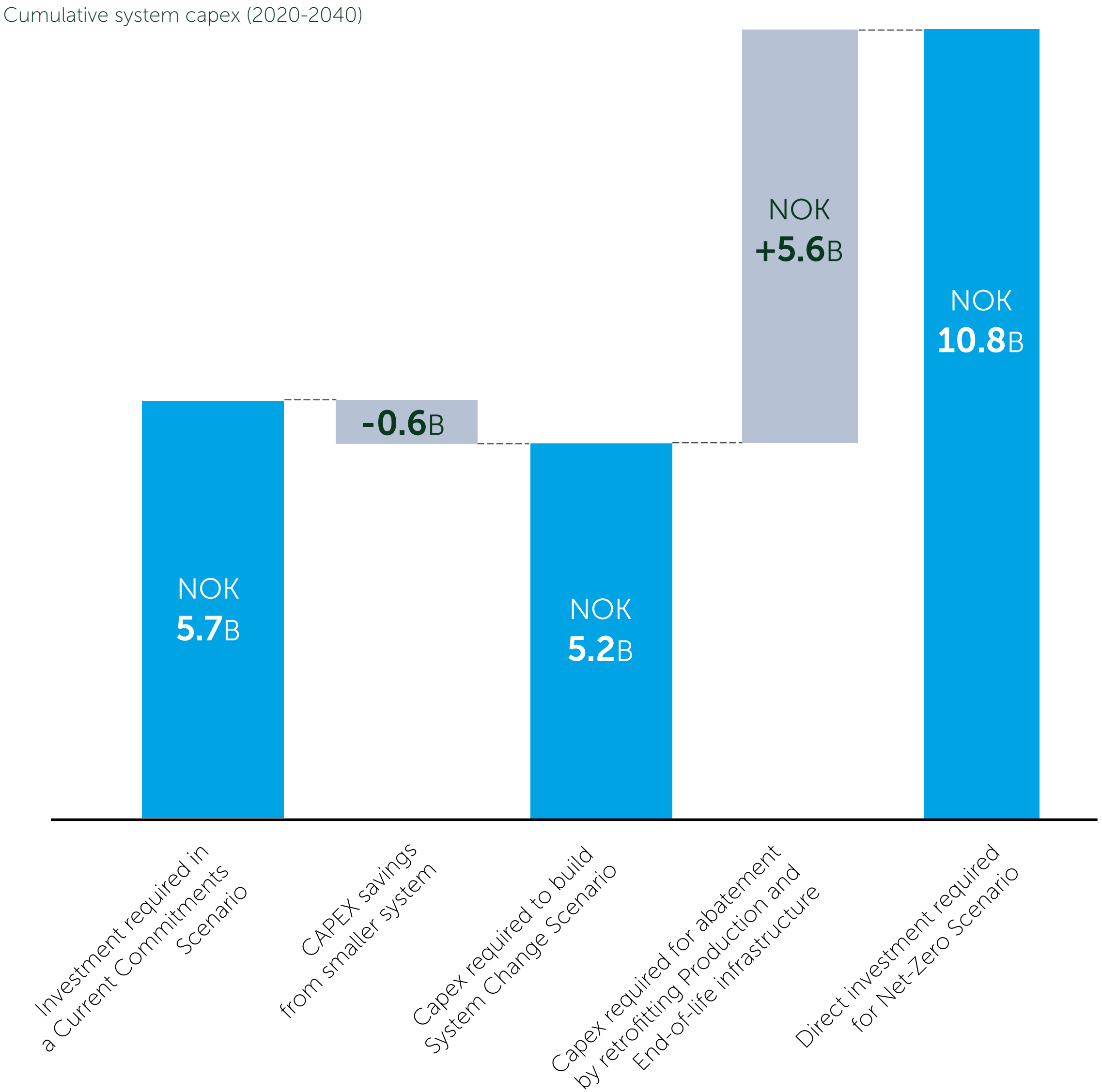
Economics & Jobs

Increasing circularity reduces the amount of net capex required to build the system by ~NOK 0.6 billion compared to scaling up the linear system infrastructure. As discussed, this is because a smaller system is required overall.

