Technical appendix 2

A prescription for change

Methodology and assumptions

SYSTEMIQ

eunomia

1. Introduction

The purpose of this technical appendix is to supplement the methodology section in the main report by providing additional detail and clarity. It describes the data sources used, the approach taken regarding baselining and modelling, the key assumptions that were applied, and the system map that was used to guide mass flow modeling of healthcare plastics.

2. Study scope and boundaries

The following principles were used to select the plastic products in scope for this report:

1. **Plastic composition –** the products should be predominantly (i.e., >50%) made of a single plastic polymer type or multiple plastic polymer types
2. **Single-use** – the products should be used only once before being disposed of
3. **Medical application** – the products should be used for patient-facing medical applications only (e.g., cannulas) or part of the same value chain that enables these medical devices (e.g., medical device packaging). This means that plastic products used in a healthcare setting but not for the purposes of healthcare delivery (e.g., plastic cafeteria utensils) are out of scope
4. **Significant volumes** – the products must represent a significant share of total plastic volume in both geographies
5. **Data availability** – data should be somewhat available to derive the plastic baseline
6. **Consistency across geographies** – products should be applicable to both North America and European settings

The **following principles** were used to determine how the products should be categorized. Products should be grouped if they follow:

- **Similar plastic composition** – they have a similar plastic composition (e.g., predominant polymer type - PVC products should be grouped)
- **Similar waste flows** – they follow a similar waste flow once used and disposed of (e.g., products hazardous waste stream - alternative treatment - incineration)
- **Similar purpose** – they are used in conjunction with one another or for the same primary purpose (e.g., gowns, aprons and masks all provide personal protection)
- **Similar "path for change"** – they have similar interventions and levers for the Moderate-Ambition Systems Change Scenario and the High-Ambition Systems Change Scenario can be applied (more detail in Appendix Section 4)

The application of these principles led to seven high-volume single-use plastic product categories commonly used in the healthcare sector. These product categories include several sub-categories:

1. **Fluid bags and tubing:** IV bags, blood and plasma donation bags, and tubing (e.g., catheters, cannulas, tubing extension sets)
2. **Gloves**
3. **Rigid devices:** syringes, venous blood collection tubes, urine sample pots, and single-use infant bottles
4. **Medical device packaging**: flexible plastic peel pouches for individual medical devices and larger flexible bags for pre-prepared medical sets
5. **Personal protective equipment (PPE) and related products** (called PPE throughout the report, for simplification): face masks, surgical gowns, aprons, caps, shoe covers, and blue wrap
6. **Pharmaceutical packaging:** pill bottles and blister packs
7. **Single-use wipes**

To ensure the scope of the analysis was both meaningful and feasible, the model focused on a defined subset of healthcare settings. This includes hospitals and clinics, medical practices (e.g., general practitioner clinics), and blood donation centers. The scope for pharmaceutical packaging also includes at-home (domestic) consumption because of the significant volume that this setting represents for this particular product category. Other healthcare settings, such as care homes, pharmacies, and emergency services, and related healthcare settings, such as laboratories and at-home care, were excluded due to variability in service models, weaker data availability, and greater complexities that would need to be considered.

The geographic scope includes Europe (EU27 and the United Kingdom) and North America (United States of America and Canada). These regions were selected based on a combination of factors, including the substantial share of global healthcare spending and comparatively greater availability of data. While the report includes findings and insights presented as regional aggregates, it is recognized that there is high heterogeneity within and across countries. Healthcare systems can vary significantly in terms of procurement practices, waste classification, infrastructure capacity, and regulatory environments. Appendices 3 and 4 provide further details through regional zoom-ins on North America and Europe, respectively.

3. The systems map as a basis for the stock-and-flow model

The above mentioned product categories are represented by two system maps (See Figure 1 and Figure 2) as a basis for the stock-and-flow model. The system maps define the specific plastic mass flows within the healthcare system and were adapted from previous, similar system maps (e.g., ReShaping Plastics[1], Breaking the Plastic Wave[2]). They were informed by desktop research and were validated with expert input to ensure real-world relevance to healthcare-specific material flows.

The system maps were designed to be relevant to both North American and European geographies, noting that healthcare systems vary significantly across regions, countries, and individual healthcare settings. As a result, terms such as "post-patient waste" were introduced to encompass all clinical waste (including hazardous waste, offensive waste, infectious waste, sharps waste) and be applicable for all geographical settings.

The plastic value chain was categorized into four components:

