



Bio-Based Plastics in Healthcare: Lessons from Serres Sylva® bC

Reducing emissions through renewable carbon and circular-ready solutions

serres

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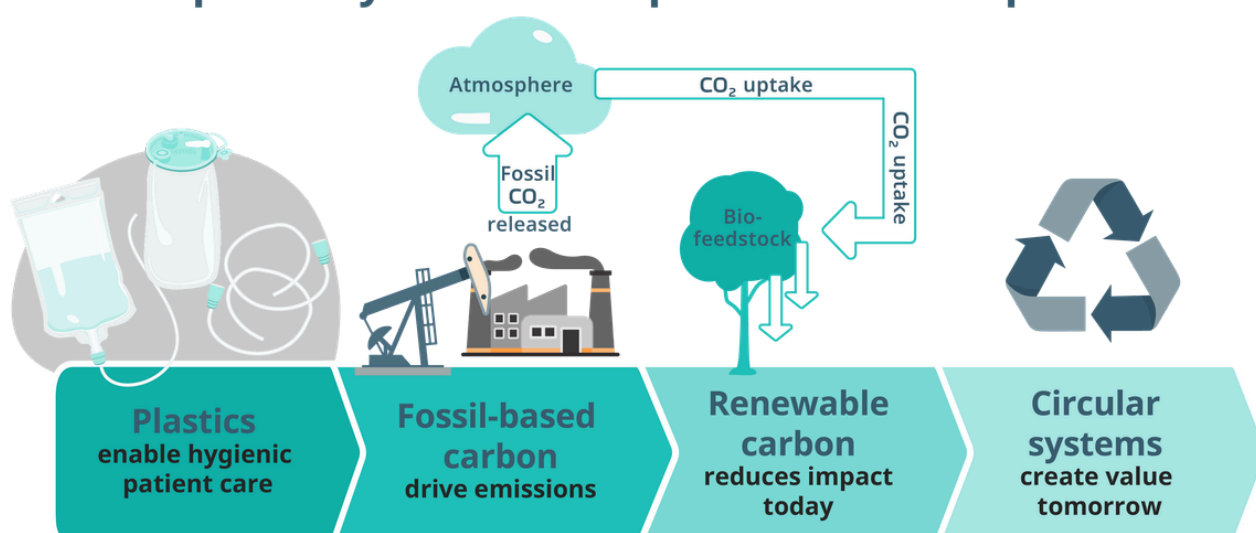
1 Executive summary

Healthcare relies on products that must meet demanding requirements for safety, hygiene, and performance. From operating rooms to intensive care unit, plastics enable critical functions and device performance that cannot be easily replaced by other materials.

At the same time, this dependence creates a climate impact. Most medical plastics are made from fossil-based materials and are often incinerated after use. A large share of these emissions originates from raw material production, making material choice a key driver of climate performance, as it determines whether new fossil carbon is introduced into the system or avoided.

This white paper shows how healthcare can reduce the climate impact of plastic products without compromising safety, performance, or clinical workflows. It demonstrates a practical pathway to circular-ready, low-carbon solutions that can be implemented within today's healthcare systems.

A pathway to lower-impact healthcare plastics



Renewable carbon and circular systems reduce reliance on fossil carbon while maintaining healthcare performance.

The paper focuses on three key solution areas:

- **Renewable and bio-circular materials** that replace fossil carbon with certified biomass-based inputs
- **Circular-ready product design** that reduces material use and supports future recycling
- **System-level approaches** that align innovation with existing infrastructure and workflows

Using Serres Sylva bC suction bags as a real-world example, the paper demonstrates how these principles can be applied in practice. Case studies illustrate how renewable carbon and circular-ready design can help hospitals reduce the climate impact of healthcare plastics without changing clinical workflows.

In the reference hospital case study presented in this paper, replacing a fossil-based suction bag with the Serres Sylva bC alternative reduced fossil greenhouse gas emissions by 28%, corresponding to a carbon handprint of 3.99 tonnes CO₂e per 100,000 suction bags annually. The study also highlights how future circular systems may create additional benefits by keeping plant-based carbon and plastic materials in circulation for longer.

2 The Need for Smarter Plastic Solutions in Healthcare

The World Health Organization (WHO) recognizes plastics as essential for delivering safe and affordable care across healthcare settings, enabling hygiene, sterility, and cost-effectiveness that cannot be compromised.¹ At the same time, WHO highlights the need to reduce the climate impact of plastics through reduction, reuse, recycling, and responsible disposal. Healthcare providers face challenges: infection control and safety requirements limit reuse, and complex material combinations restrict recyclability.

While healthcare systems exist to provide care and protect health, their operations also generate an environmental footprint across emissions, material use, and waste management, as illustrated in Figure 1.

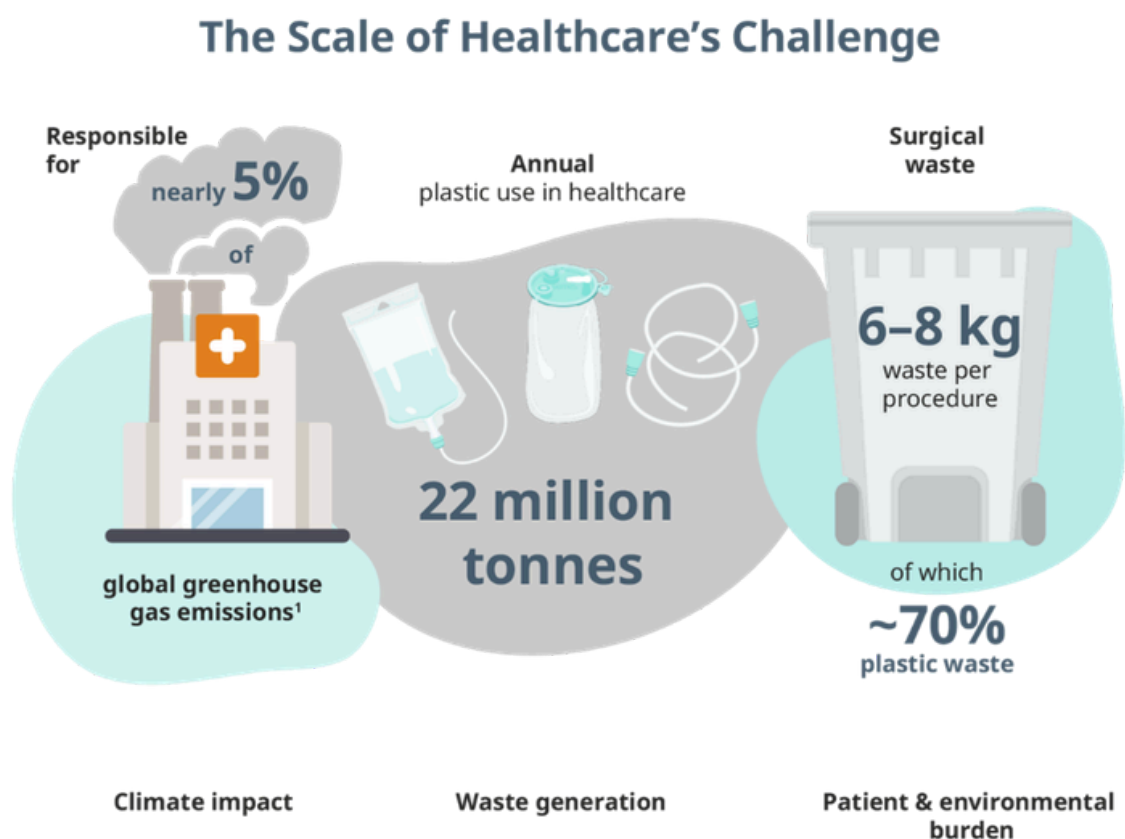


Figure 1 Healthcare systems contribute to climate emissions², consume large volumes of plastic materials³, and generate substantial amounts of waste⁴.

2.1 How Circular Economy Reduces the Impact of Healthcare Plastics

A circular economy (CE) offers a pathway to reducing the climate impact of healthcare plastics by improving material efficiency and keeping resources in use for longer. Recent analysis by the European Environment Agency shows that circular economy strategies can reduce emissions across all stages of a product lifecycle, as summarized in Table 1.⁵

Table 1 How Circular Economy Strategies Reduce Emissions Across the Product Life Cycle. Adapted from the European Environment Agency (EEA).

Lifecycle Stage	Circular Economy Action	Climate Mitigation Effect
Before use	Circular design, sustainable material selection, lightweighting	Reduces resource extraction and embedded emissions; enables reuse and recyclability later in the cycle
During use	Extending product lifetimes (reuse, repair, refurbishment, shared use)	Reduces demand for new products and materials, lowering product-related emissions.
After use	Recycling/keeping materials in circulation	Avoids primary resource extraction and reduces landfill methane emissions; keeps carbon in the material loop longer.