However, the Net-Zero Scenario still requires an additional NOK 5.6 billion of direct capital to abate the residual emissions of the circular system, predominantly needed for production (45%) and end-of-life (28%) abatement infrastructure[v]. It is worth noting that this does not include the wider costs of scaling out supply side abatement technologies, such as green hydrogen production or CCUS capabilities, which will often be shared between other sectors.

This represents a total cumulative investment of NOK 10.8 billion, slightly more than double the capex required for an unabated circular system, which represents a non-trivial increase in transition costs. However, estimates[w] suggest that the impact on end user products across sectors will be only 1-3%.

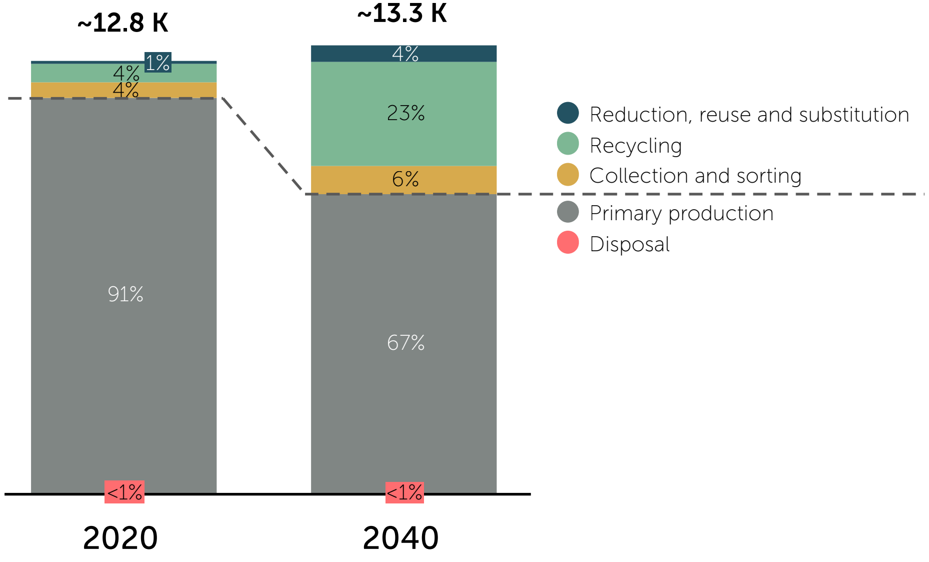
EXHIBIT 33 **The Net-Zero Scenario requires large capital deployment into higher risk, more nascent technologies**



[v] Noting that macroeconomic decarbonisation factors such as abatement costs of other sectors or broader economic electrification have not been included.
[w] Using an academic approach called Leontief's Matrix estimating the value chain ripple effects of price increases.

EXHIBIT 34 **The Net-Zero Scenario drives new job creation and a more diversified mix of employment opportunities**