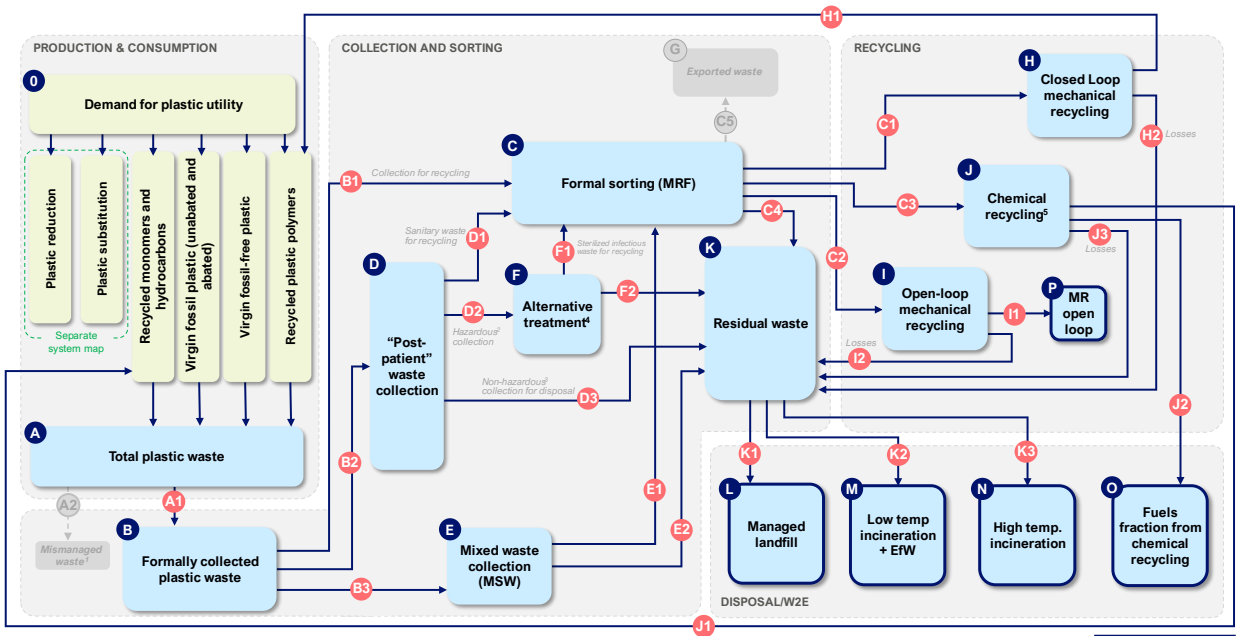
1. **Production and consumption**
2. **Collection and sorting**
3. **Recycling**
4. **Disposal / waste to energy**

Each product category flows through the systems map slightly differently depending on the most common setting in which the product is used, the level of contamination (with both infectious and non-infectious bodily fluids), the regulatory requirements that stipulate a particular disposal route, and the geography. Once the products were baselined with respect to their particular production and disposal pathway (method described in Technical Appendix Section 4), the system maps were used to estimate the impacts of the circularity levers (e.g., the application of a particular lever could shift the flow from one mass flow arrow to another). As such, the systems map serves as the foundation of the model, enabling the estimation of the impacts of interventions across material, GHG emissions, and cost dimensions.

Note, the system map disregards the potential increase in durable plastic (or other materials) mass associated with shifting to reusable products. The system map – and therefore the project – only takes into consideration the mass flows of single-use plastic.

Figure 1

Main System Map

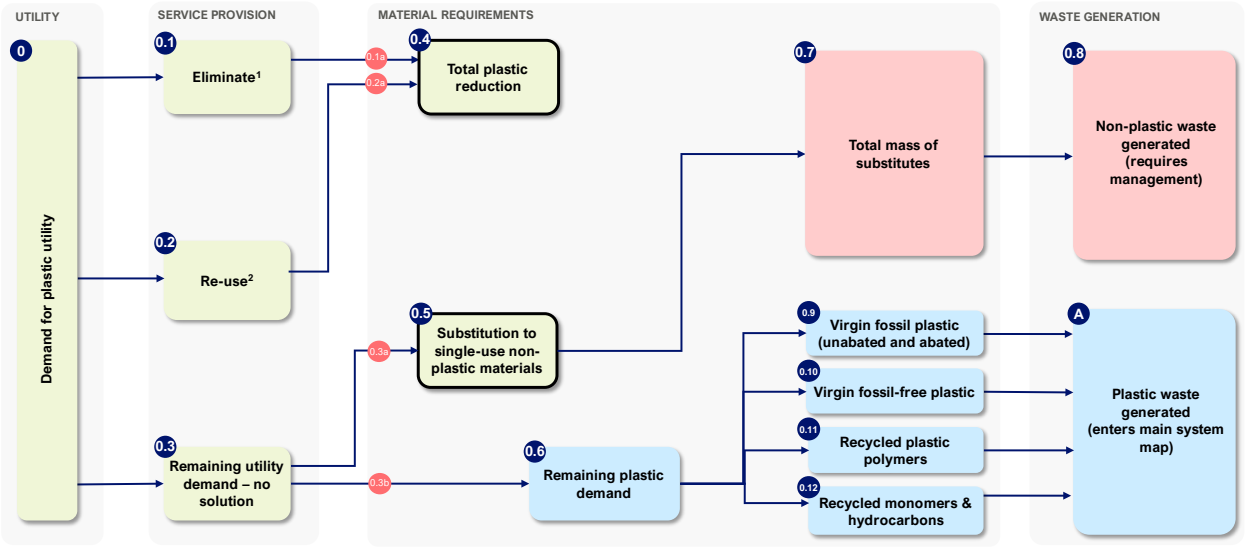


[1] Out of scope. Assumption that in North America and Europe, mismanaged medical waste is ~0. Therefore, arrow A1 = 100 and A2 =0 for simplicity (if there is zero DRS in the system)
[2] Hazardous waste is any clinical waste that required AT before disposal, such as highly infectious waste and cytotoxic and cytostatic waste
[3] Non-hazardous waste is any clinical waste that does not require AT before disposal, such as unrecyclable pharmaceutical pack aging and offensive/sanitary waste etc.
[4] E.g., sterilization, autoclaving etc. [5] pyrolysis, dissolution and depolymerisation

