Aligning the Global Plastics Treaty with <1.5°C

Investigating a 40x40 plastic reduction target and its impact on plastics carbon reduction pathways

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Report For

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Executive Summary

This study aims to model scenarios for how the global economy might respond to the proposed "40x40" target in the context of negotiations for a new *International Legally Binding Instrument (ILBI)* to end plastic pollution. It evaluates the amount of primary material that needs to be removed and its climate impact in relation to a 1.5°C-aligned carbon budget for plastics. The study aims to demonstrates whether the global reduction target, if agreed by Member States, can align the ILBI with climate goals and support the transition to a safer, more sustainable circular economy for plastics. Previous modelling efforts have primarily focused on policy packages to 'end' plastic pollution, emphasising demand-side measures across the lifecycle. However, less attention has been given to the climate aspect, a crucial pillar for any new Multilateral Environmental Agreement, especially in the context of the triple planetary crisis.

40x40 – a 40% reduction in global primary plastic production by 2040, from a 2025 baseline.

There are two likely routes in which the plastics economy will respond to a 40 per cent reduction in primary plastic production for which the following scenarios are presented:

- **40x40 Business as usual (BAU) Demand:** The projected BAU demand trajectory stays constant which leads to a requirement to increase recycling rates to 63% to balance the decrease in primary material.
- **40x40 Reduced Demand:** Recycling rate is set at 43% in line with Nordic Council of Ministers 'Global rules' and OECD 'Global ambition' scenarios. As modelled in these reports, a package of global policies will also be needed to reduce overall demand to keep to a primary material limit of 281Mt – 40% less primary material than expected to be used by 2025.

Figure E 1 shows how these two scenarios could impact the total plastics on the global market. With BAU demand projections, 40x40 with continued demand growth is likely to be significantly harder to achieve due to requiring a 63% recycling rate. By introducing demand reduction measures a much lower recycling rate of 43% is needed, albeit much higher than the current capacity.

Figure E 1 – Impacts on Global Plastics Demand from Implementing 40x40 (million tonnes/ year)

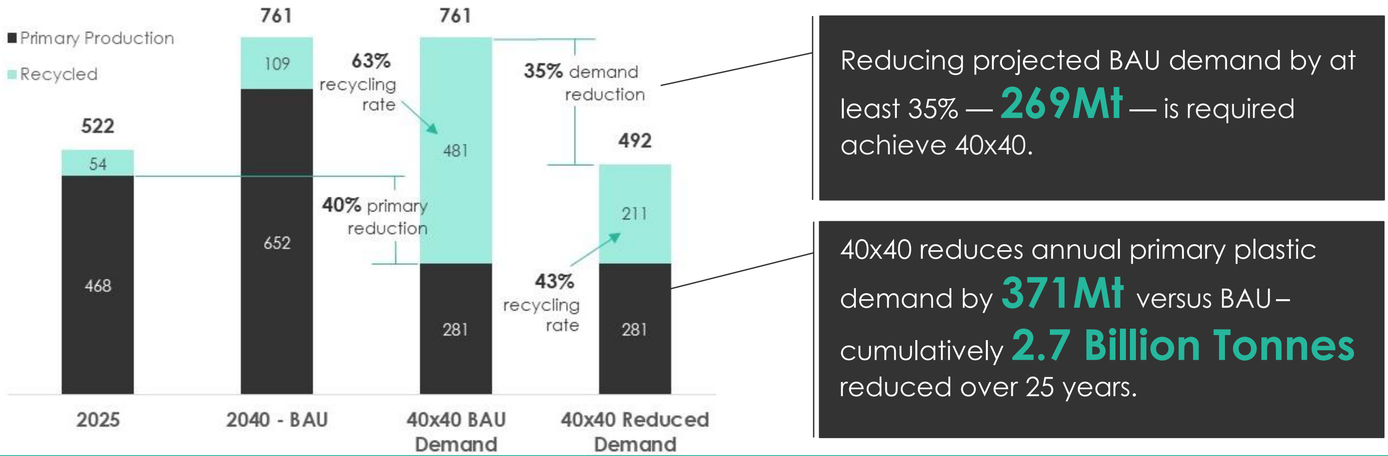
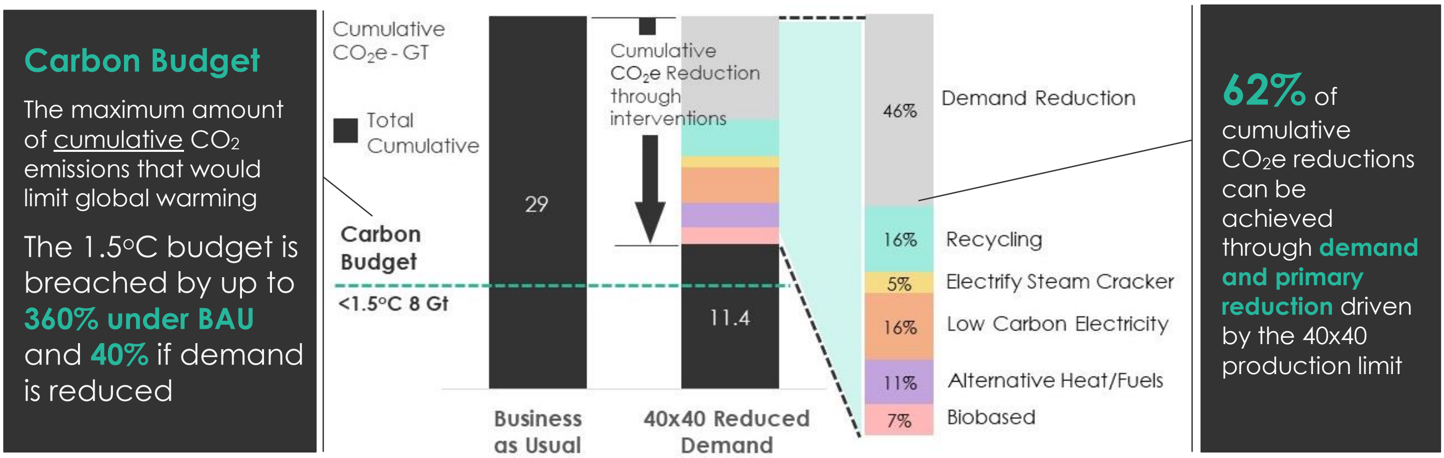


Figure E 2 illustrates a comparison between 'BAU' and 'reduced demand' scenarios from a carbon budget perspective, focusing specifically on polypropylene (PP) and polyethylene (PE). It demonstrates how implementing 40x40, combined with plastics industry decarbonisation, can significantly lower cumulative CO_2e emissions, breaching the 1.5°C carbon budget by 40% instead of 360%.