System employment in 2020 and 2040

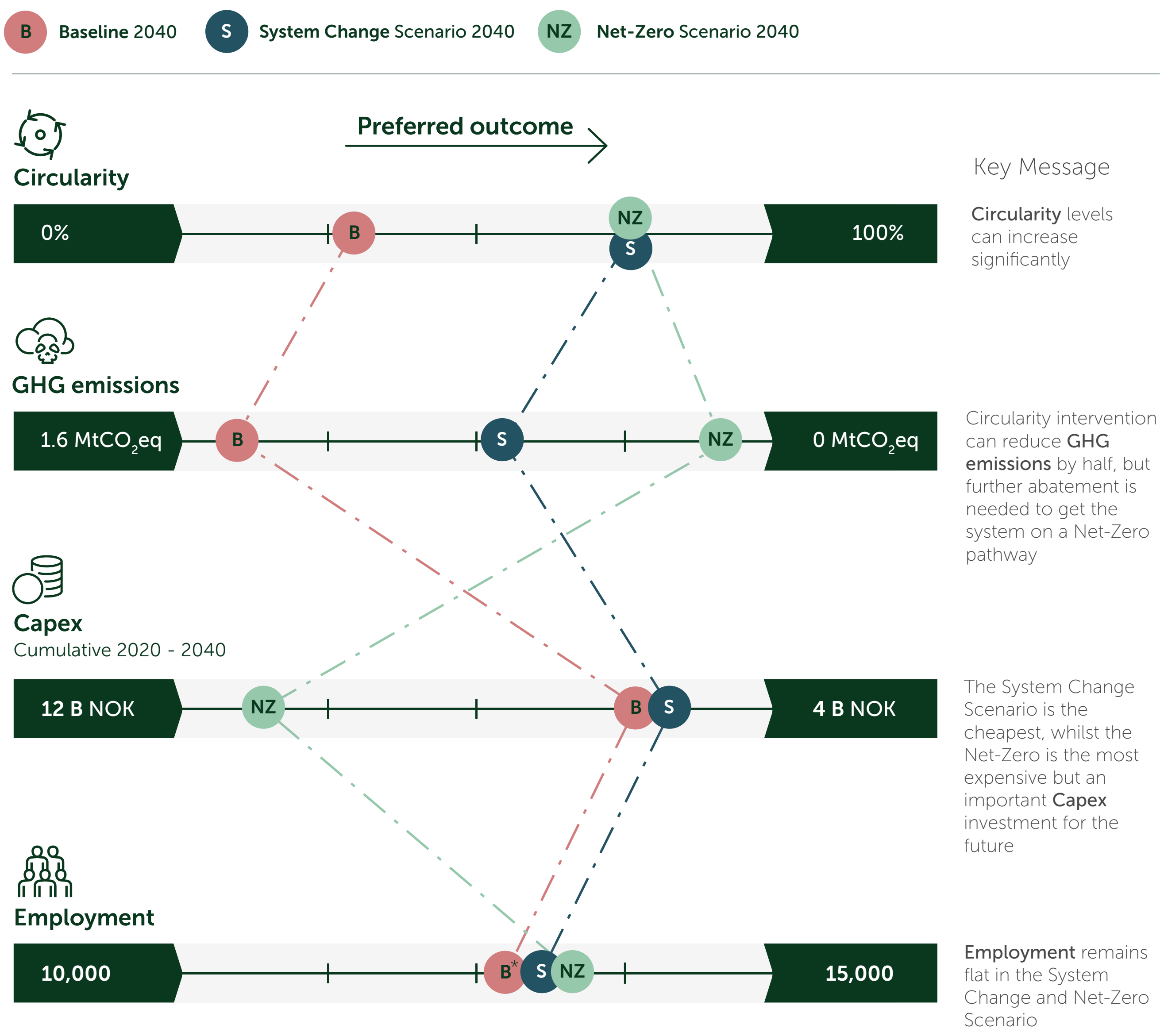


The analysis reveals a similar number of jobs in the Net-Zero Scenario compared to the 2020 baseline but with significant shifts from production to circularity. About 33% of new roles will be through the application of circularity strategies, the majority in recycling.

Jobs in primary plastics production will decrease by ~24%, (noting many of these may be abroad). A just transition needs to ensure that the legacy fossil employee base is adequately reskilled to participate in the new low-emissions economy. Notably, should Norway choose to domesticate its plastics value chain, this offers an employment opportunity to the highly skilled labour force currently dedicated to the declining oil & gas sector. Care must be taken to ensure jobs quality is maintained during the transition to new business models.

Conclusion

EXHIBIT 35 **The System Change and Net-Zero Scenarios outperform the Baseline Scenario in circularity and GHG emissions, for an affordable investment, while keeping employment stable**



*2020

Conclusion

Coupled with Part 1 of the Achieving Circularity study, this report offers a pioneering vision for how to transform the Norwegian plastic system by 2040 to a circular, low-carbon model.