3

Figure 2

Upstream System Map



[1] Includes product bans, fees, reduced overpackaging (lightweighting), extending product life, increase utility per package and virtualising
[2] Switching single -use plastics to re -usable items (includes both switching to a new material to enable reuse or reusing the s ame product)

4

4. Establishing the baseline and BAU scenario to 2040

Establishing the 2023 baseline involved determining current volumes of plastic mass for each product category, estimating how these volumes currently flow through the system maps described above, before using these estimations to generate GHG emissions and total cost baseline estimations.

Both primary and secondary data sources were used to establish the baseline for plastic mass. The volume estimates were developed using a combination of available procurement data from an NHS England Trust, purchased datasets from BCC research[3,4], and desktop research findings. Once an appropriate mass baseline was determined, the numbers were compared to other publicly available estimates (e.g., the values reported in *Measuring and Reducing Plastics in the Healthcare Sector*[5] and *Decarbonizing the Medical Devices Industries (Décarbonons les industries des dispositifs médicaux*[6])) to confirm the baseline was comparable and in the correct order of magnitude.

Once baseline numbers were determined, proportions for each mass flow arrow within the system maps were estimated for each product category. Our approach was based off a few key principles and assumptions:

1. Mass flow arrow estimations should reflect how individual products are most commonly used within different healthcare settings and for what purposes (e.g., if products are mainly used in direct contact with patients, they will typically head to Arrow B2 "post-patient waste collection" after use);

2. The split of post-patient waste collection should follow known practices in healthcare settings for managing clinical waste.

    a. For example, in the UK, there are several waste streams depending on the circumstances in which the product was used. The NHS publishes data each year in their Estates Returns Information Collection (ERIC)[7] detailing the proportions going to the three main waste streams. In 2023/2024, the split was as follows:

Table 1

NHS UK Clinical waste streams and current waste flows

%	Bag	Disposal pathway	Proportion 2023/24
Offensive	Yellow with black stripes	Low temperature incineration	35%
Clinical infectious	Yellow	High temperature incineration	25%
Clinical highly infectious	Orange	Alternative treatment, then low temperature incineration	40%

Given the disposal pathway differs for each stream, this information was used to calculate the proportions to LTI and EfW and the proportions to HTI at end-of-life for each product category in Europe.

For those product categories where several sub-product categories exist, mass flow arrow estimations were made for each individual sub-product category and a weighted average based on plastic mass estimations was calculated to determine the overall mass flow at the product category level. You can find the detailed waste flow assumptions for each product category for the 2023 baseline in Table 2 for Europe and Table 3 for North America.

Table 2

Baseline waste flow assumptions per product category, Europe[1]

	System Map ID	Gloves	PPE	Wipes	Fluid bags + tubing	Rigid devices	Pharma packaging	Device packaging
Share formal collected plastic	Arrow A1	100%	100%	100%	100%	100%	100%	100%
Share formal collection for recycling	Arrow B1	0%	0%	0%	0%	0%	0%	0%
Share "post-patient" waste collection	Arrow B2	50%	90%	50%	100%	100%	50%	90%
Share mixed waste collection	Arrow B3	50%	10%	50%	0%	0%	50%	10%
Share sorted waste to MR (closed loop)	Arrow C1	0%	0%	0%	0%	0%	0%	0%
Share sorted waste to MR (open loop)	Arrow C2	0%	0%	0%	0%	0%	0%	0%
Share sorted waste to chemical recycling	Arrow C3	0%	0%	0%	0%	0%	0%	0%
Share sorted waste to losses	Arrow C4	100%	100%	100%	100%	100%	100%	100%
Share "post-patient" sanitary waste to formal sorting	Arrow D1	0%	0%	0%	0%	0%	0%	0%
Share "post-patient" sanitary waste to alternative treatment	Arrow D2	40%	40%	40%	10%	0%	0%	40%
Share "post-patient" sanitary waste to losses	Arrow D3	60%	60%	60%	90%	100%	100%	60%
Share of alternative treatment to formal sorting	Arrow F1	0%	0%	0%	0%	0%	0%	0%
Share of alternative treatment to losses	Arrow F2	100%	100%	100%	100%	100%	100%	100%
Share of mixed waste to formal sorting	Arrow E1	0%	0%	0%	0%	0%	0%	0%
Share of mixed waste to losses	Arrow E2	100%	100%	100%	100%	100%	100%	100%
Share of MR (closed loop) actually recycled	Arrow H1	0%	0%	0%	0%	0%	0%	0%
Share of MT (closed loop) to losses	Arrow H2	100%	100%	100%	100%	100%	100%	100%
Share of MR (open loop) actually recycled	Arrow I1	0%	0%	0%	0%	0%	0%	0%
Share of MR (open loop) to losses	Arrow I2	100%	100%	100%	100%	100%	100%	100%
Share of chemical recycling to plastic	Arrow J1	0%	0%	0%	0%	0%	0%	0%
Share of chemical recycling to fuel	Arrow J2	0%	0%	0%	0%	0%	0%	0%
Share of chemical recycling to losses	Arrow J3	100%	100%	100%	100%	100%	100%	100%
Share of losses to managed landfill	Arrow K1	0%	0%	0%	0%	0%	0%	0%
Share of losses to LTI	Arrow K2	88%	100%	88%	64%	23%	50%	98%
Share of losses to HTI	Arrow K3	13%	0%	13%	36%	77%	50%	3%