From a carbon budget perspective, 40x40 would represent a minimum ambition scenario to keep the ILBI's objectives aligned with global climate aspirations and would require significant action along the value chain, in addition to industry decarbonisation efforts, to be feasible. Relying solely on industry decarbonisation without production or demand reduction would result in cumulative emissions of 15Gt by 2050 and 17Gt by 2060. The ability to adjust the 40x40 target and measures taken to achieve it up to and beyond 2050 would therefore be necessary to reach a Paris-aligned trajectory for plastics.

Figure E 2 – Impacts on PE/PP Carbon Budget from Implementing 40x40 Reduced Demand



Conclusions and Recommendations

The scenarios modelled for this study show two potential ways in which—from a purely mass flow basis—the 40x40 target could be achieved. The following core findings highlight both the level of ambition that a 40x40 target might align with and where it fits into the wider climate debate:

1. It is clear that if the current demand trajectory is maintained, the 40x40 target is unlikely to be achievable as it would require *a minimum* of a 63% recycling rate.

Given that the current global recycling rate is estimated to be around 10%, increasing this by over 6 times and capacity by almost 10 times in 15 years would be extremely challenging and would push the limits of technical feasibility. Most studies that aim for ambitious goals suggest that achieving 40-45% recycling should be the focus over that time.

2. Achieving 40x40 requires a reduction in demand of 35%—269Mt annually—compared to BAU by 2040, along with realistic recycling rates. 2025 would therefore need to be 'peak plastic'.

Comparing results from other studies that quantify reduction measures through to 2040, we find achieving 40x40 is likely to be feasible. The proposed 269Mt demand reduction from 2040 BAU aligns with the higher end of these estimates. However, overall plastics demand must not increase above projected 2025 levels. A 43% recycling rate is also required, necessitating a fourfold increase in global capacity from current levels and requires assumptions about the technical feasibility and environmental safety of existing and new recycling technologies.

3. Even with strong plastic demand reduction as a response to 40x40, and significant value chain decarbonisation, the plastics industry are still likely to be some way from aligning with a 1.5°C carbon budget.

A 40x40 limit on primary production supported by demand reduction are critical decarbonisation drivers, yet focusing solely on these will still risk breaching even the higher 1.7°C budget – similarly for actions only on upstream production decarbonisation. Therefore, coordinated efforts across the value chain, product lifecycle, and international collaboration will be essential. All control measures in the ILBI should be viewed with a climate lens to create a holistic package of policies.

4. All action assumes a peak of 2025 where both demand and GHG intensity begin a downward trend. Further delay jeopardises any reduction targets and climate goals.

Strong action from the plastics industry is essential beyond recycling. A singular focus on recycling, especially if tied to legacy fossil fuel production, will not suffice for a credible Net Zero pathway. With up to half the carbon budget for plastics potentially spent by 2025, the next five years will be critical in shaping the trajectory. To facilitate this transition, the ILBI should include a global reduction target to act as the 'guiding star' for measuring ambition in ending plastic pollution and keeping 1.5°C alive for the plastics industry.

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Objective

Aligning the Global Plastics Treaty with <1.5°C

The UN is working with multiple stakeholders around the world on an *International Legally Binding Instrument* (ILBI) "the plastics treaty" with the primary aim is to reduce plastic pollution and the associated impacts on human health and the environment. Within the mandate and the negotiations to date, the issue of how to approach production related measures and specifically what form a reduction target could take has been a fundamental issue negotiators have grappled with.

There is a recognition that in order to reduce plastic pollution, it will be necessary to reduce plastic production and use to 'sustainable levels' — to reduce GHG emissions and other negative impacts associated with extraction and production — but also reduce the amount of waste that needs to be managed at end of life in a system already overwhelmed with existing volumes.

At the fourth round of negotiations, Rwanda and Peru proposed that countries agree to a global binding primary plastic reduction target of 40% by 2040 from a 2025 baseline.[1] – hereafter referred to as 40x40. The proposal also underlines the requirements for such a target to align with circular economy and global warming (Paris Agreement 1.5°C limit) objectives. A 2025 baseline is used as it aligns with the year the ILBI would open for ratification if negotiations are finalised at the fifth round of negotiations in 2024.

The objective of this study is therefore to model scenarios for how the global economy may respond to a 40x40 target, from the perspective of the amount of primary material that needs to be removed from the system and, the climate impact of this in relation to a 1.5°C aligned carbon budget for plastics.

40x40 – a **40**% reduction in global primary plastic production by 20**40**, from a 2025 baseline.

Scope and Methodology

The scope of this report is the focus on the plastics sector from the perspective of its global value chains.

Previous Eunomia material decarbonisation pathway modelling focused on a 'top down' approach by assessing the carbon abatement potential of sectors and mapping this on a timeline to 2050. This allowed a window into the trajectories that might be required when looking at cumulative carbon emissions in the context of a 'carbon budget' rather than focusing on the aim of Net Zero.

Carbon Budget

The maximum amount of cumulative carbon dioxide emissions that would limit global warming to a given level

This study takes the lessons learned from that approach and takes a bottom-up approach to modelling in much the same way that typical Life Cycle Assessment (LCA) is conducted – by building a model of the processes that contribute to the carbon footprint of a product. Where this differs from LCA is that these are then mapped over time with interventions that would replace technologies or fuel sources for decarbonised equivalents. The implementation timeline for these interventions gives us a potential decarbonisation pathway for the industry.