It demonstrates that durable applications are a highly effective use of plastics, providing benefits to society over a prolonged period of time and that, despite the many challenges and complexities, a more sustainable low-emissions circular system is feasible. Circularity interventions can achieve unprecedented levels of resource efficiency across all sectors, and are an affordable, and scalable means of emissions reductions, therefore supporting sectors to grow whilst mitigating the key negative impacts of plastics (see Exhibit 35).

The analysis shows the solution is not just about reusing and recycling, but also "rethinking" uses of plastic through new business models and dematerialisation. To realise this, the system requires a joint vision and strategy. The Norwegian plastics system faces an important decision on the role it plays in the global transition to high circularity and low emissions.

Norway has the opportunity to create the plastic system that is in harmony with the economy and the planet for future generations of Norwegians.

It can demonstrate to the world that this model is feasible – not just as a means of mitigating the negative effects of plastic on the climate, environment and human health, but as an exciting opportunity for growth and innovation in a thriving circular, net zero economy.

Glossary

Additives
Plastic is usually made from polymer mixed with a complex blend of materials known as additives. These additives, which include flame retardants, plasticisers, pigments, fillers, and stabilisers, are used to improve the different properties of the plastic or to reduce its cost.

Automotive shredder residue (ASR)
Automotive shredder residue is an automotive waste stream that results from shredding automobiles. It includes a mixture of ferrous and non-ferrous metals and plastics.

Baseline
The baseline (scenario) serves as a primary point of comparison for an analysis. In this study, the outputs of the Business-as-Usual scenario are referred to as the baseline.

Bio-based (materials)
A material wholly or partly derived from biomass.

Biodegradable (materials)
A material that can, with the help of microorganisms, break down into natural components (eg. water, carbon dioxide, biomass) under certain conditions.

Capex (Capital expenditures)
Funds used by an organisation to acquire or upgrade assets such as property, buildings, technology or equipment.

Carbon capture and storage (CCS)
Use of carbon capture technology to extract CO_2 from potential system emissions streams, followed by transport and storage of CO_2 long term in underground saline aquifers.

Carbon Capture and Usage (CCU)
Use of carbon capture technology to extract CO2 from potential system emissions streams then use it, in this case through the Methanol-to-Olefins process to make new polymers.

Carbon recycling
- Capturing CO_2 at end-of-life incineration that would otherwise be emitted into the atmosphere then using it in a closed loop through the Methanol-to-Olefins (MTO) process to make new polymer.

Chemical recycling
While the term is used in different ways, in this report, chemical recycling refers to processes that break down polymers into individual monomers or other hydrocarbon products that can then serve as building blocks or feedstock to produce polymers again. Four chemical recycling technologies are considered in this study:

- **Dissolution:** Dissolution describes a process where plastic waste is dissolved in a solvent-based purification process to separate polymers from additives and contaminants. Note that dissolution is often referred to as "physical recycling" rather than chemical recycling since the chemical constitution of the polymer remains intact throughout the process.
- **Depolymerisation:** Depolymerisation is a chemical process that different combinations of chemistry, solvents and heat to break up the polymer into monomers or shorter fragments. It is thus the reverse process of polymerisation under application of chemical solvents.
- **Pyrolysis:** Pyrolysis is the thermal process of heating up plastic under the absence of oxygen. It converts polymers into a range of simpler hydrocarbon compounds in the form of liquid pyrolysis oil.
- **Gasification:** Gasification is a process where mixed after-use materials are heated in the presence of limited oxygen to produce syngas that can be converted into polymers again.

Circularity
Circularity is a measure of resource efficiency, i.e. the degree to which (re)used materials replace new virgin materials. In this study, the circularity metric is defined as the share of plastic utility that is either reduced, substituted by circular materials, or recycled mechanically or chemically. It excludes plastic disposed in a linear fashion or plastic entering stock.

Collection separated at source
The collection of individual components of solid waste (such as plastic) separated into different collection containers by the user, in order to recover the material or to facilitate its collection and disposal. Separate collection, as well as sorting, washing, and compounding/extrusion of plastic waste is a precondition for high-quality recycling as contamination with other materials is limited.