Table 3

Baseline waste flow assumptions per product category, North America

	System Map ID	Gloves	PPE	Wipes	Fluid bags + tubing	Rigid devices	Pharma packaging	Device packaging
Share formal collected plastic	Arrow A1	100%	100%	100%	100%	100%	100%	100%
Share formal collection for recycling	Arrow B1	0%	0%	0%	0%	0%	0%	0%
Share "post-patient" waste collection	Arrow B2	70%	66%	70%	100%	100%	10%	10%
Share mixed waste collection	Arrow B3	30%	34%	30%	0%	0%	90%	90%
Share sorted waste to MR (closed loop)	Arrow C1	0%	0%	0%	0%	0%	0%	0%
Share sorted waste to MR (open loop)	Arrow C2	0%	0%	0%	0%	0%	0%	0%
Share sorted waste to chemical recycling	Arrow C3	0%	0%	0%	0%	0%	0%	0%
Share sorted waste to losses	Arrow C4	100%	100%	100%	100%	100%	100%	100%
Share "post-patient" sanitary waste to formal sorting	Arrow D1	0%	0%	0%	0%	0%	0%	0%
Share "post-patient" sanitary waste to alternative treatment	Arrow D2	19%	19%	19%	19%	19%	19%	19%
Share "post-patient" sanitary waste to losses	Arrow D3	81%	81%	81%	81%	81%	81%	81%
Share of alternative treatment to formal sorting	Arrow F1	0%	0%	0%	0%	0%	0%	0%
Share of alternative treatment to losses	Arrow F2	100%	100%	100%	100%	100%	100%	100%
Share of mixed waste to formal sorting	Arrow E1	0%	0%	0%	0%	0%	0%	0%
Share of mixed waste to losses	Arrow E2	100%	100%	100%	100%	100%	100%	100%
Share of MR (closed loop) actually recycled	Arrow H1	0%	0%	0%	0%	0%	0%	0%
Share of MT (closed loop) to losses	Arrow H2	100%	100%	100%	100%	100%	100%	100%
Share of MR (open loop) actually recycled	Arrow I1	0%	0%	0%	0%	0%	0%	0%
Share of MR (open loop) to losses	Arrow I2	100%	100%	100%	100%	100%	100%	100%
Share of chemical recycling to plastic	Arrow J1	0%	0%	0%	0%	0%	0%	0%
Share of chemical recycling to fuel	Arrow J2	0%	0%	0%	0%	0%	0%	0%
Share of chemical recycling to losses	Arrow J3	100%	100%	100%	100%	100%	100%	100%
Share of losses to managed landfill	Arrow K1	98%	97%	98%	95%	97%	100%	100%
Share of losses to LTI	Arrow K2	0%	0%	0%	0%	0%	0%	0%
Share of losses to HTI	Arrow K3	2%	3%	2%	5%	3%	0%	0%

Finally, to estimate baseline GHG emissions, GHG emissions factors for each mass aggregation step were multiplied to their respective estimated volumes for each product category[i]. This step was repeated to determine total system cost using CAPEX and OPEX estimations for each mass aggregation step. For information regarding the sources for the emission factors and cost factors related to each mass aggregation step, please see Table 4[ii].

Table 4

Sources for emission factors and cost factors

Process step	GHG Emission Factors	Costs	
		North America	Europe
Virgin plastic production (fossil)	ecoinvent 3.11 (various production datasets)[iii]	Desktop research on product purchase price (for packaging categories source was Fossil Free Plastics, Systemiq (2025))[8]	
Virgin plastic production (biobased)	Fossil Free Plastics, Systemiq[8]	Fossil Free Plastics, Systemiq[8]	
Virgin plastic production (fossil abated)	Fossil Free Plastics, Systemiq[8]	Fossil Free Plastics, Systemiq[8]	
Plastic conversion	ecoinvent 3.11 (various conversion datasets)	Reshaping Plastics, Systemiq[1]	
Formal collection	ecoinvent 3.11 (municipal waste collection service by 21 metric ton lorry)	Expert estimate	
Formal sorting	ecoinvent 3.11 (treatment of waste polyethylene, for recycling, sorted, sorting)	Reshaping Plastics, Systemiq[1]	
Alternative treatment	Rizan et al.[9]	UNEP[10]	ERIC[7]
Closed loop MR	ecoinvent 3.11 (polyethylene production, high density, granulate, recycled)	Reshaping Plastics, Systemiq[1]	
Open loop MR	ecoinvent 3.11 (polyethylene production, high density, granulate, recycled)	Reshaping Plastics, Systemiq[1]	
Chemical recycling (pyrolysis)	Consumer Goods Forum[11]	Reshaping Plastics, Systemiq[1]	
Chemical recycling (dissolution)	PlastEurope[12]	Reshaping Plastics, Systemiq[1]	
Chemical recycling (depolymerisation)	JRC Technical Report[13]	Reshaping Plastics, Systemiq[1]	
LTI	ecoinvent 3.11 (treatment of waste plastic, mixture, municipal incineration)	N/A	ERIC[7]
HTI	ecoinvent 3.11 (treatment of waste plastic, mixture, municipal incineration)	Practice GreenHealth[14]	ERIC[7]
Managed Landfill	ecoinvent 3.11 (treatment of waste plastic, mixture, sanitary landfill)	Practice GreenHealth[14]	ERIC[7]
Reduce - reuse	Keil et al.[15]	N/A (assumption that costs for reuse = costs for single-use)	
Substitute - Paper - Production	ecoinvent 3.11 (kraft paper production)	Reshaping Plastics, Systemiq[1]	
Substitute - Coated paper - Production	ecoinvent 3.11 (kraft paper production)	Reshaping Plastics, Systemiq[1]	
Substitute - Compostables - Production	ecoinvent 3.11 (polylactic acid production, granulate)	Reshaping Plastics, Systemiq[1]	