Focus on Polyethylene/Polypropylene

Owing to the complexity of this approach, and the need to map and model global value chains, the focus for this study has been put on a sub-sector of plastics, notably polyethylene and polypropylene which are produced from the steam cracking of fossil fuels (from either oil or natural gas extraction). This sector accounts for 40% of the global plastics demand and around 35% of its CO_2 emissions.

The conclusions in this study are therefore illustrative, but likely to apply to the whole plastics sector even though the value chain interventions might differ in their specifics and challenges.

For the sector we include their direct CO_2 emissions, the CO_2 from direct and indirect energy use, and upstream emissions from raw materials use up to the factory gate as well as the end-of life impact of recycling and incineration. To avoid the potential overlap or double counting between sectors and to keep the focus on the operations of the material value chain energy use in downstream transport, is out of scope.

It is important to account for upstream emissions (also known as Scope 3) as they can be a significant part of the overall impact. Often, industries are almost entirely responsible for driving these emissions, even if they are not emitted directly. CO_2 emissions from fossil fuel extraction and processing are therefore included.

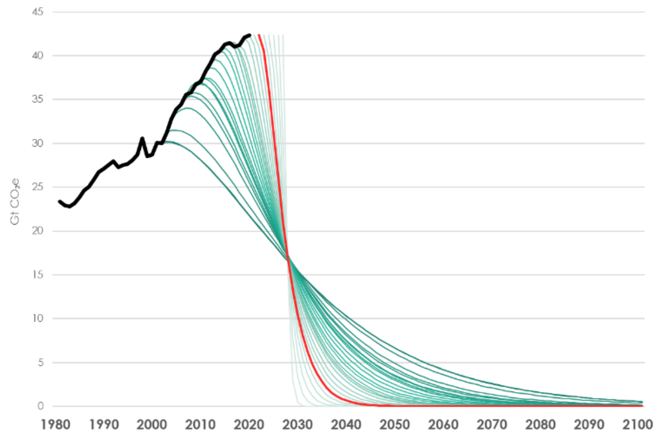
Non-CO_2 emissions (methane) are also included from extraction due to their importance and lack of inclusion in other inventories. The model reflects recent studies showing methane emissions released during oil and gas extraction are on average around 10 times higher than previously estimated. This data originates from the IEA which has compiled the most comprehensive dataset on operations, country-specific emissions intensities, and major emissions events, forming the Global Methane Tracker.[2] Starting in 2024, this data is beginning to be integrated into life cycle inventories—notably, Ecoinvent which is used in this study.[3] These inventories link increased methane emissions to important plastics feedstocks such as naphtha where downstream impacts of end products can now be calculated.

Carbon Budgeting

Carbon budgeting is an important concept introduced by the IPCC to demonstrate that there is a limit to how much CO_2 can be released before global warming results in key climate tipping points. As shown in Figure 1, as time passes without reaching the peak of CO_2 emissions, the steeper the reduction trajectory is needed to stay within a global budget. To tackle this in manageable ways we can assign proportions of the budget to industries and sectors to help determine where decarbonisation focus should be and what actions must be taken.

Eunomia's previous carbon budgeting reports[4,5] allocate budgets to sectors based on their current CO_2 emissions share. This contrasts with the Mission Possible Partnership (MPP)[6], which classifies some industries as 'hard to abate' and grants them larger budgets, assuming other sectors are more able to decarbonise faster. These include materials such as metals and concrete along with aviation and shipping. MPP uses the IPCC's 50% probability of staying within 1.5°C, yielding a 500Gt budget, while Eunomia previously opted for a more precautionary approach by using the 66% probability, resulting in a 400Gt budget. The SBTi have also used 500Gt as their budget.[7] This choice is subjective rather than grounded in scientific consensus at this time.

Figure 1 – Global Carbon Budget Pathways



Source: Adapted from Robbie Andrews (2019); based on Global Carbon Project & IPPC SR15

Uncertainty in carbon budget setting is further heightened by non-CO_2 greenhouse gas (GHG) emissions, which could alter the budget by ±220Gt, depending on future mitigation.[8] Net CO_2 from land use, land-use change, and forestry (LULUCF) is also included in the IPCC budget, but there's no agreement on its exact contribution. The MPP assigns 50Gt to LULUCF, assuming deforestation ends by 2030, while this study takes a more conservative approach, allocating 59Gt based on 2019 LULUCF emissions of 6.6Gt.

The IPCC's estimate for global 2019 CO_2 emissions is 38Gt with an additional 6.6Gt for LULUCF. Splitting the 400Gt budget proportionally leaves a total budget for non- LULUCF of 341Gt compared with MPP's of 450Gt.

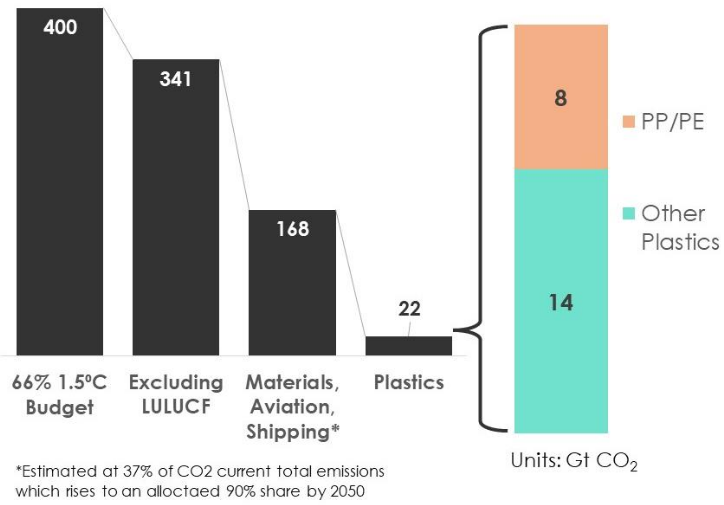
Despite uncertainties in climate projections, ambitious targets remain crucial to avoid irreversible changes. This study adapts its method to account for 'hard to abate' sectors, expanding MPP's list to include plastics due society's reliance on these materials and their current reliance on fossil fuels. The share of global GHGs for these hard to abate sectors, currently 37%, are set based on a scenario where this share increases steadily to 90% by 2050.