This means moving away from treating plastics as disposable. The focus shifts to material efficiency, renewable carbon, and circular-ready product design that reduces material use while supporting future recycling pathways.

3 The Role of Renewable Raw Materials in Healthcare Plastics

Reducing the climate impact of healthcare plastics requires a shift from fossil-based to renewable carbon feedstocks (the starting raw materials used to make plastics). Today, most healthcare plastic products are still manufactured using fossil resources such as coal, natural gas, and oil, contributing to greenhouse gas emissions across healthcare supply chains.

These materials introduce new fossil carbon into the atmosphere during production and end-of-life incineration. A large share of the climate impact of healthcare plastics originates from raw material production—for example, around 45% in a life cycle assessment of a single-use medical device—making feedstock choice a key driver for emission reduction.⁷

Circularity Delivers Real Climate Impact

A recent European Environment Agency Review of 131 studies found that circular economy strategies can reduce greenhouse gas emissions by an average of 33% compared to business-as-usual.⁶

“Why carbon matters in plastics? Carbon is the core building block of plastic materials.

Traditionally, this carbon comes from fossil sources such as oil and natural gas. Replacing fossil carbon with renewable carbon reduces the overall climate impact of plastic products.”

Renewable carbon, in contrast, is sourced from the atmosphere, plants, or existing biological and industrial waste streams. Biomass provides a renewable carbon source by capturing CO₂ from the atmosphere through photosynthesis. When used in plastics manufacturing, this carbon remains part of the natural carbon cycle. It does not introduce new fossil carbon into circulation.⁸ Advances in processing and material technologies now make it possible to produce plastics from bio-based feedstocks with performance equivalent to fossil-based materials.

However, these benefits are not always fully reflected in standard product-level carbon footprint calculations. Current life cycle assessment (LCA) methodologies may not fully capture the effects of biogenic carbon.⁹

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Reaching climate neutrality requires capturing carbon from the atmosphere for storage and for use as substitute to fossil carbon.

— European Commission, Sustainable Carbon Cycles¹⁰

3.1 What Makes a Plastic “Bio-Based”?

Bio-based plastics are produced from renewable biomass raw materials—such as plants, residues, or organic waste—instead of fossil-based resources such as oil and natural gas. Because the carbon in these feedstocks originates from the atmosphere or biosphere, they do not introduce new fossil carbon into circulation. Products can be fully or partly bio-based, depending on the share of renewable carbon used.

Their full climate benefit is achieved when combined with circular economy principles that keep materials in use longer, reduce reliance on virgin resources, and enable recycling. Together, renewable carbon and circularity create a more climate-efficient plastic ecosystem.

The concept of biogenic carbon—carbon captured from the atmosphere by plants through photosynthesis and subsequently stored in biomass—helps explain this system. The flow diagram in Figure 2 illustrates how this carbon moves through the lifecycle, from biomass growth to product use and end of life. Table 2 provides an overview of commonly used biomass feedstock categories.

Table 2 Examples of biomass feedstocks used in bio-based plastics and their key sustainability considerations.

Feedstock category	Typical sources	Key characteristics	Sustainability considerations
Food-crop biomass	Sugarcane, corn, cereal crops	Grown specifically for material or energy use; predictable supply	Can compete with food production; land-use, water, and fertilizer impacts must be carefully managed. Technically viable.
Non-food crop biomass	Wood, cellulose crops, forestry biomass	Derived from non-edible plant material (parts that's people do not eat)	Lower food-system impact, but might have land use and biodiversity considerations
Agricultural residues	Wheat straw, corn stover, bagasse	By-products of food and crop production	Utilizes existing biomass streams; limited availability and logistics complexity. Supports circularity principles.
Forestry residues & by-products	Tall oil, sawdust, pulp industry residues	Waste streams from forestry and paper industries	Generally low land-use impact; sustainability depends on forest
Organic waste oils and fats	Used cooking oil (UCO), waste animal fats	Waste-derived lipid feedstocks	Avoids food competition; repurposes waste; typically lower lifecycle GHG emissions. Supports circularity principles.

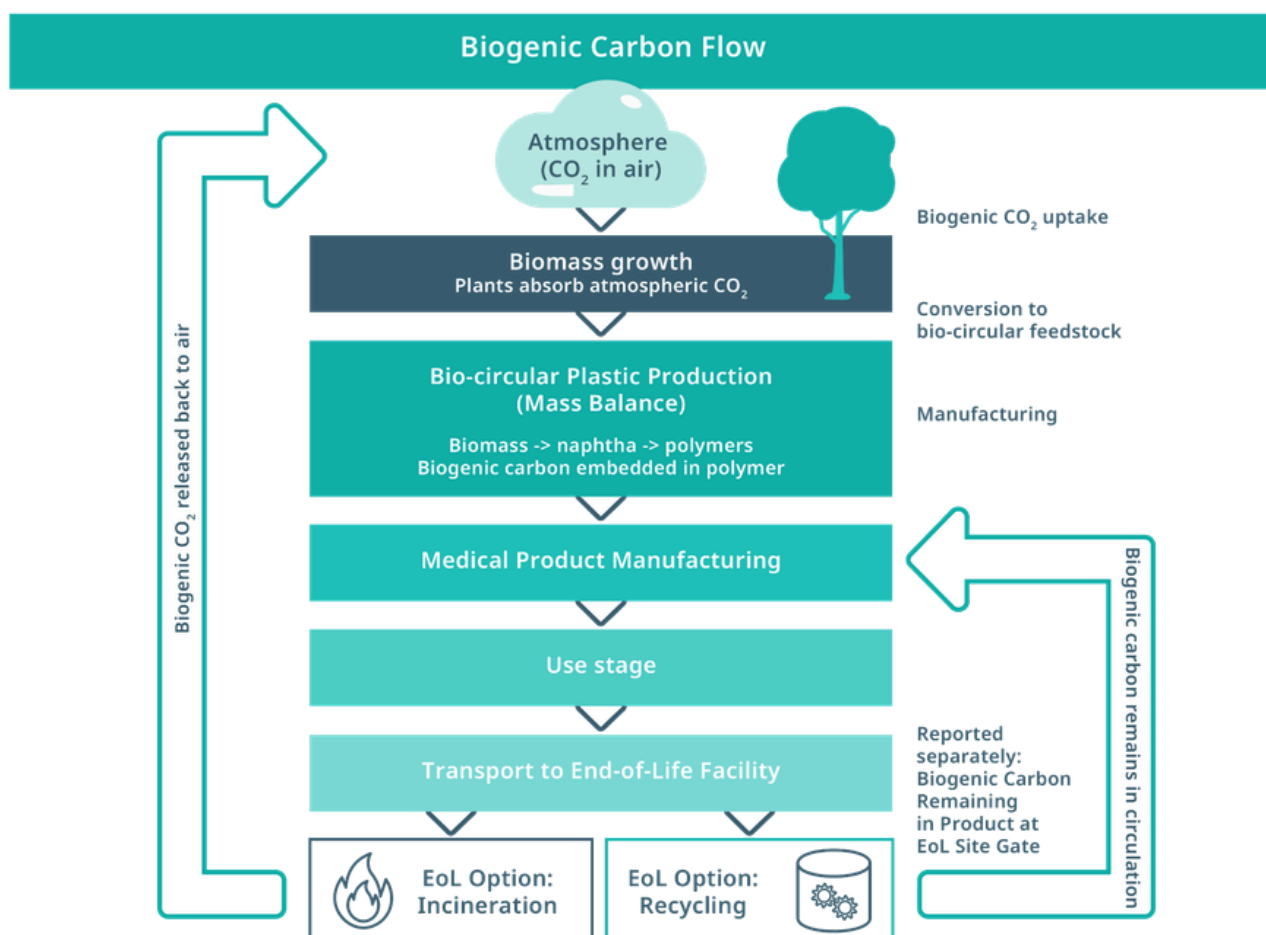


Figure 2 Biogenic carbon flow in plastic products. Biogenic carbon captured by plants becomes part of plastic materials and can either return to the atmosphere at end-of-life (EoL) or remain in circulation through recycling. Keeping biogenic carbon in the material system for longer may contribute to additional climate benefits.

3.2 Evidence for the Benefits of Renewable Carbon

Independent LCA research shows that renewable carbon materials consistently outperform fossil-based alternatives. A meta-analysis of 130 studies found that 80 of 98 bio-based products had a lower carbon footprint, with emerging products delivering on average 45% lower lifecycle emissions.¹¹ Together, these findings confirm that renewable carbon provides consistent and measurable emission reductions across product categories, including healthcare.