[i] Note, the emissions associated with the production of plastic relates to the emissions associated with the polymer production process only and dos not include the emissions in procuring and transporting feedstock.
[ii] For specific detail regarding the primary sources used within some of the quoted reports, please reach out to plastics@systemiq.earth
[iii] All ecoinvent 3.11 sources use IPCC 2021 GWP100 APOS method

Substitute - Paper - Waste management (EOL)	Breaking the Plastic Wave, Systemiq & Pew Charitable Trusts[2]	Reshaping Plastics, Systemiq[1]
Substitute - Coated paper - Waste management (EOL)	Breaking the Plastic Wave, Systemiq & Pew Charitable Trusts[14]	Reshaping Plastics, Systemiq[1]
Substitute - Compostables - Waste management (EOL)	Breaking the Plastic Wave, Systemiq & Pew Charitable Trusts[2]	Reshaping Plastics, Systemiq[1]

To estimate the BAU scenario to 2040, compound annual growth rate (CAGR) projections of 2.2% for Europe and 1.5% for North America were applied, based on a synthesis of secondary literature, demographic trends, and healthcare activity forecasts (for more detail, please see Appendix Section 5 on Key Assumptions). These growth rates are highly directional, as the objective of this report is not to precisely anticipate evolution of key healthcare metrics (e.g., healthcare spend, demographic trends, pharmaceutical drug consumption, hospital days per inhabitant…) to estimate future plastic consumptions. The growth rates were applied uniformly to all seven product categories, maintaining the same relative plastic mass shares as in the 2023 baseline. Critically, it was assumed that there is no structural change in how plastic flows through the system – that is, all mass flow arrow estimations remain unchanged from the baseline, reflecting a continuation of current clinical, procurement, and waste management practices. Emissions and cost estimates were generated using the same methodology as for 2023 (Equations 1 and 2), meaning emissions and cost intensity factors were held constant through to 2040.

It should be noted that the data landscape for healthcare plastics remains fragmented, with limited publicly available information on procurement volumes and volumes of waste sent through different end-of-life pathways. Where data was unavailable, directional estimates based on desktop research were developed and validated with expert input. All cost and GHG emissions factors used in this report are based on 2023 baseline estimates and should be viewed as indicative and an illustrative starting point to explore potential impacts of different interventions. Notably, costs are considered in 2023 Dollars / Euros (i.e., no inflation or currency effects are taken into account between 2023 and 2040).

5. Lever development and intervention quantification methodology

To explore how different enabling conditions may influence the uptake of circularity levers and interventions, two forward-looking scenarios were developed: a **Moderate-Ambition System-Change Scenario** and a **High- Ambition System-Change Scenario**.

These scenarios were developed through the application of several circularitycirculariry and decarbonization levers. Each lever assessed was identified through a combination of desktop research, expert consultation, and comprehensive literature review of known interventions targeting plastics in healthcare and comparable sectors. In total, five levers were selected and then modelled based on their potential for impact. Four of these levers are defined as circularity levers, whilst one is defined as a decarbonization-specific lever.

Three of the circularity levers are considered to be "upstream" levers that impact the total mass of plastic entering the system with one considered as "downstream" lever that impacts the flow of plastic waste once it has entered the system.

The final lever does not impact the total mass of plastic demanded nor divert plastic waste into a particular end-of-life stream, but has the potential to reduce the GHG emissions associated with plastic production and disposal.

Circularity levers:

Upstream levers:

1. **Refuse, Rethink, Reduce**[iv]**:** Interventions that eliminate or reduce unnecessary single-use plastic
2. **Reuse**: Transitioning from single-use to reusable alternatives
3. **Substitute materials:** Switching from plastic materials to alternative materials with lower GHG emissions

Downstream lever:

4. **Improve recycling:** Interventions under this lever aim to increase the proportion of plastic waste that is collected, sorted, and recycled

Decarbonization-specific lever:

5. **Procure low-emission plastics:** This lever captures the emissions savings from procuring plastics with lower upstream carbon intensity. While these interventions do not reduce demand, they have the potential to lower lifecycle emissions.