This approach recognises that *all* sectors need time to decarbonise regardless of whether their path is clearer (in energy for example). The result of this is that the hard-to-abate industries are assigned 49% (168Gt) of the cumulative GHG emissions budget through to 2100. This compares with 166-188Gt for the same sectors in the SBTi pathway to Net Zero.

Of that 168Gt, plastics have a combined budget of 22Gt which is set based on their current emission levels – see Figure 2. This is an increase from 16Gt in previous Eunomia reports due to the change in methodology. Of the 22Gt, polymers based on ethylene/propylene production are given a budget of 8Gt.

Due to the lack of agreement around climate projections described, the results are presented with 1.5°C 50% and 66% probabilities and, also in relation to a 1.7°C budget which the IPCC estimates to be 700Gt. This translates into a budget for PE/PP of 16Gt which sets the overall budget range between 8-16Gt.

Figure 2 – Carbon Budget Setting



Plastic Pollution Reduction -What scenarios have other studies modelled?

Several recent studies have focused on 'demand-side' measures that will reduce plastic use. This would, in turn, reduce plastic pollution, which is expected to worsen without coordinated 'top-down' intervention.

While studies agree on the importance of downstream measures, the precise mix and impact of each remain debated. However, all studies concur that a business-as-usual approach with minor, incremental adjustments is unsustainable and insufficient for meaningful change. They also agree that relying solely on scaling waste management will fall far short of ending plastic pollution, making production and consumption reduction essential. Additionally, they all highlight that delayed action would have devastating consequences for plastic pollution.

The Nordic Council of Ministers (NCM) in their 'Global Rules' Scenario[9] shows that by **2040 plastic use can be reduced by 262Mt** relative to a BAU scenario. This includes action to reduce production through virgin plastic targets/limits and fees along with shifts away from single use plastics. The study also focuses on a 30% primary reduction by 2040 from a 2019 baseline. This is somewhat similar to a 40% reduction from a 2025 baseline due to the OECD projected increase in demand between 2019 and 2025.

The *Breaking the Plastic Wave* report[10] by The Pew Charitable Trusts & Systemiq also includes demand-side reduction measures totalling **201Mt by 2040.** The lower figure is likely due in part to the reduced scope of sectors considered in the report and reduction measures being achieved without considering production limits and focusing on single use reduction and substitution – the latter potentially shifting some of the environmental burden elsewhere.

A recent OECD policy scenario analysis focuses[11] on the policy levers and the resulting level of coordination that can result from international agreements. Their 'Global Ambition' scenario results in a **demand reduction of around 230Mt by 2040** of which primary demand is reduced by 95Mt from the 2020 baseline. Compared to a 40x40 target this is the equivalent of a 22% primary reduction from 2025.

In the context of the wider discussion on plastic pollution reduction, the present study seeks to determine whether the demand reductions modelled in the above-mentioned studies (201-261Mt) can also be driven by the primary production limit using 40x40. We also identify how the reductions modelled in the above studies would impact climate goals.

40x40 Scenarios

Which scenarios will reach a 40x40 target?

Using material flow data and projections from the OECD[12] to reflect a Business as usual (BAU) approach, a 40% primary reduction by 2040 means lowering from 468Mt primary production in 2025 to 281Mt in 2040.

There are two likely routes in which the plastics economy will respond to a 40 per cent reduction in primary plastic production:

- **40x40 BAU Demand:** The projected BAU demand trajectory stays constant which leads to a requirement to increase recycling rates to 63% to balance the decrease in primary.
- **40x40 Reduced Demand:** Recycling rate is set at 43% in line with Nordic Council of Ministers report 'Global rules' and OECD 'Global ambition' scenarios. The overall demand must therefore reduce to keep to a primary limit of 281Mt.

Figure 3 shows how these two potential scenarios could impact the total plastics on the global market.

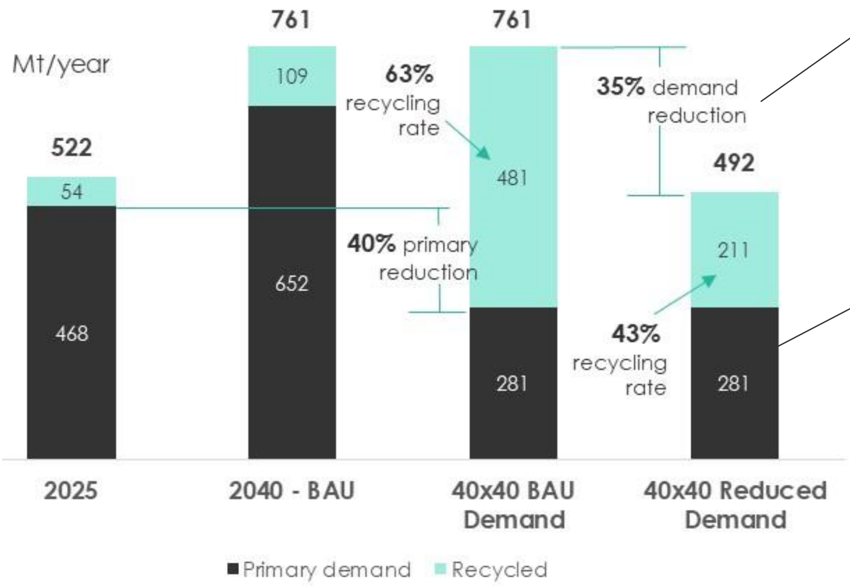
With BAU growth in demand, a high recycling rate of 63% is required to reduce the primary demand from 468Mt to 281Mt whilst still maintaining a compound annual growth rate (CAGR) of 2.5%. This is a considerable increase from an expected 14% recycling rate in 2040 extrapolated from OECD BAU waste management projections. Given that the current global recycling rate is estimated to be around 10%, to maintain demand growth recycling capacity must be increased by almost 10 times within 15 years (from 54Mt to 481Mt).