As energy systems transition to renewables and industrial processes electrify, the carbon footprint of these materials will continue to decline, bringing plastic systems closer to near-zero emissions over time.¹²

Scientific literature, including meta-analyses and EU Joint Research Centre evaluations, supports these findings. Appendix A summarises the most relevant studies.

Primary vs Secondary Biomass

Primary biomass comes from crops grown for feedstock (e.g., sugarcane, cereals crops). Secondary biomass uses waste and by-products like used cooking oil, reducing environmental impact and further supporting circularity.

Why Use Used Cooking Oil [UCO]?

Used cooking oil (UCO) is a sustainable feedstock that repurposes waste, avoids competition with food crops, and lowers greenhouse gas emissions—making it a strong and scalable options for circular healthcare plastics.

3.3 How Renewable Carbon Supports Net-Zero Targets in Healthcare Plastics

Not all sectors can rely only on electrification to reach net zero. Plastics, chemicals, and other carbon-based materials will continue to require carbon inputs. In these cases, biomass is the preferred renewable carbon source, as recognized by EU policy and industry roadmaps, helping to reduce reliance on fossil carbon.^{13 14}

Industry leaders agree that reaching net zero in materials requires two parallel shifts: replacing fossil feedstocks with circular carbon and electrifying production with renewable energy. Together, these shifts reduce reliance on virgin fossil resources and eliminate fossil fuel use in processing.¹⁵

3.4 Policy Drivers for the Transition to Renewable Carbon

European and international policy frameworks—such as the EU Bioeconomy Strategy, the Circular Economy Action Plan, and the Sustainable Carbon Cycles initiative—emphasize the need to shift plastics away from fossil feedstocks and toward renewable, sustainable carbon sources. Industry roadmaps align with this direction, projecting that bio-based feedstocks will supply over 40% of carbon demand by 2050, signaling a systemic move away from fossil-based materials.¹⁶

For further policy details and references, see Appendix B: Policy Guidance Supporting Renewable Carbon.

4 Designing Healthcare Plastics for Circularity

Most of the environmental impact of a plastic product is determined at the design stage, including decisions about material choice and end-of-life management. Designing products to stay in circulation can significantly reduce their overall impact.¹⁷

Design decisions determine potential, but real environmental impact depends on how well products perform within existing healthcare, waste management, and recycling systems.

Circular product design can address these challenges by considering the full lifecycle of plastic products. This approach ensures that products are fit for purpose during use while being optimized for recovery and keeping materials in circulation at end-of-life.

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Reduce demand for virgin materials as much as possible, while ensuring plastics stay in circulation and leakage into the environment is minimized—by recirculating products and materials and keeping them in our economies for as long as possible.

— United Nations Environment Programme (2023)¹⁸

4.1 Key Circular Design Principles for Plastic Products

Design decisions influence environmental impacts and determine how well products can support circularity. Table 3 summarizes the key principles outlined by GACERE (Global Alliance on Circular Economy and Resource Efficiency) in its Circular Design of Plastic Products policy brief.¹⁹

Table 3 Circular design principles that help reduce environmental impact and support material circulation.

Circular Design principle	Description
Design for reduction and optimization	Achieve the same function with less material while maintaining product quality.
Design for prolonged product use and reuse	Make products durable for multiple uses and easy to clean or process for reuse.
Design for repairability and enabling refurbishing	Enable easy repair by allowing disassembly and part replacement without discarding the whole product.
Design for recyclability	Ensure the product can be recycled at end-of-life by using recyclable plastic materials and avoiding non-recyclable additives or composites.

For hospitals, circular product design reduces material use and end-of-life incineration, lowers waste-management costs, supports sustainability targets such as reduced virgin plastic use, and improves readiness for future recycling as infrastructure develops.

4.2 The Three Steps to Recyclability

However, designing for circularity is not sufficient on its own — products must also work within real-world systems. Achieving recyclability is not only about product design. It also depends on infrastructure and market systems working together. This can be understood as a three-step journey—from design to real-world implementation and scale²⁰:

Step 1: Designed for Recycling (Technical Recyclability)

Products need to be designed so that recycling is technically possible. This includes using compatible materials, avoiding harmful additives, and favouring mono-material solutions where feasible. When this is not possible, components should be easy to separate.



Step 2: Real-Life Testing

Technical recyclability alone is not enough. Products need to be collected and sorted in hospitals and processed within existing recycling systems. This stage is often tested through pilots that demonstrate that recycling works in real conditions.



Step 3: Recyclability at Scale

The goal is widespread adoption. Recycling systems need to function across regions and user groups, supported by adequate infrastructure and stable demand for recycled materials. At this stage, circularity becomes standard practice rather than an exception.

This means selecting safe and recyclable materials, designing for efficient sorting, and increasing the use of recycled content. These choices reduce reliance on virgin plastics, support healthcare providers in advancing circularity, and strengthen the climate benefits of bio-based plastics by keeping biogenic carbon in circulation and avoiding new fossil carbon inputs in the material system.

5 Mass Balance: A Scalable Approach to Circular Plastics

Scaling biobased and recycled feedstocks requires solutions that work within existing production systems. The mass balance approach provides a practical way to increase the use of renewable and recycled feedstocks while maintaining product quality and ensuring certified allocation of sustainable content.

Figure 3 illustrates how renewable and fossil feedstocks can be processed within the same plastic manufacturing system while certified accounting ensures traceable allocation of renewable content throughout the value chain.

Products made using this approach have the same properties and performance as fossil-based plastics, allowing them to replace fossil-based plastics without changes to existing applications. This approach enables a stepwise transition without costly new infrastructure, making it possible to grow production in line with market demand.²¹

“Think of mass balance like the electricity grid: renewable and conventional energy flow together, but the share of renewable energy is measured and credited. The same principle applies to plastics.”

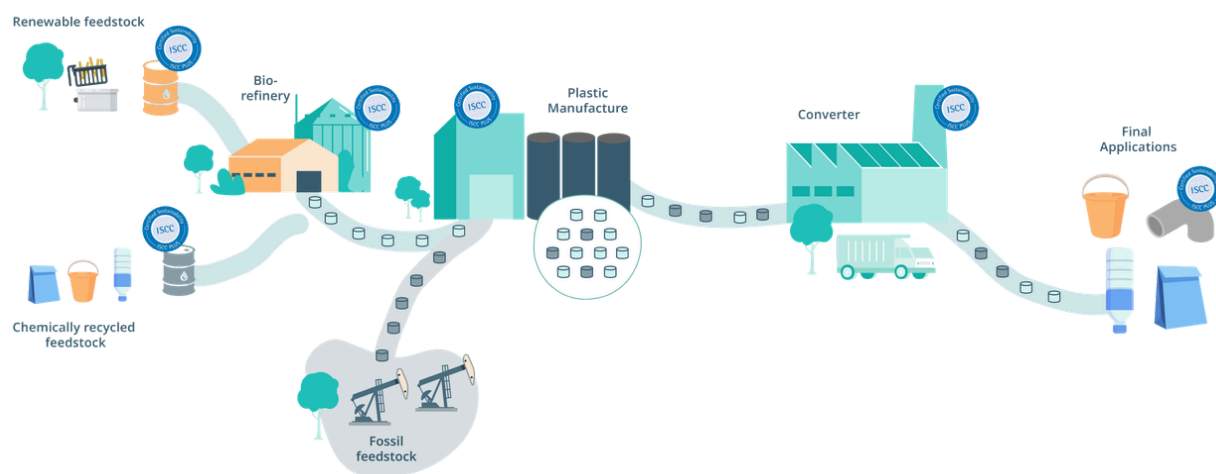


Figure 3 Simplified illustration of the mass balance approach. Renewable and fossil feedstocks are processed within the same plastic manufacturing system, while certified accounting ensures that the allocated share of renewable content can be traced through the value chain. Products maintain the same quality and performance as fossil-based alternatives.

Table 4 summarizes the key advantages of the mass balance approach and why it enables a scalable transition to circular feedstocks.

Table 4 Key advantages of the mass balance approach for scaling renewable and recycled feedstocks.

Benefit	Why it matters
Scalable	Supports the growth of bio-based /recycled feedstocks without building new infrastructure. Production can expand in step with market demand.
Flexible	Allows adjustment of bio-based and fossil feedstock ratios to meet customer needs—balancing cost and sustainability goals.
Cost-Efficient	Avoids the expense of separate production lines and storage facilities, accelerating adoption of bio-based / recycled materials.
Equal & constant quality	Maintains existing product specifications, eliminating the need for retesting or workflow changes.