Glossary

Contamination
Contamination occurs in recycling when non-target materials are placed in recycling waste streams. These non-target materials include organic waste, other chemicals, or polymer mixtures. Contamination alters the physico-chemical properties of the secondary raw material.

Closed loop recycling
Closed loop recycling describes the recycling process in which the output (recyclate) is included in a product of the same sector (i.e. packaging) and which in turn can be recycled again.

Compostable (materials)
Materials, including compostable plastic and non-plastic materials, that are approved to meet local compostability standards (for example, industrial composting standard EN 13432 where industrial-equivalent composting is available).

Design for Recycling (DfR)
The process by which companies design their product and its packaging to be recyclable.

Downstream solutions
Solutions applied post-consumer. This includes collection, sorting, mechanical recycling, chemical recycling and disposal.

Disposal
The end-of-life deposition of the waste materials. Disposal routes are defined in this study as incineration with energy recovery, landfilling, and fuels fraction from chemical recycling.

Elimination
Practices that reduce unnecessary plastic packaging directly at source or through innovative product design and solutions.

End-of-life (EOL)
End-of-life is a generalised term to describe the part of the lifecycle proceeding the use-phase.

Extended Producer Responsibility (EPR)
Schemes that enable producers to contribute to the end-of-life costs of products they place on the market.

Feedstock
Any bulk raw material – virgin or secondary – that is the principal input for an industrial production process Plastic is currently to a large extent produced from petrochemical feedstock, i.e. from fossil fuels.

Formal waste sector
Individuals or enterprises who are involved in public or private sector recycling and waste management activities which are sponsored, financed, recognized, supported, organized or acknowledged by the formal solid waste authorities.

Hydrogen (colours)

- **Green:** hydrogen manufactured using renewable energy exclusively by electrolysing water
- **Blue:** hydrogen manufactured through steam methane reforming to split natural gas then sequester the CO_2 in saline aquifers through CCS
- **Grey:** hydrogen manufactured through steam methane reforming without any carbon capture

Incineration with energy recovery / Waste-to-energy
Waste-to-energy refers to the incineration of (plastic) waste with recovery of generated energy.
Waste-to-energy schemes use plastic waste as a fuel to generate power.

Leakage
Materials that do not follow an intended pathway and 'escape' or are otherwise lost to the system. Litter is an example of system leakage.

Lever
A specific solution modelled within a system intervention.

Like-to-like recycling
Like-to-like recycling describes the processes where recyclates are used for the same application again (e.g. bottles-to-bottles recycling).

Managed landfill
A place where collected waste has been deposited in a central location and where the waste is controlled through daily, intermediate and final cover, thus preventing the top layer from escaping into the natural environment through wind and surface water.

Mismanaged waste
Collected waste that has been released or deposited in a place from where it can move into the natural environment (intentionally or otherwise). This includes dumpsites and landfills that are not managed by applying daily cover to prevent waste interacting with the air and surface water. Uncollected waste is categorised as unmanaged.

Glossary

Mechanical recycling
Operations that recover after-use plastics via mechanical processes (grinding, washing, separating, drying, re-granulating, compounding), without significantly changing the chemical structure of the material.

Mixed waste streams
Waste streams are flows of specific waste, from its source through to recovery, recycling or disposal. In mixed waste streams, different materials are mixed which decreases the recyclability of this waste stream due to contamination and difficulties in separating those materials.

Municipal Solid Waste (MSW)
According to the EU Landfill Directive, municipal solid waste is defined as "waste from households, as well as other waste which, because of its nature or composition, is similar to waste from households". In the scope of this study, it includes all residential and commercial plastic that is collected by or on behalf of municipal authorities and thus excludes but excludes industrial packaging waste.

New delivery models
Services and businesses providing utility previously furnished by short-lived plastic in new ways, with reduced material demand.

Open-loop recycling
Process by which polymers are kept intact, but the recyclate leaves the sector to be converted into another type of product (e.g. park benches, fibres) and is unlikely to be recycled again due to the degraded quality and/or material properties.