In the reduced demand scenario, overall demand needs to be reduced by 35% (269Mt) compared to BAU in 2040 to compensate and move from a peak of 761Mt in 2025 to 492Mt in 2040 – a negative CAGR of 0.4% meaning that demand for plastics peaks in 2025. As a result, recycling capacity also has to grow around 4-fold over that time. This reduction in demand would require further policies agreed in the plastics treaty utilising the full lifecycle approach to align with the 40x40 limit.

In both 40x40 scenarios the primary demand in 2040 results in a 57% decrease from the BAU trajectory – a reduction of 371Mt. Cumulatively this is a reduction of 2.7 Billion Tonnes over 25 years.

Figure 3 – Impacts on Global Plastics Demand from Implementing 40x40

Implementing a 40% primary reduction target where the market responds either through high recycling (40x40 BAU Demand) or a combination of recycling and demand reduction (40x40 Reduced Demand).



Reducing projected BAU demand by at least 35% — **269Mt** — is required achieve 40x40.

40x40 reduces annual primary plastic production by **371Mt** versus BAU – cumulatively **2.7 Billion Tonnes** over 25 years.

How does 40x40 support climate goals?

Figure 4 shows the same scenarios, but from the perspective of the carbon budget and focused specifically on PP/PE. We see how 40x40 impacts cumulative CO_2e emissions out to 2050.[i] The BAU scenario follows the projected growth demand, but without decarbonisation of the plastics value chain – a worst-case scenario which sees the carbon budget breached by 2-4 times.

In the 40x40 BAU demand scenario with recycling at 63%, and value chain decarbonisation implemented, the cumulative emissions are reduced to 12.5Gt – exceeding the most precautionary 1.5°C budget by 50%.

In the 40x40 reduced demand scenario the situation improves, but the cumulative emissions still breach both 1.5°C budgets. Notably, in this scenario, 62% of the cumulative reduction comes from demand reduction and recycling – both potential direct outcomes of implementing a primary production cap.

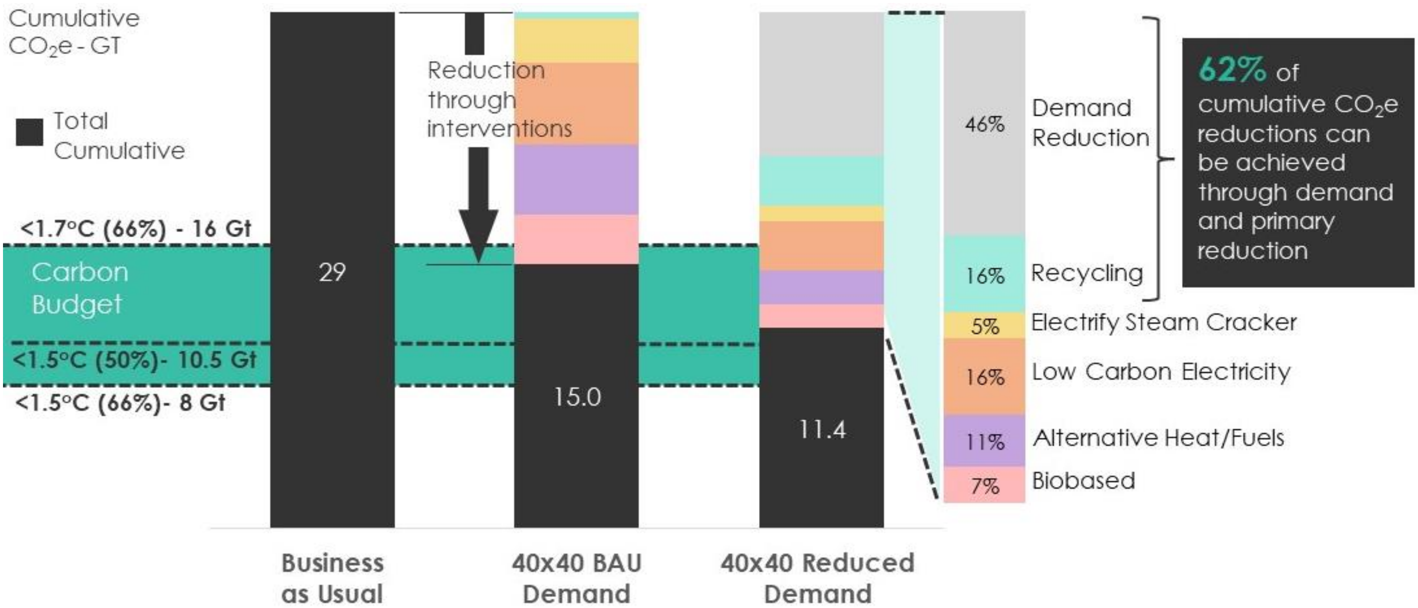
To aim to stay within the budget the plastics industry itself will also need to decarbonise its activities with various interventions mainly aimed at eliminating reliance on fossil fuels. These are described in more detail in the Appendix.

Notably, in either 40x40 scenario, recycling and/or demand reduction which results directly from a 40x40 primary production limit does not bring the cumulative emissions into the range of even a <1.7°C carbon budget. A 40x40 target is therefore not sufficient on its own to meet climate goals but would form a significant part of the required action in this sector. Incorporating upstream decarbonisation of the plastics sector in tandem with reducing demand would be required to stay within 1.7°C.

However, far more aggressive decarbonisation of the plastics value chain, coupled with additional demand reduction, is essential to stay within a 1.5°C budget. Speed of implementation is crucial: the sooner interventions are widely adopted, the greater their impact on cumulative emissions. Triggering a 'freeze' on capacity expansion starting in 2025 would greatly enhance these efforts. In this context, the journey is as important as the destination.

Figure 4 – Impacts on PE/PP Carbon Budget from Implementing 40x40

A full suite of interventions both upstream and downstream is needed to stay below 1.7°C, but <1.5°C is unattainable without further demand reduction.



[i] Note: it is important to extend cumulative emissions projections out further than 2040 as it is unlikely that all decarbonisation activities would be fully implemented by that point. A budget for cumulative CO_2 emissions does not have a timeframe associated with it.