Within each lever, several interventions were identified through desktop research and expert consultation. This involved reviewing case studies and published reports on initiatives carried out at the hospital and health system level, and speaking with healthcare professionals about the interventions they had implemented or observed in practice. Each intervention was then evaluated using a directional scoring system based on five enabling factors – readiness/feasibility, performance, affordability, regulations, and convenience – and assigned a score from 0% to 75% for each. The scoring was informed by findings from case studies and discussions with experts who provided insights on real-world feasibility and barriers to adoption. The scoring system can be seen in Table X.4:

[iv] Note, because the scope of the report is single-use plastic in healthcare facilities (as detailed in point 2 of Scope and Boundaries section), this lever does not cover designing for durability (making products last longer so they do not need frequent replacement) and designing for repairability (ensuring products can be fixed rather than discarded) but is rather solely focused on elimination. However, designing for durability and repairability is relevant for the Reuse lever to ensure that the reusable products can be used over multiple cycles.

Table 5

Scoring system for future scenarios

Enabling factor	Key question	Scoring (directional)				
		75%	50%	25%	10%	0%
Readiness / Feasibility	Is the solution readily available and scalable? Recycle / Disposal - Does the infrastructure allow for recycling? Reduce - What would be the expected level of reduction?	Solution readily available and already at scale Reduce – Not applicable	Solution readily available and easily scalable Reduce – Very high reduction potential	Solution readily available, and can be scaled somewhat easily over time Reduce - High reduction potential	Existing solution but not readily available yet Reduce – Some optimization potential	No feasible solution expected within the next 10 years Reduce – Consumption already optimized
Performance	Would it generate higher or lower performance? Reduce - Is it difficult to reach the theoretical optimal utility? Recycling / Disposal – Not applicable	Better performance than SUP Reduce – Very easy to reach reduction potential	Similar performance and safety than SUP Reduce – Somewhat easy to reach reduction potential	Meets performance requirements in most cases, not safety issue Reduce – Neutral	Plausible that performance and safety requirements will be met by 2030-35 Reduce – Difficult to reach reduction potential	Does not meet performance or safety requirements Reduce – Extremely difficult to reach reduction potential
Affordability	Would it generate net costs or net savings?	Net savings as of today	Similar costs as of today	Slightly more expensive at scale	Significantly more expensive, some expectations for economies of scale in the future	Significantly more expensive and no expectations for meaningful economies of scale / learning curve to reduce cost in the future
Regulation	Would regulations accelerate or slow down adoption?	Current regulations encourage adoption	Favorable regulations can be easily implemented	Neutral	Unfavorable regulations as of today	Very unfavorable regulations as of today, unlikely to change by 2040
Convenience	How convenient is the new solution?	More convenient	Neutral – as convenient	Less convenient but manageable at scale	Not at all convenient for HCPs	

Level of "penetration" by 2040 (e.g., % of reduction volume, % of single-use items switched to reusables, % of collected waste sent for recycling) was then calculated by taking the minimum score across each five enabling factors. For example, if an intervention scored "green" in four enabling factors, but "yellow" in one, the penetration score would be 25%. Each intervention received two directional penetration scores to represent the score lin a High-Ambition Systems Change Scenario versus a Moderate-Ambition Systems Change Scenario. Where an intervention was applicable to only a subset of a product category, a secondary calculation was completed to determine the final number taken through to the scenario-specific modelling. For example, if an intervention was only applicable to IV bags, the penetration scores calculated for the intervention were multiplied by the proportion IV bags represented of the entire fluid bags and tubing product category.

6. Scenario-specific modeling approach

Once the penetration figures for each intervention across each scenario were calculated, they were applied to our systems map to calculate the resulting impact on overall plastic mass, total GHG emissions, and total system cost.

For the upstream interventions, penetration figures were applied directly to the upstream R&S systems map. For the downstream lever (Improve recycling), the current plastic mass flow was first mapped, the penetration figures applied at the correct systems map stage, and the resulting impact on each mass flow arrow calculated using a set of assumptions (e.g., percentage of losses at MRFs, losses at recycling, most likely recycling pathway etc.). Summing the impact of these levers gave us an estimation for total plastic mass in 2040 for each product category. Estimations for total GHG emissions and total system cost in 2040 were then determined using the same methodology as establishing the baseline (emissions factor (or cost factor) for each mass aggregation step multiplied by total plastic volume for the respective aggregation step – see Equation 1 and Equation 2). The emissions factors and costs factors remain constant between 2023 and 2040 to isolate the impact of each circularity and decarbonization lever (i.e., if all else remains constant, then this is the resulting impact).

Note, the five levers were applied in a step-by-step approach to reflect the prioritization of upstream interventions before downstream and decarbonization-specific interventions, in the order listed in the report (starting by evaluating opportunities for (1) Refuse, Rethink, Reduce, then (2) Reuse and (3) Substitute materials, then (4) Improve recycling before considering (5) Procure lower-emission plastics).

7. Key assumptions

The model is based on a set of core assumptions that guide quantification across all scenarios. These assumptions are applied consistently across the BAU, Moderate-Ambition, and High-Ambition Scenarios unless otherwise specified. This section outlines the key assumptions and modeling parameters that have the greatest influence on material, emissions, and cost estimates.