5.1 Certification Requirement

For the mass balance approach to be credible, all value chain actors must hold ISCC PLUS certification. This ensures traceability and independent verification of bio-based and recycled feedstock claims across the supply chain.

Furthermore, ISCC PLUS certification guarantees that sustainability product claims are backed by independent review, building trust across the entire supply chain.

6 How Carbon Footprints Are Calculated for Bio-Based Healthcare Plastics

This section explains why carbon footprint results for bio-based plastics can differ in practice. Results vary depending on how carbon uptake by plants during biomass growth, end-of-life emissions, and biogenic carbon flows are treated. The section introduces the main carbon-accounting approaches used to calculate product greenhouse gas emissions and explains the assumptions behind the results presented in this paper.

6.1 How Biogenic Carbon Influences Carbon Footprint Results

When plastics are made from biomass, plants absorb CO₂ from the atmosphere and store that carbon in the material (see Figure 4). The key question is how this stored carbon should be treated. Should it be counted as a climate benefit—and for how long?

This is especially relevant when products are reused or recycled.

Q: Does my product contain bioplastic?

A: Not always. Mass balance tracks and allocates the share of sustainable feedstock within a production system. Your product may not physically contain bio-based plastic material, but the certified amount is guaranteed through audited documentation. This system ensures that the overall use of renewable or recycled resources grows in line with demand—like how renewable electricity is credited in the power grid.

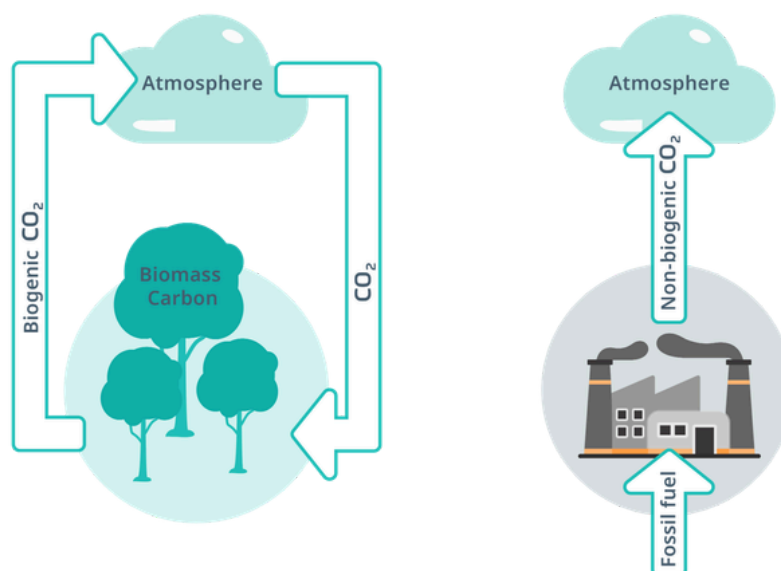


Figure 4 The source of carbon is one of the most important factors influencing the climate impact of plastics. Fossil carbon is extracted from underground reserves, whereas biogenic carbon is captured from the atmosphere by plants through photosynthesis.

There are two commonly used approaches for biogenic carbon accounting in carbon emission assessment, as summarized in Table 5 .^{22 23 24}

The first approach, often called 0/0 or “carbon-neutral”, assumes that biogenic CO₂ absorbed during biomass growth and CO₂ released at end-of-life (e.g., incineration) cancel each other out. As a result, it gives no credit for carbon uptake during biomass growth and does not recognize potential benefits from keeping biogenic carbon in circulation through recycling or repeated material use.

The second approach, -1/+1 or “physical carbon flow”, explicitly tracks biogenic carbon through the system. Carbon captured from the atmosphere during biomass growth is included in the assessment, and carbon released later is reported separately. This allows biogenic carbon flows to be reported explicitly within the assessment boundary.

The approach also highlights the potential value of keeping carbon in circulation through reuse or recycling. Because this can result in substantially different reported outcomes, clear communication is essential to avoid misleading conclusions.

Recent reviews also note that there is currently no universally accepted method for consistently accounting for delayed emissions and carbon storage effects across all LCA frameworks.²⁵

Example:

“Imagine a plant absorbs carbon and that carbon becomes part of a medical plastic product. Under the 0/0 method, this stored biogenic carbon is not counted as a benefit—the uptake and later release are treated as cancelling out. Under the -1/+1 method, the carbon uptake is recognised as part of carbon-flow accounting for as long as the carbon remains in the product or material loop. until it is eventually released at end-of-life.”

What is Biogenic Carbon?

Biogenic carbon is absorbed by plants from the atmosphere and stored in biomass. When used e.g. in plastics, this carbon becomes part of the material system. Additional climate benefits may arise when the carbon remains in circulation through reuse and recycling for extended periods.^{28 29}

What is Fossil Carbon?

Fossil carbon is carbon stored in coal, oil, and gas for millions of years. When extracted and used, it releases CO₂ into the atmosphere, adding new carbon to the cycle and driving climate change.^{30 31}

Table 5 Comparison of the two most common approaches used to account for biogenic carbon in bio-based plastics.

Aspect	0/0 Approach	-1/+1 Approach
Core principle	Uptake and release cancel out.	Uptake = -1, release = +1
Biogenic carbon treatment	Does not explicitly report biogenic carbon flows.	Reports biogenic carbon flows separately.
Where it tends to fit best	Often used when the carbon is assumed to return quickly (e.g., biofuels).	Favoured for materials and circular-economy assessments.
What this means	Simpler, but does not capture circular benefits.	More complete but needs careful communication.

These differences can lead to significantly different reported emission results for the same product, which is important when assessing and comparing climate claims.

Industry Recommendation

Industry bodies, including Plastics Europe, recommend the -1/+1 approach because it better reflects physical carbon flows and supports fair comparison between fossil- and bio-based products.²⁶ Increasingly, industry organizations, policymakers, and procurement frameworks are encouraging transparent reporting of biogenic carbon flows.

To maintain credibility, system boundaries should be clearly specified, and fossil and biogenic emissions should be reported separately to avoid misinterpretation or double counting. Recent hospital procurement guidance also recommends reporting results both with and without biogenic carbon to support transparent comparison and decision-making.²⁷

Communication note: Results that appear “net-negative” under the -1/+1 approach reflect biogenic carbon-flow accounting within the defined system boundary and should not be understood as permanent carbon removal or an additional emission reduction.

6.2 What the Carbon Handprint Shows

The carbon handprint methodology, developed by the Technical Research Centre of Finland (VTT) and Lappeenranta University of Technology (LUT), shifts the focus from minimizing negative impacts (footprint) to maximizing positive impacts. A handprint quantifies the climate benefits an offered solution provides relative to a baseline solution. It provides a structured framework for communicating those benefits transparently and responsibly.³²

For example, if a bioplastic product reduces emissions compared to a fossil-based alternative, the difference represents its handprint.

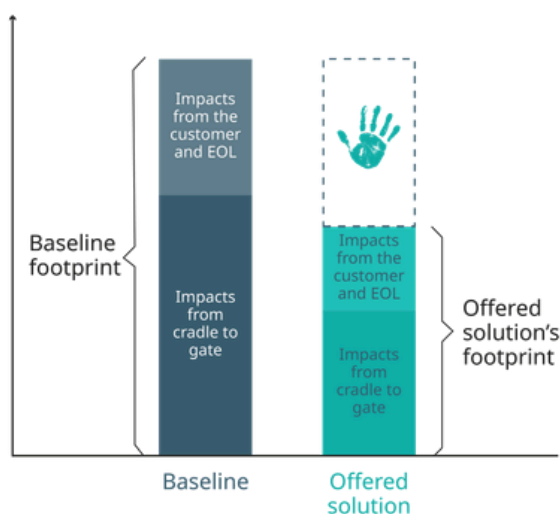


Figure 5 The carbon handprint represents the climate benefit achieved when an improved solution reduces greenhouse gas emissions compared with a baseline alternative. In this study, the handprint is generated by replacing fossil-based plastic with certified bio-circular material, thereby avoiding new fossil carbon input into the product system.

Alignment With Established Handprint Research

In this white paper, the carbon handprint is used to show the climate benefit of replacing a fossil-based healthcare product with an equivalent solution made from renewable, bio-based feedstocks. Put simply, this benefit comes from avoiding the introduction of new fossil carbon into the material system while using carbon that is already part of the natural cycle.³³

Handprint metrics show the positive climate impact of choosing renewable materials.