Conclusions and Recommendations

The scenarios modelled for this study show two potential ways in which—from a purely mass flow basis—the 40x40 target could be achieved. The following core findings highlight both the level of ambition that a 40x40 target might align with and where it fits into the wider climate debate:

1. It is clear that if the current demand trajectory is maintained, the 40x40 target is unlikely to be achievable as it would require *a minimum* of a 63% recycling rate.

Given that the current global recycling rate is estimated to be around 10%, increasing this by over 6 times and capacity by almost 10 times in 15 years would be extremely challenging and would push the limits of technical feasibility. Most studies that aim for ambitious goals suggest that achieving 40-45% recycling should be the focus over that time.

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Comparing results from other studies that quantify reduction measures through to 2040, we find achieving 40x40 is likely to be feasible. The proposed 269Mt demand reduction from 2040 BAU aligns with the higher end of these estimates. However, overall plastics demand must not increase above projected 2025 levels. A 43% recycling rate is also required, necessitating a fourfold increase in global capacity from current levels. current levels and requires assumptions about the technical feasibility and environmental safety of existing and new recycling technologies.

3. Even with strong plastic demand reduction as a response to 40x40, and significant value chain decarbonisation, the plastics industry are still likely to be some way from aligning with a 1.5°C carbon budget.

A 40x40 limit on primary production supported by demand reduction are critical decarbonisation drivers, yet focusing solely on these will still risk breaching even the higher 1.7°C budget – similarly for actions only on upstream production decarbonisation. Therefore, coordinated efforts across the value chain, product lifecycle, and international collaboration will be essential. All control measures in the ILBI should be viewed with a climate lens to create a holistic package of policies.

4. All action assumes a peak of 2025 where both demand and GHG intensity begin a downward trend. Further delay jeopardises any reduction targets and climate goals.

Strong action from the plastics industry is essential beyond recycling. A singular focus on recycling, especially if tied to legacy fossil fuel production, will not suffice for a credible Net Zero pathway. With up to half the carbon budget for plastics potentially spent by 2025, the next five years will be critical in shaping the trajectory. To facilitate this transition, the ILBI should include a global reduction target to act as the 'guiding star' for measuring ambition in ending plastic pollution and keeping 1.5°C alive for the plastics industry.

Appendix

Global Plastics Groups

Table A 1 shows data from the OECD Global Plastics Outlook.[13] These predict significant growth of all polymers out to 2060. The scenarios looking at the mass flows of material to meet a 40x40 target consider this growth in the BAU case and take into account all polymers. For the demand reduction scenario, the overall total is reduced without consideration around whether this may affect polymer groups differently.

For the decarbonization pathways and the carbon budgeting, the focus is on polyethylene and polypropylene. These represent 40% of polymers by mass currently and the OECD project this to continue. This is an important group of polymers as they are used widely and produced predominately via steam crackers. The conclusions for this group can also be applied more widely as ethylene from steam cracking is also used in several other polymers including PVC and PET. Fibres are also around 57%[14] polyester which is the same polymer as PET, but under a different name. These groups total around 70% of the market making steam cracking a critical technology for understanding decarbonisation pathways.

Table A 1: Polymer groups now and projected (million tonnes)

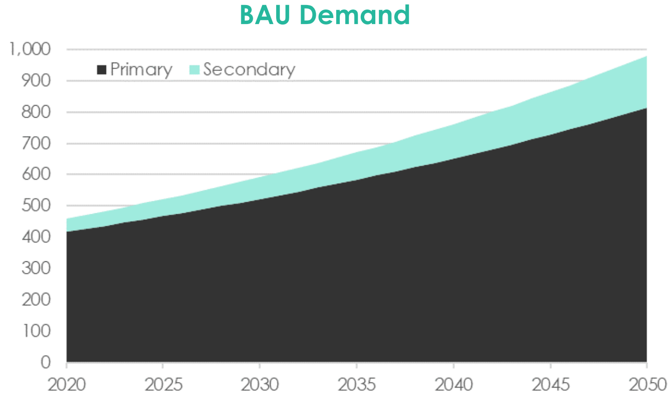
Polymer Group	2019	2060
Fibres	60	159
HDPE	**56**	**140**
LDPE, LLDPE	**54**	**165**
Other	92	250
PET	25	61
PP	**73**	**195**
PS	21	55
PUR	18	48
PVC	51	131
SA	9	25
Total	**460**	**1231**
Total PE/PP	**183**	**501**

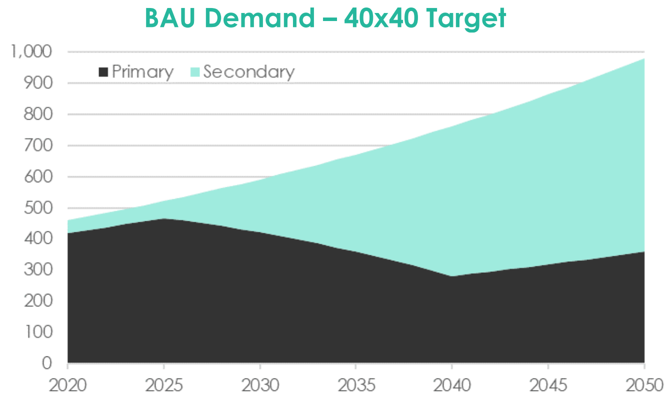
Global Plastics Use Scenarios

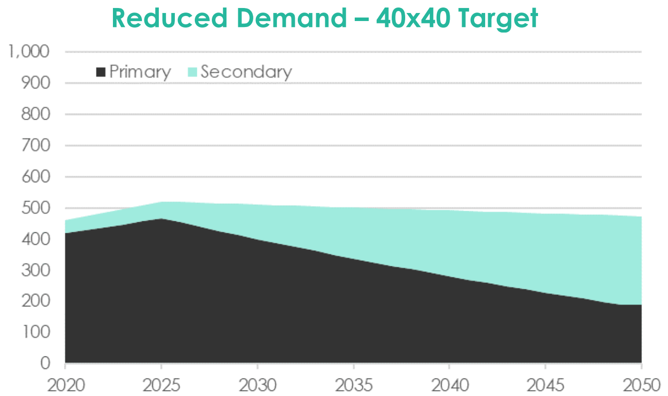
Figure A 1 shows the three scenarios with the relationship between primary and secondary material over time. It is assumed that recycling improves linearly and that the BAU demand 40x40 scenario peaks with recycling at 63% in 2040. For the reduced demand scenario recycling hits 43% in 2040, but continues to a peak of 60% by 2049.