Given the different regulatory environments between North America and Europe, the following region-specific assumptions were applied to reflect the differences in waste classification and treatment pathways. These assumptions were developed based on national strategy documents (e.g., NHS Clinical Waste Strategy), desktop research, and consultation with subject matter experts.

Table 6

Regional-specific driving assumptions for disposal pathways[2]

North America	Europe
• 85% of all healthcare waste is non-hazardous and the remaining 15% includes regulated medical waste (RMW) and hazardous waste[16] • Within regulated medical waste, red bag waste and sharps will be sent for alternative treatment (typically autoclave) and then landfilled whereas pathological waste and trace chemotherapy waste will be sent directly to high-temperature incineration • Hazardous waste is also sent directly to high-temperature incineration • Non-hazardous waste is landfilled	• 40% of post-patient waste is classified as "highly-infectious clinical waste" and requires high-temperature incineration • 25% of post-patient waste is classified as "infectious clinical waste" and requires alternative treatment and low-temperature incineration • The remaining 35% is classified as "offensive waste" and requires low-temperature incineration

Additional driving assumptions:

- **System flow:** Plastic waste flows remain unchanged compared to the baseline until 2040
- **Compound Annual Growth Rate (CAGR):** The CAGR assumptions for the baseline demand were derived from multiple sources including Eurostat data on historical growth in healthcare spending, surgical procedures growth, population growth, inpatient discharges, outpatient volumes, NHS Clinical Waste Strategy, and Medicaid enrollment.[17–19,71,86,87] This resulted in the following CAGR assumptions for Europe and North America:
    - **Europe:** 2.2% CAGR from 2023 to 2040
    - **North America:** 1.5% CAGR from 2023 to 2040
- **Emissions factors:** Assumed to remain constant across the time horizon (2023 – 2040)
- **Costs:** All costs are considered to be in 2023 U.S. Dollars or Euros and all costs remain stable by 2040 (i.e., no cost efficiency or optimization considerations taken into account in the model)
- **Compounded Effects of Levers:** The interventions from all fives levers are applied sequentially as described in the *"Levers development and intervention quantification methodology"* section above, however, the interactions between levers, such as overlapping impacts, compounding effects, or any marginal changes resulting from the order in which levers are applied, are not modeled. Each lever is treated independently in terms of its estimated impact, and potential synergies or trade-offs between interventions are not explicitly captured.
- **2030 estimations:** 2030 penetration estimations for the High-Ambition Systems Change Scenario and Moderate-Ambition Systems Change Scenario are 30% of the 2040 penetration estimations to represent a scale-up over time as the intervention matures. For the procure low-emissions plastic lever, 2030 estimations are 20% of the 2040 penetration estimations as take-up is likely to be slow initially.
- **Disposal pathways –** disposal in Europe follows norms and practices in the United Kingdom and disposal in North America follows norms and practices in the USA
- **Disposal pathways for losses –** all residual losses in the system (e.g., losses from sorting or losses from recycling) are sent to low-temperature incineration in Europe and landfill in North America.

While not all inputs and assumptions made in the model calculations are detailed in this appendix, the above assumptions represent the driving factors that greatly impact the model's outputs.

Data gaps and limitations

Producing a robust and forward-looking assessment of plastic consumption and circularity potential in the healthcare sector then comes with significant data challenges. Despite growing interest in the topic, data availability and consistency across the value chain remains very limited – especially when compared to other high-consumption sectors like packaging or automotive. This report therefore relies on directional estimates and modeling assumptions to fill critical knowledge gaps. Key data gaps include:

- **Procurement and consumption data**: Publicly available, product-level procurement data for hospitals and health systems is sparse—particularly at the country or system level aggregated across healthcare settings (hospitals, clinics, emergency services, blood donation centers, medical practices, private practices, socio-medical buildings etc.). Data is fragmented, typically siloed within individual providers or procurement consortia, and rarely includes volumes or weights. This makes it difficult to establish reliable baselines of plastic consumption by product type, region, or healthcare setting. **Waste treatment and end-of-life pathways**: Waste stream classification, segregation practices, and end-of-life treatment routes (e.g., landfill, incineration, or recycling) are highly variable across regions and facilities. Most public statistics do not disaggregate healthcare plastics, making it challenging to assess how much clinical plastic waste is "post-patient", recyclable, actually recycled, treated, landfilled or incinerated. Some hospitals have conducted waste audits over a limited time period or across specific services. However, most of these waste audits cannot be extrapolated to the whole system, as each service has very different plastic application and consumption patterns. However, such waste audits were leveraged to check consistently of our estimates regarding the baseline. **Country of origin and upstream data**: There is little transparency in the country of origin of medical plastic products or components. This makes it difficult to attribute production emissions accurately, or to assess the embedded emissions from transport and upstream processes, especially in globalized supply chains. These estimates thus do not include upstream emissions from global transportation networks or the carbon cost of expanded fossil-based polymer production capacity, which is also set to grow.
- **Emission factors and cost assumptions**: Existing emission and cost factors for many plastic healthcare products are incomplete or outdated.
- **Impact data for circularity interventions**: The actual effectiveness of interventions like reduction, reuse, or substitution is still not documented at scale. Pilots are often small-scale, inconsistent in scope, or lack rigorous data collection. In addition, the impact of such intervention is highly context-specific. As a result, estimating future performance, scalability, and emissions impact involves high degrees of uncertainty.