“They highlight avoided emissions and circularity benefits that traditional footprints don’t capture. For hospitals, this means demonstrating added value in climate strategies, procurement decisions, and sustainability reporting—not just meeting requirements, but clearly differentiating solutions that deliver measurable benefits.”

7 Putting Renewable Carbon into Practice with Sylva® bC

The Serres Sylva bC suction bag provides a practical example of how renewable carbon and circular-ready design can be applied in healthcare. It shows how material choice can reduce environmental impact while maintaining product performance.

Serres Sylva bC combines two complementary sustainability approaches: renewable carbon feedstocks that reduce dependence on fossil resources, and a lightweight mono-material design that reduces material use, improves recyclability, and supports future circular pathways. Renewable carbon is sourced from plant-based used cooking oil (UCO) and allocated through an ISCC PLUS-certified mass balance approach, replacing fossil feedstocks in plastic manufacturing. The solution remains compatible with the Serres suction system, including the Serres Nemo on-site medical fluid waste disposal device.

Figure 6 provides an overview of the Serres Sylva bC value chain, showing how renewable carbon becomes part of a healthcare plastic product and how circular end-of-life pathways can support future climate benefits.

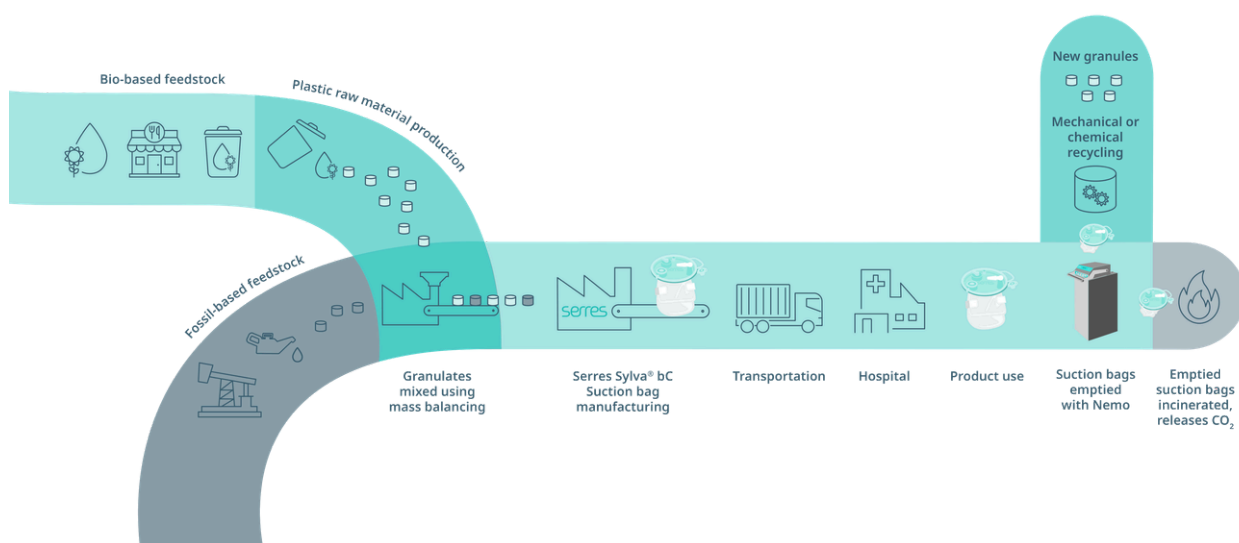


Figure 6 An overview of the Serres Sylva bC value chain. Renewable carbon from plant-based used cooking oil (UCO) is allocated through a mass balance approach and becomes part of the product, reducing the need for new fossil carbon inputs. After use, the suction bag can follow different end-of-life pathways, including incineration or recycling, depending on local infrastructure and waste management practices.

7.1 From Material Choices to System-Level Circular Readiness

Serres Sylva® bC supports the transition towards circular healthcare by reducing reliance on virgin fossil plastics and enabling future recycling pathways. This is achieved by combining certified bio-circular feedstocks, a recyclable mono-material design, and compatibility with existing hospital workflows.

To enter recycling systems, the suction bag must first be emptied using a fluid emptying device i.e. Serres Nemo, and pre-treated to ensure safe handling in line with local waste management practices. When these conditions are met, hospitals can move beyond disposal-focused end-of-life management and keep plastic materials in circulation for longer through recycling.

At this level, circular benefits depend on how feedstock choice, product design, and infrastructure work together. Table 6 summarizes the key elements and conditions that enable this transition.

Table 6 Key features of the Serres Sylva bC solution that support lower environmental impact and future circularity.

Measure	Why It Matters for Hospitals /Sylva bC Advantage
Carbon Handprint	Shows quantified emission reductions compared to fossil-based alternatives, supporting Scope 3 reporting and procurement decision-making.
Bio-Based Plastic Content (%)	2L solution contains 68% bio-circular material (ISCC PLUS certified), reducing reliance on fossil feedstocks and avoiding new fossil carbon input.
Biomass Feedstock Origin	Uses plant-based used cooking oil (UCO) as feedstock, which avoids competition with food production, repurposes waste, and reduces upstream emissions.
Circular Design	Lightweight mono-material design reduces material use and waste, while improving recyclability. Does not contain harmful chemicals.
System Compatibility	Fully compatible with existing hospital systems, maintaining performance and safety without requiring workflow changes as fossil-based alternatives.
Workflow Changes	No changes required to clinical practice, waste handling, or suction workflows, enabling immediate implementation.

8 Case Study: The Carbon Handprint of Serres Sylva bC

Hospitals face growing expectations to demonstrate measurable progress toward climate-aligned care. To support more sustainable procurement decisions, we conducted two case studies to quantify the climate benefits of transitioning from fossil based suction bags to the Serres Sylva bC 2 L suction bag.

The 2 case studies evaluate two complementary aspects of climate impact. These benefits are driven by avoiding the introduction of new fossil carbon into the product system:

- 1. The renewable material benefits:** What emission reduction is achieved by replacing fossil based plastic with certified bio-circular material?
- 2. End-of-life scenario benefits:** How do circular pathways, such as mechanical recycling, further reduce emissions?

Together, these studies translate design and material choices into quantified climate impacts, based on clearly defined assumptions and system boundaries. In both analysis, collected fluids are emptied using the Serres Nemo on-site medical fluid waste disposal device, which substantially reduces the mass of waste requiring disposal.

8.1 Study 1: Replacing Fossil-Based Plastic with Bio-Circular Material

Purpose and methodology of the study

This study quantifies the climate benefit of replacing a fossil-based 2 L Serres Sylva suction bag with the Serres Sylva bC suction bag, which contains 68% bio-circular plastic manufactured from plant-based used cooking oil (UCO) feedstock.

The analysis follows a cradle-to-end-of-life-site-gate approach and compares life cycle emissions under identical supply-chain and use conditions. The end-of-life site gate is the point where used products enter end-of-life treatment, such as incineration or recycling. Emissions from the treatment process itself are not included in this study.

This boundary avoids assumptions about specific end-of-life treatment pathways, allowing future circular solutions to be assessed separately.

Fossil greenhouse gas emissions and biogenic carbon flows are reported separately. Detailed methodology is provided in Appendix C.

Reference hospital scenario

The carbon handprint case study was conducted at a reference hospital in the Netherlands, with an annual usage of 100 000 suction bags. (Table 7).

Table 7 Reference hospital scenario used in the carbon handprint case study.

Parameter	Value
Location of hospital	The Netherlands
Annual usage	100 000 suction liners
Weight of waste box	1 kg
Disposed waste	Used suction bag. Waste box
Distance from hospital to disposal site	370 km

8.2 Emission Reduction Results and Scenarios

Replacing a fossil-based suction bag with Serres Sylva bC 2 L suction bags demonstrates measurable reductions in climate impact. The primary benefit assessed in this study is the avoidance of new fossil carbon inputs into the product system.

Scenario S0 represents the fossil-based baseline, S1 shows the effect of material substitution using Serres Sylva bC, and S2 reports biogenic carbon flows separately.

The difference between S0 and S1 reflects the avoidance of fossil carbon inputs, while S2 provides additional carbon-flow information within the defined system boundary and should not be interpreted as permanent carbon removal or an additional emission reduction.

Table 8 Scenarios used in the carbon handprint case study and what the reported results represent.

Scenario	Comparison	Result	What it means
Fossil-based baseline (S0)	Serres Sylva 2 L suction bag	Baseline	Reference product under identical supply-chain and use conditions.
Serres Sylva bC 2L (S1)	68% ISCC PLUS-certified bio-circular plastic allocated through mass balance.	28% lower fossil greenhouse gas emissions	Reduction achieved by avoiding new fossil carbon inputs.
Biogenic carbon-flow view (S2)	Biogenic uptake reported separately.	Reported separately	Shows carbon flows within the defined boundary.