Figure A 1: Global Plastics Use Scenarios (Million tonnes)

Three mass flow scenarios are used as the basis for the modelling. Beginning and end points are based on data from the OECD with linear interpolation between those points. Recycling is determined by the start and end years in the intervention timelines.







GHG Emissions Pathways

The following interventions are modelled for decarbonisation of the PE/PP value chain. It should be noted that the pathway and potential interventions should not be considered as definitive and there are still many technological and financial limitations and barriers to overcome. It should be viewed as a 'what if?' scenario to show what significant decarbonisation activities might look like within a manageable timeframe. For example, the magnitude of the role of chemical recycling and bio-based plastics—both controversial subjects—is yet to be established but they are likely to be part of the end mix of solutions at least in part. Decarbonisation towards Net Zero is also likely to involve some trade-offs where other environmental concerns might arise as a result. Such trade-offs are not addressed here but would need consideration.

The Steam Cracker. Steam crackers are the principal way in which ethylene and propylene are synthesised from petrochemical feedstocks. Currently, a significant proportion of the fossil feedstock is consumed in the process to generate heat and pressure. If the steam cracker is electrified, this accounts for around a 30% reduction in the GHG emissions of primary resin production. Its relatively low contribution to the decarbonisation overall is due to the high recycling rates needed to meet 40x40 and that the virgin resin needs to be converted into the final product. The latter can account for up to around a third of the GHG emissions of the final plastic product and is required regardless of whether recycled of virgin material is used. Despite the steam crackers lower contribution, conversion to electricity could serve as a key enabler of low-carbon chemical recycling in later years, provided that advancements in feedstock processing and flexibility are achieved.

Recycling. The recycling intervention assumes a basic mechanical recycling process in a 'best case' scenario. This is unlikely to be a true representation of achieving a high recycling rate globally. Particularly for PE/PP, chemical recycling is likely to be needed if these materials continue to be used in food packaging. Mechanical recycling of PE/PP into food grade applications—with the strict requires that this brings—is somewhat challenging and not yet proven at significant scale. This is where steam cracker decarbonisation becomes more important as the recycled plastic (in the form of pyrolysis oil) will most likely be processed through the steam cracker to produce ethylene and propylene. However, there is a lot of uncertainty around the size of the role chemical recycling can play at this time given it is unproven at scale and would require substantial investment..

Low Carbon Electricity. Reducing fossil fuels in electricity generation is a corner stone of decarbonisation globally. For plastics, after the steam cracker (assuming it is electrified), the biggest uses of electricity are in the polymerisation and conversion processes. Downstream, electricity is also used in recycling and remelting the plastic.

Biobased. The principal benefit for moving to bio-ethylene when fossil-based processes have exhausted avenues for decarbonisation is the elimination of methane emissions associated with fossil fuel extraction. There is also no fossil-based CO_2 released if the material is incinerated at the end of life. Upstream GHG emissions from manufacturing of bio-ethylene are highly uncertain into the future but are assumed to at least keep pace with the best in class in fossil-based in other aspects of manufacture. It is also possible that the steam cracking route could be avoided altogether with the production of ethylene from bio-ethanol. This process might become more viable in future as carbon-footprint becomes a bigger driver and the price can be reduced as production volumes increase.

Heat and Fuels. The largest remaining impacts come from other fuels used in the process and the upstream emissions from feedstock and direct process emissions. Heat and fuel will need to be provided by electricity, biofuels or hydrogen.

Remaining Emissions. With the modelled interventions there are still 4-8% GHG emissions remaining. These will be hard to eliminate completely and most Net Zero plans typically assume some form of off-set or carbon capture to respond to the remaining emissions. Such interventions have not been modelled here due to the lack of credibility of offsets that have issues with overstating the benefits and allowing a business-as usual attitude. Similarly, carbon capture is still highly experimental and costly at this time with limited applications.

Figure 5 and Figure 6 show the decarbonisation pathways for the two 40x40 scenarios with annual emissions between 2020 and 2050. For the BAU demand scenario, the aggressive recycling trajectory offsets the increase in emissions from demand growth. As recycling peaks at 63% in 2040, other interventions are needed to outpace demand growth from that point.

In the reduced demand scenario, the demand reduction itself has the largest impact on decarbonisation. As described elsewhere, by 2040 this results in a 35% reduction in demand relative to the BAU case. The modelled scenario also assumes that there is no further growth after 2040 – as 2025 is 'peak plastic'. This means that by 2050, demand is reduced by 52% relative to BAU growth projections.