Opex (Operating expenses)
Expenses incurred during the course of regular business, such as general and administrative costs, sales and marketing, or research and development.

Sub-system and plastic categories
Three plastic material categories which we have modelled as flowing separately through the system map: rigid monomaterial plastics, flexible monomaterial plastics, or multilayer/ multimaterial plastics.

Plastic
A synthetic material made from a wide range of organic polymers

Plastic demand
Plastic demand is defined as the volume of plastic utility minus the volume of plastic utility fulfilled by reduce and substitute levers.

Plastic to fuel (P2F)
Process by which the output material of chemical conversion plants is refined into alternative fuels such as diesel.

Plastic to plastic (P2P)
Several chemical conversion technologies are being developed that can produce petrochemical feedstock that can be reintroduced into the petrochemical process to produce virgin-like plastic – a route which we define as 'Plastic to Plastic' (P2P).

Plastic utility
The valuable services (including protection, food preservation, etc.) that are provided by plastic under a business as usual scenario. In alternative scenarios, services of equivalent value could be provided in other ways with less plastic. In other words, all scenarios analysed in this study have the same plastic utility (e.g. consumer demand for services), but the way which this utility is delivered can vary massively – in some scenarios it is done via virgin plastic, in others with recycled plastic, and in others with new delivery models.

Recyclable
In order for something to be deemed recyclable, the system must be in place for it to be collected, sorted, reprocessed and manufactured back into a new product or packaging– at scale and economically. Recyclable is used here as a short-hand for 'mechanically recyclable'.

Recycling rate
In this study, the (effective) recycling rate refers to the quotient of the volume of output stream from a recycling plant (i.e. recyclate) and the total mass of plastic waste generated.

Recyclate (secondary plastic)
Recyclate is the output material of recycling processes that can be directly used as a secondary raw material for plastic conversion.

Reuse models
Replacement of single-use packages with reusable items owned and managed by the user or by services and businesses which provide the utility (New Delivery Models).

Glossary

Sorting
Physical processing techniques and processes to separate materials in waste streams. Sorting is typically performed in Material Recovery Facilities (MRFs) or specific Plastic Recovery Facilities (PRFs). Sorting can be performed automatically with sorting technologies or manually.

Substitution
Replacement of plastic by sustainable and circular materials.

System cost
Total system cost comprise cumulative capex and opex at each stage of the value chain for the respective scenarios and periods, including production and waste management of both plastics and substitute materials. System costs are funded through both capital investment and from P&L.

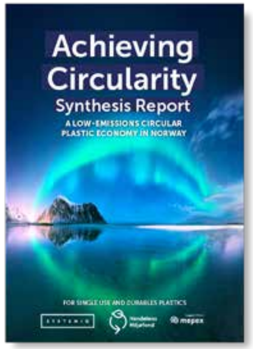
Upstream solutions
Solutions applied pre-user. This includes design for recycling (D4R); Reduce levers such as eliminate, reuse (consumer), reuse (new delivery model); and Substitute levers such as paper, coated paper and compostable plastic.

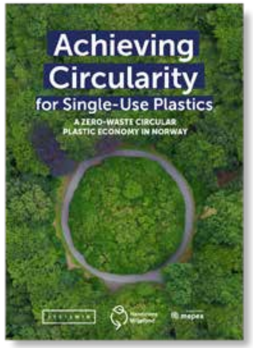
Virgin plastic
Virgin plastic is the polymer resin produced directly from the petrochemical feedstock.