Measured Reduction in Fossil Emissions from Avoided Fossil Carbon Input

Replacing a fossil-based suction bag with the Serres Sylva bC alternative reduces fossil based emissions by approximately 28% under a cradle-to-end-of-life-site-gate comparison.

Figure 7 summarizes the carbon handprint generated by replacing fossil-based plastic with certified bio-circular material, comparing the fossil-based baseline (S0) with the Serres Sylva bC solution (S1). For the defined functional unit of 100,000 suction bags, this corresponds to a carbon handprint of approximately 3,99 tonnes CO₂e, representing the difference between Scenario 0 and Scenario 1. This handprint represents the fossil greenhouse gas emissions avoided through material substitution and does not include biogenic carbon flow effects.

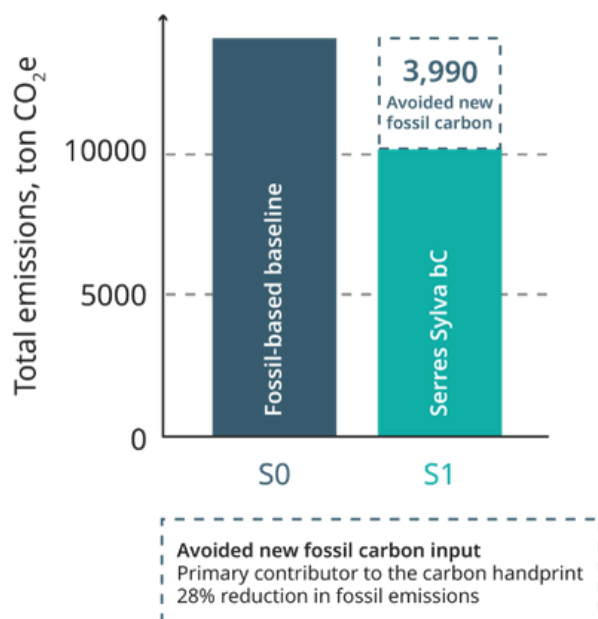


Figure 7 Carbon handprint of Serres Sylva bC 2L generated through material substitution. Based on a reference hospital using 100,000 suction bags annually, the handprint of 3.99 tonnes CO₂e represents the reduction in fossil greenhouse gas emissions achieved by replacing fossil-based plastic with certified bio-circular material and avoiding new fossil carbon input into the product system.

How Biogenic Carbon Accounting Affects the Results

Under the -1/+1 approach, biogenic carbon flows are reported separately as physical carbon flows within the defined system boundary. Figure 8 illustrates the amount of biogenic carbon remaining in the product at the end-of-life site gate. This information is reported separately to support transparent carbon-flow reporting and emerging discussions on product carbon storage.

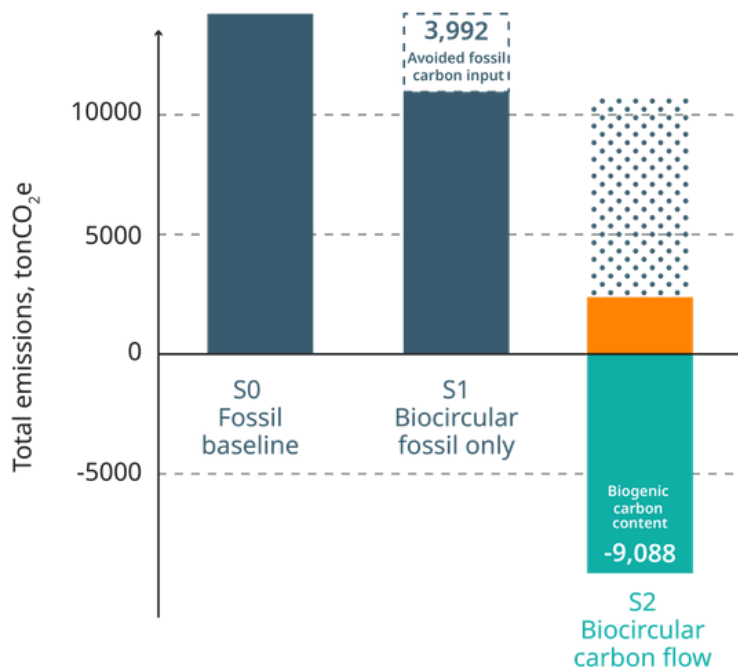


Figure 8 Biogenic carbon reported at the end-of-life site gate within the defined system boundary. Based on a reference hospital using 100,000 suction bags annually, the figure shows the amount of biogenic carbon originating from atmospheric CO₂ captured by plants during biomass growth and remaining in the product when it enters end-of life treatment. This value is reported separately as part of carbon-flow accounting and should not be interpreted as an additional emission reduction or permanent carbon removal.

In Scenario S2, approximately 9.1 tonnes CO₂e of biogenic carbon remains in the product at the end-of-life site gate within the defined system boundary. Potential additional climate benefits may arise if the carbon remains in circulation through effective recycling and other circular material-use systems.

Emerging guidance, such as the GHG Protocol Land Sector and Removals Standard, may recognize carbon retained in products (referred to as product carbon storage) as a separate reporting category while the carbon remains in circulation within the material system.³⁴

In systems where materials are collected, recycled, and reintroduced into new products, keeping biogenic carbon in circulation for longer periods can contribute to additional climate benefits. Both fossil-based and bio-circular products may be recycled through similar systems; however, these additional benefits are linked to the continued circulation of biogenic carbon and depend on the development of effective closed-loop systems and supporting infrastructure.

8.3 Case Study 2 — End-of-Life Scenarios

Purpose and approach

This study examines how circular end-of-life pathways can further reduce emissions beyond those achieved through bio-based plastics alone. The assessment compares four scenarios combining material type (fossil-based or bio-circular) and end-of-life treatment (incineration or mechanical recycling) to evaluate their effect on total CO₂e emissions, as summarized in Table 9. The assessment is based on research from the Finnish Environment Institute (SYKE)³⁵.

Table 9 Comparison of fossil-based and bio-circular 2 L suction bags under incineration and mechanical recycling pathways.

Scenario	End-of-Life	Material type	Description
S0 (baseline)	Incineration	Fossil-based plastic	Fossil-based suction bag (current standard practice).
S1	Incineration	68% bio-circular plastic	Bio-circular suction bag under typical disposal conditions.
S2	Mechanical recycling	Fossil-based plastic	Fossil-based bag with circular end-of-life pathway.
S3	Mechanical recycling	68% bio-circular plastic	Bio-circular bag combined with recycling.

In this study, fluids are emptied using an on-site fluid emptying device, and the emptied suction bags are pre-treated before recycling to ensure safe and compliant processing. The analysis applies a cut-off (0/0) approach for UCO-based feedstocks and includes substitution effects where recycled material replaces virgin plastic inputs. Full methodological details are provided in Appendix D.

Emissions reduction summary

The results show that end-of-life choices significantly influence climate performance:

- Switching from a fossil-based to a 68% bio-circular suction bag reduces emissions by approximately 23% under end-of-life incineration.
- Combining bio-circular material with mechanical recycling increases the reduction to approximately 37% compared to the fossil-based incineration baseline.

Figure 9 summarizes the results for the four end-of-life scenarios evaluated in Study 2, highlighting the combined effects of bio-circular materials and recycling.

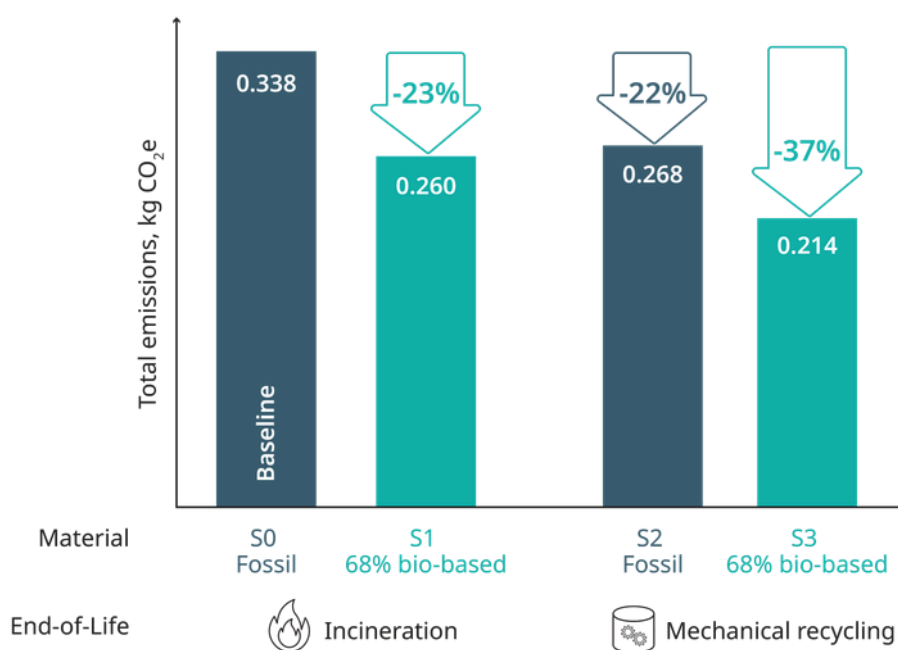


Figure 9 Climate impacts of four end-of-life scenarios for a 2 L suction bag in a reference hospital setting. The comparison illustrates how different circular economy measures contribute to emission reductions, with the greatest benefit achieved by combining bio-circular material and mechanical recycling.