Figure 5 – PP/PE GHG Emissions Pathway – BAU Demand

BAU demand, 68% recycling rate by 2040

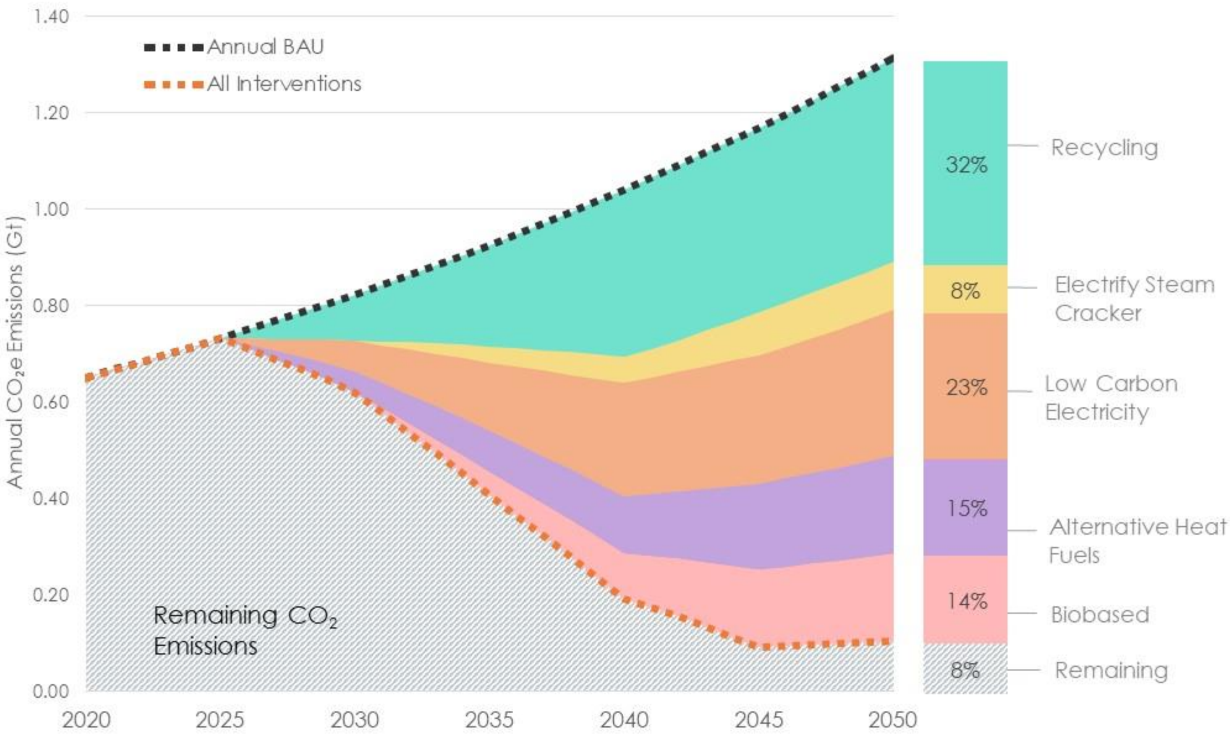
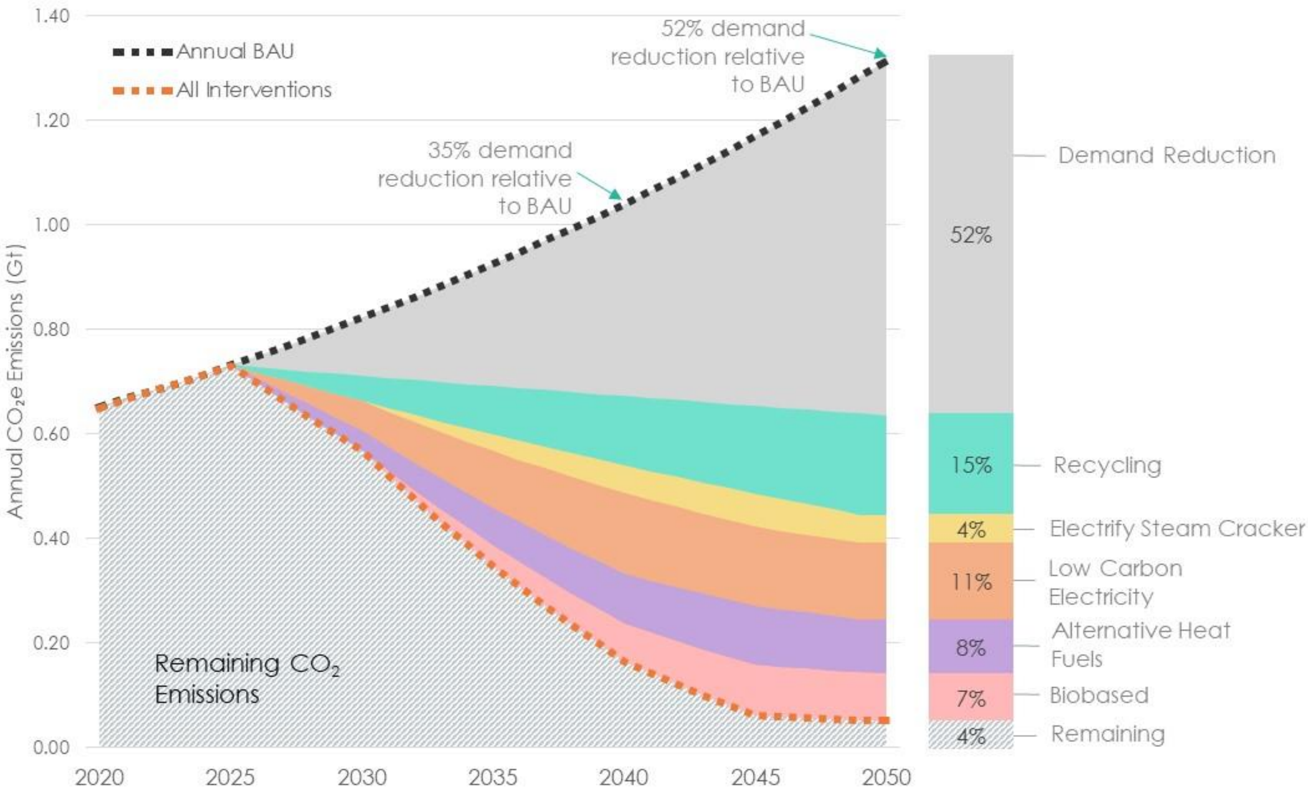


Figure 6 - PP/PE GHG Emissions Pathway – Reduced Demand

Lower demand, 43% recycling rate by 2040, 60% recycling rate by 2049



Intervention timeline

Table A 2 shows the timing of the interventions used in the decarbonisation pathways.

Table A 2: Timeline of PE/PP Interventions

Intervention	Start Year	End Year
Recycling – BAU demand	2025	2040
Recycling – Reduce Demand	2025	2049*
Steam Cracker	2030	2045
Electricity	2025	2040
Heat	2025	2045
Biobased	2030	2045
*Note that in the reduced demand scenario recycling hits 43% in 2040		

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