Implications for future decision-making: Addressing these data gaps will be essential to enable smarter, evidence-based decisions on plastic use in healthcare. Key actions include:

- Improved disclosure and standardization of procurement and waste data at provider and national levels
- Development of harmonized life cycle inventories and emissions datasets for healthcare plastics
- Clearer tracking of product origin and supply chain footprint
- Greater transparency and independent evaluation of pilot projects and interventions

Implications for this report: Given these gaps, all estimates presented in this report should be considered **highly directional** and subject to substantial uncertainty. In some cases, estimates need to be extrapolated from a single country or health system to regional averages, which introduces uncertainty. The goal is not to provide a precise forecast or historical accounting, but rather to explore **what could be achieved** under different systems-change scenarios. This analysis aims to illuminate potential impact pathways, guide policy and industry focus, and establish a shared framework for future data improvement and collaboration. While care was taken to ensure internal consistency and alignment with best available evidence, the findings should be seen as indicative, not predictive. Please review the Appendix for the full Methodology. This report offers a **vision of possibility**, grounded in best available evidence, but shaped by the recognition that better data must be part of the solution.

References

1. Systemiq Ltd. *ReShaping Plastics: Pathways to a Circular, Climate Neutral Plastics System in Europe*. https://www.systemiq.earth/wp-content/uploads/2022/05/ReShapingPlastics-v2.1.pdf.
2. Systemiq Ltd. *Breaking The Plastic Wave: A Comprehensive Assessment of Pathways towards Stopping Ocean Plastic Pollution*. Pew Charitable Trusts https://www.systemiq.earth/wp-content/uploads/2020/07/BreakingThePlasticWave_MainReport.pdf.
3. BCC Research. https://www.bccresearch.com/market-research/plastics/medical-plastics-global-markets.html.
4. Health Care Without Harm. *Measuring and reducing plastics in the healthcare sector*. https://europe.noharm.org/resources/measuring-and-reducing-plastics-healthcare-sector.
5. The Shift Project. *Décarbonons les industries des dispositifs médicaux*. https://theshiftproject.org/app/uploads/2025/06/Synthese-Decarbonons-les-Dispositifs-Medicaux.pdf (2025).
6. NHS England. *Estates Returns Information Collection* (ERIC). NHS England Digital https://digital.nhs.uk/data-and-information/publications/statistical/estates-returns-information-collection.
7. Systemiq Ltd. *Fossil Free Plastics: Driving Clean Industrial Leadership in Europe*. *https://www.systemiq.earth/downloads*/Systemiq-Fossil_Free_Plastics-EN.pdf (2025).
8. Rizan, C., Bhutta, M. F., Reed, M. & Lillywhite, R. *The carbon footprint of waste streams in a UK hospital*. J. Clean. Prod. 286, 125446 (2021).
9. United Nations Environment Programme (UNEP). *Compendium of Technologies for Treatment/Destruction of Healthcare Waste*. https://www.medconstructor.org/wp-content/uploads/2020/03/Compendium_Technologies_for_Treatment_Destruction_of_Healthcare_Waste_2012.pdf (2012).
10. Sphera Solutions, Inc. Life Cycle *Assessment of Chemical Recycling for Food Grade Film*. The Consumer Goods Forum https://www.theconsumergoodsforum.com/wp-content/uploads/2022/04/Life-Cycle-Assessment-of-Chemical-Recycling-for-Food-Grade-Film.pdf (2022).
11. Sa, S. & Villers, J. The VinyLoop Eco-Footprint. VinyLoop Ferrara SpA (2012).
12. Garcia-Gutierrez, P. et al. *Environmental and Economic Assessment of Plastic Waste Recycling: A Comparison of Mechanical, Physical, Chemical Recycling and Energy Recovery of Plastic Waste*. Publications Office of the European Union https://data.europa.eu/doi/10.2760/0472 (2023).
13. Practice Greenhealth. *Sustainability Benchmark Data*. https://practicegreenhealth.org/metrics-and-awards/sustainability-benchmark-reports (2024).
14. Keil, M., Viere, T., Helms, K. & Rogowski, W. *The impact of switching from single-use to reusable healthcare products: a transparency checklist and systematic review of life-cycle assessments*. Eur. J. Public Health 33, 56–63 (2023).
15. World Health Organization (WHO). *Health-care waste*. https://www.who.int/news-room/fact-sheets/detail/health-care-waste (2024).
16. NHS England. *NHS clinical waste strategy*. NHS clinical waste strategy https://www.england.nhs.uk/long-read/nhs-clinical-waste-strategy/.
17. Eurostat. *Health Database*. https://ec.europa.eu/eurostat/web/health/database.
18. Williams, E., Mudumala, A., Hinton, E. & Published, R. R. *Medicaid Enrollment & Spending Growth: FY 2024 & 2025*. KFF https://www.kff.org/medicaid/issue-brief/medicaid-enrollment-spending-growth-fy-2024-2025/ (2024)