8.4 Why this matters for hospitals

These case studies show that both material choice and end-of-life pathways influence the climate impact of single-use medical products. Replacing fossil-based plastic with bio-based materials delivers immediate reductions, while circular end-of-life systems can provide additional benefits as infrastructure develops.

Together, the studies show that material choices made today can create both immediate and future climate benefits.

9 How Hospitals Can Act on Low-Carbon Plastics

Healthcare will continue to rely on plastics because they help meet demanding requirements for safety, hygiene, and performance. However, fossil-based materials are no longer aligned with long-term climate and circular economy goals.

The case studies show that hospitals can reduce emissions today by replacing fossil based plastic with certified bio-circular plastic derived from renewable feedstocks, thereby avoiding new fossil carbon input into the material system. In the reference hospital case, this resulted in a 28% reduction in fossil greenhouse gas emissions (3.97 tonnes CO₂e per 100,000 suction bags annually). Potential additional future benefits may arise by keeping biogenic carbon in circulation through recycling and repeated material use.

Actions Hospitals Can Take Today:

1

Update procurement criteria

Integrate ISCC PLUS–certified bio-based materials and circular-ready products into sourcing requirements.

2

Align key stakeholders

Bring together procurement, sustainability, OR management, and environmental teams to align goals and enable coordinated decision-making.

3

Use handprint metrics in decision-making

Use carbon handprint data to quantify avoided fossil emissions and support procurement decisions, Scope 3 reporting, and sustainability targets.

4

Conduct case studies in real settings

Conduct case study to quantify environmental benefits within your hospital's own workflows.

5

Communicate circularity benefits

Communicate both current and future benefits. Highlight avoided fossil carbon emissions today, while clearly distinguishing potential future benefits that depend on recycling systems and supporting infrastructure.

Terminology

Bio-based Plastics

Plastics made partly or fully from renewable biomass feedstock sources—such as plants or organic waste—instead of fossil fuels.

Biogenic Carbon

Carbon captured from the atmosphere by plants through photosynthesis and stored in biomass. Unlike fossil carbon, it is part of the natural carbon cycle.

Circular Design / Circular-Ready Design

Product design that reduces material use and supports reuse or recycling.

Circular Economy (CE)

An approach that keeps materials in use for longer through reduction, reuse, and recycling.

Carbon Footprint

The total greenhouse gas emissions associated with a product, service, or system.

Carbon Handprint

The climate benefit achieved when an offered solution reduces emissions compared with a baseline alternative.

ISCC PLUS Certification

An international sustainability certification system that verifies traceability and compliance for biobased and recycled materials through independent audits.

Mass Balance Approach

A chain-of-custody method that enables traceable allocation of renewable or recycled feedstocks within mixed production systems

Product carbon storage

Biogenic carbon retained in a product or material system and reported separately from emissions and carbon removals while it remains in circulation.

Renewable Carbon

Carbon sourced from biomass, the atmosphere, or existing biological waste streams instead of fossil resources.

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About Serres

Serres is a Finnish company specializing in sustainable surgical fluid management solutions for hospitals worldwide. We focus on bringing responsible workflow to the operating room by making surgical suction and disposal safe and sustainable.

Learn more www.serres.com



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APPENDIX A: Scientific Evidence Supporting Renewable Carbon

Appendix A summarizes key scientific evidence supporting the use of renewable carbon in plastics. Meta-analyses, EU Joint Research Centre evaluations, and academic studies consistently show that replacing fossil-based feedstocks with renewable alternatives reduces greenhouse gas emissions and fossil resource use.

Table A1 highlights the most relevant findings and their relevance for healthcare procurement.

Table A1 Key Scientific Evidence Supporting Renewable Carbon.

Finding	What the Science Shows	Why It Matters for Hospitals
Lower Carbon Footprint	Meta-analysis: 80/98 bio-based products show lower emissions; on average ~45% lower GHG footprint vs fossil alternatives. ¹	Demonstrates measurable Scope 3 reductions across product categories.
Feedstock Choice Drives Impact	Studies consistently show that the carbon source is one of the strongest determinants of a product's environmental footprint. Renewable feedstocks significantly reduce GHG emissions and fossil-resource depletion compared to fossil-based materials. ²	Hospitals can lower Scope 3 emissions immediately by choosing products made with renewable carbon— without workflow changes.
Second-Generation Feedstocks Perform Best	Evaluations by the EU Joint Research Centre highlight that bioeconomy innovations deliver superior climate performance when using collected waste i.e. cooking oil, feedstocks. ³	Waste-based feedstocks avoid land-use impacts and food-resource competition, making them a credible and sustainable choice for medical plastics.
Fossil carbon is a major driver of warming	Around 70% of global warming is caused by fossil-carbon emissions, indicating a structural need to reduce virgin fossil inputs across product value chains. ⁴	Replacing fossil-based plastic with renewable carbon directly addresses one of healthcare's largest Scope 3 emission sources.
Circularity Amplifies Benefits	Research shows that combining renewable feedstocks with circular practices—recycling, reuse, or longer material retention—keeps biogenic carbon in circulation and increases overall climate benefit. ⁵	Hospitals gain additional long-term reductions as recycling infrastructure evolves.

¹ <https://doi.org/10.1038/s41467-023-43797-9>

² Lange, Green Chem., 2025, DOI: 10.1039/D5GC05590C

³ [JRC Publications Repository - Substituting conventional products with bioeconomy innovations: analysis of potential environmental impacts using a Life Cycle Assessment perspective](#)

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APPENDIX B: Policy Guidance Supporting Renewable Carbon

Appendix B summarizes key policy frameworks and industry roadmaps supporting the transition from fossil-based plastics to renewable carbon.

These policies provide a clear direction for healthcare organizations, confirming that biobased and circular-ready solutions align with future regulatory and procurement expectations.

Table B1 Key Policy and Industry Drivers for Renewable Carbon in Plastics.

Source	Key guidance
EU Bioeconomy Strategy & Circular Economy Action Plan ^{6 7}	Calls for reducing fossil carbon use and embedding circularity in product design and materials. Supports renewable carbon as a preferred feedstock for plastics and chemicals.
Sustainable Carbon Cycles Communication (EU) ⁸	Sets target: at least 20% of carbon in plastics and chemicals must come from sustainable non-fossil sources by 2030
Global Bioeconomy Policies (e.g. Canada ^{9 10} , Singapore ¹¹ , Australia ¹²)	National bioeconomy strategies support the deployment of bio-based plastics and chemicals through investment, innovation incentives, and circular-economy policies that reduce dependence on fossil feedstocks.
CEFIC Carbon Managers Roadmap ¹³	Forecasts that by 2050, bio-based feedstocks will account for >40% of total carbon demand, while the share of fossil feedstocks falls to ~35%. Chemical recycling and carbon capture will complement this transition and create a more resilient supply chain.
Healthcare Guidance (A Prescription for Change) ¹⁴	Recommends switching to low-GHG plastics and substituting fossil-based materials with bio-based alternatives as an effective way for hospitals to cut supply-chain emissions while maintaining safety and performance.
CHARME Bioplastics Guidance for Healthcare Procurement (2026) ¹⁵	Recommends a closed-loop approach, where bio-based materials return to new products, and calls for reporting results with and without biogenic carbon to enable transparent comparison.