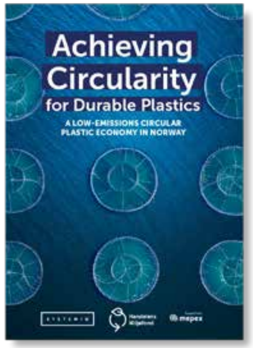
A full glossary of terms can also be found at https://systemiq.earth/reports/glossary

Further Reading

This study is part of the Breaking the Plastic Wave series







Contact

We would be happy to discuss or present the insights from the 'Achieving Circularity' studies in more detail. Please contact the team at **plastic@systemiq.earth**

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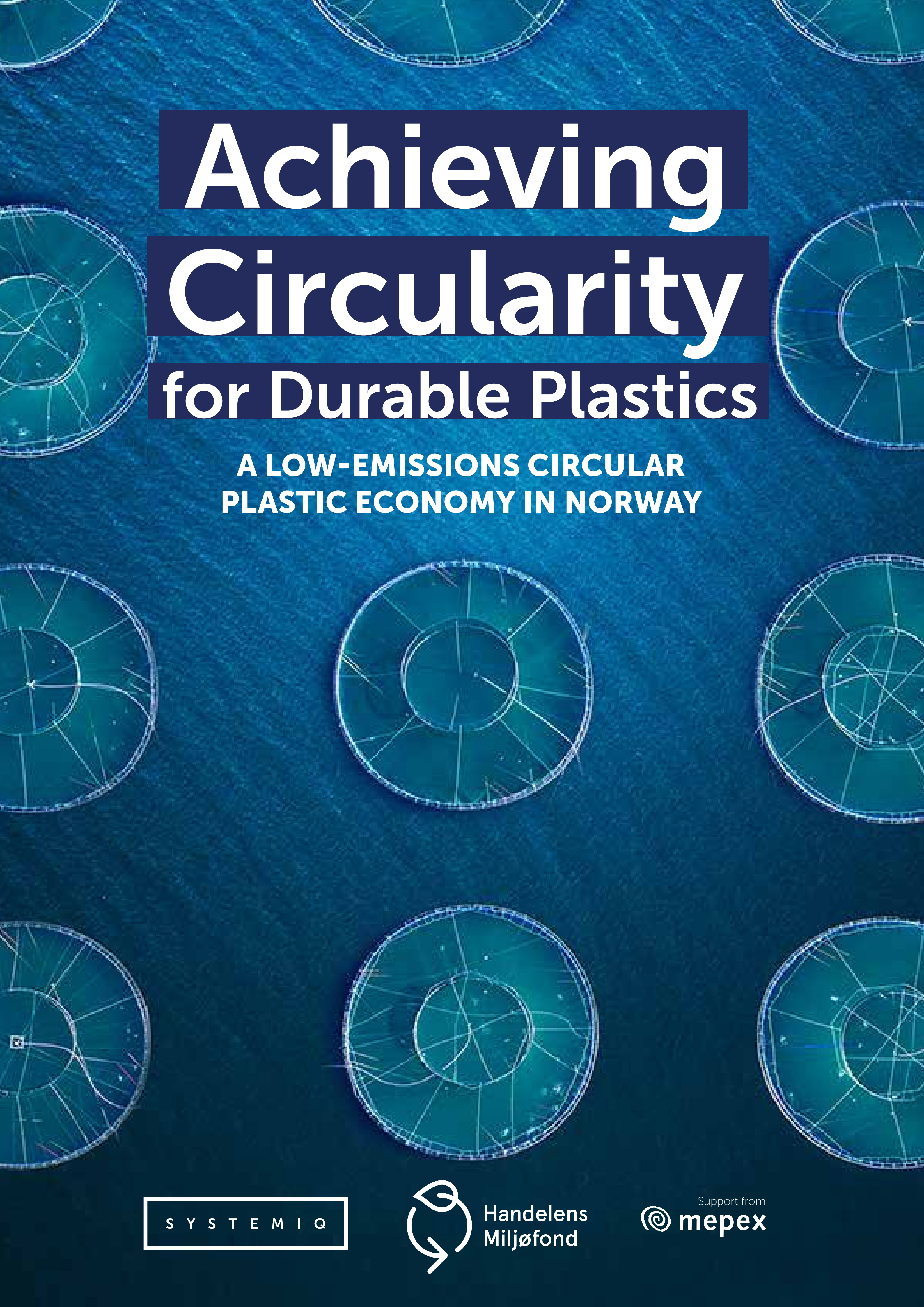

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