⁶ https://environment.ec.europa.eu/strategy/bioeconomy-strategy_en

⁷ [Circular Economy - Environment - European Commission](#)

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¹² [Report outlines blueprint to grow Australia's bioeconomy - Centre for Agriculture and the Bioeconomy](#)

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¹⁴ <https://eunomia.eco/reports/a-prescription-for-change/>

Appendix C: Product Carbon Handprint Methodology (Study 1)

This appendix summarizes the methodology used to calculate the carbon handprint of the Serres Sylva bC 2 L suction bag presented in Section 8.1. The assessment follows ISO 14067 principles and the VTT/LUT Carbon Handprint methodology¹⁶. The cradle-to Serres gate part was critically reviewed, while hospital workflow and disposal data were provided by the reference hospital.

The purpose of the study is to quantify the climate benefits achieved when replacing a fossil-based 2L suction bag with Serres Sylva bC, containing 68% ISCC PLUS–certified bio-circular feedstock derived from plant-based used cooking oil (UCO) and allocated via a mass balance approach. Both products are manufactured in Finland.

This substitution reduces emissions by avoiding the use of fossil carbon while maintaining the same product function, performance, and clinical use. The study isolates the effect of replacing fossil-based plastic with certified bio-circular material while keeping all other conditions unchanged.

Scope and Functional Unit

- **Product studied:** Serres Sylva bC 2L suction bag (68% bio-circular feedstock)
- **Baseline:** Fossil-based Serres Sylva 2L suction bag with identical function and manufacturing site
- **Functional unit:** 100,000 suction bags used annually at a reference hospital in the Netherlands
- **Use context:** Bags used in operating rooms; fluids emptied using the Serres Nemo on-site fluid disposal device

System Boundary (cradle-to-end-of-life site gate)

The assessment applies a cradle-to-end-of-life site gate boundary, covering all life cycle stages up to the arrival of the used product at the treatment facility. This boundary isolates the effect of material substitution while avoiding assumptions about specific end-of-life treatment pathways, which vary across healthcare systems and may change as circular solutions develop. Results therefore reflect emissions within a clearly defined and comparable product system, aligned with ISO 14067 principles.

The carbon footprint assessment includes:

Upstream (Cradle-to-Gate)

- Extraction and production of raw materials and packaging materials
- Transportation of raw materials and packaging to the manufacturing site
- Production of packaging materials

Core processes (Gate-to-Gate)

- Manufacturing and assembly at the Serres facility in Kauhajoki, Finland
- Electricity and district heating used in production
- Treatment of production waste

Downstream (Gate-to-End-Of-Life Gate)

- Transportation of finished products to customers in the Netherlands
- Use stage (clinical application)
- Transportation to the end-of-life treatment facility (i.e. incineration or recycling)

Table C1 Key study inputs, assumptions, and data sources used in the carbon handprint assessment

Category	Description
Standards followed	ISO 14067:2018; Carbon Handprint methodology developed by VTT and LUT
Calculation platform and emission data	OpenCO2 calculation tool using emission data from the OpenCO2.net database
Activity data	Product mass: 52 g per unit; annual volume: 100,000 units; reference case: hospital in the Netherlands
Data quality	Primary data from 2025 operations; site-specific data from Serres Kauhajoki (Finland); technology coverage based on actual manufacturing processes and site technology
Purchased energy	Market-based GHG emission factors from local energy suppliers
Raw materials	Verified third-party databases and supplier-specific data where available
Transport	Supplier-specific transport data where available; otherwise average transport data and tonne-kilometre-based calculations

Biogenic Carbon Accounting

To enable fair comparison between fossil- and bio-based plastics, the study applies the –1/+1 approach, where biogenic CO₂ uptake is treated as a negative emission and release as a positive emission. Biogenic carbon flows, including biogenic carbon remaining in the product at the end-of-life site gate, are reported separately from fossil emissions within the defined system boundary. No broadly accepted methodology currently exists for consistently quantifying the climate significance of delayed emissions and carbon retained in products across assessment frameworks.¹⁷

Table C2 Greenhouse gas emission components and biogenic carbon flows included within the defined system boundary.

GWP Component	Included	Notes
Fossil CO ₂ emissions	✓	All fossil emissions occurring up to the EoL site gate are included.
Biogenic CO ₂ uptake (atmospheric carbon uptake during biomass growth)	✓	Accounted for as –1 during biomass growth and allocated to the bio-circular feedstock via mass balance. Essential for fossil vs. bio-based comparability.

Biogenic CO ₂ emissions during plastic manufacturing	✓	Includes biogenic CO ₂ emissions occurring during feedstock processing and polymer production within the system boundary.
Biogenic CO ₂ release (at end-of-life)	✗ (excluded)	Occurs after EoL site gate and therefore outside the main system boundary.
Biogenic carbon in product at EoL site gate	✓ (reported separately)	Biogenic carbon remaining in the product at the EoL site gate, reported separately to support transparent carbon-flow reporting and alignment with emerging reporting practices for carbon retained in products.

Summary of Results

The assessment showed that replacing a fossil-based suction bag with Serres Sylva bC reduced fossil greenhouse gas emissions by 28% within the defined cradle-to-end-of life-site-gate system boundary. This corresponds to a carbon handprint of appr. 3.99 tonnes CO₂e per 100,000 suction bags annually in the reference hospital case study. The reported reduction reflects the avoidance of new fossil carbon input and associated upstream emissions.

Biogenic carbon flows were reported separately as part of carbon-flow accounting. Approximately 9.1 tonnes CO₂e of biogenic carbon remained in the product at the end of-life site gate within the defined system boundary. This value is reported separately from the carbon handprint and should not be interpreted as an additional emission reduction or permanent carbon removal.

Potential additional climate benefits may arise if biogenic carbon remains in circulation through effective recycling and other circular material-use systems. These effects depend on the performance of closed-loop systems and supporting infrastructure and are not included in the reported handprint result. Emerging guidance may recognize carbon retained in products (referred to as product carbon storage) as a separate reporting category while the carbon remains in circulation.¹⁸ Detailed calculation results and full study documentation are available upon request.

Appendix D Methodology for Study 2: End-of-Life Scenarios

The end-of-life analysis in Study 2 is based on a life cycle assessment (LCA) carried out by the Finnish Environment Institute (SYKE). The assessment follows the principles of ISO 14040 and focuses on quantifying the climate impacts of different disposal pathways for a 2-litre single-use suction bag used together with a multi-use rigid suction canister.

The system boundary covers the full life cycle, including raw material extraction, manufacturing of the suction bag, lid, canister, and emptying device, as well as use-phase processes and end-of-life treatment.

Manufacturing, use, and disposal activities are modelled in Finland, while the bio-based feedstock (used cooking oil) is assumed to be collected and processed in the Netherlands. Transport of materials and waste streams is included.

A baseline scenario assumes a virgin fossil-based 2 L bag that is filled during use, emptied on-site in the operating room ward using the Nemo fluid emptying device, and incinerated.

Alternative scenarios assess changes in the value chain, including the use of bio-based materials and mechanical recycling. These scenarios are summarised in Table D1.

Climate impacts were calculated using the Environmental Footprint 3.1 impact assessment method. A cut-off approach was applied for the bio-based material derived from used cooking oil, meaning that burdens from the oil's original use were not allocated to the system. Substitution benefits were included where recycled materials replace virgin plastic inputs.

Foreground data for manufacturing and use was provided directly by the product manufacturer, while background datasets were sourced primarily from ecoinvent 9.6.

Table D1 End-of-life scenarios and key assumptions used in the assessment.

Scenario	Raw Materials & Manufacturing	Use Phase	End-of-Life Treatment
S0: Baseline. fossil based suction solution	Single-use suction bag + multi-use rigid canister made from virgin materials	Bag filled, emptied with Nemo device, and packed into a waste bag.	Emptied bag solution incinerated with waste bag (energy recovery)
S1: 68 % Bio-based suction bag solution	Canister from virgin materials; suction solution made 68 % from UCO-based bio-plastic + multi-use rigid canister made from virgin materials	Bag filled, emptied with Nemo device, and packed into a waste bag.	Emptied bag solution incinerated with waste bag (energy recovery)

S2: Fossil based suction solution + mechanical recycling	Single-use suction bag + multi-use rigid canister made from virgin materials	Bag filled, emptied with Nemo device, and packed into a waste bag.	Emptied bag mechanically recycled after autoclave disinfection
S3: 68 % Bio-based suction bag solution + mechanical recycling	Canister from virgin materials; suction solution made 68 % from UCO-based bio-plastic + multi-use rigid canister made from virgin materials	Bag filled, emptied with Nemo device, and packed into a waste bag.	Emptied bag mechanically recycled after autoclave disinfection

The scenarios presented in this white paper correspond to a simplified subset of the full scenario set analysed by SYKE. The selected scenarios focus specifically on the climate impacts of bio-circular material substitution and mechanical recycling.