IN-DEPTH

Reassessing single-use plastic products in the airline sector

A report on the opportunities and challenges of replacement

26 March 2024

This report provides visibility to the challenges faced by the air transport industry when it comes to single-use plastic products (SUPP) along with practical recommendations to the industry and its various stakeholders, including regulators. Collaboration across the aviation value chain is vital to enable circular economy principles, while seeking for a sectoral approach to facilitate the reduction and replacement of SUPP.

ABOUT

This report was prepared by the International Air Transport Association (IATA) with support from Travel Without Plastic and WRAP.

IATA is the trade association for the world's airlines, representing some 320 airlines or 83% of total air traffic. IATA's mission is to represent, lead, and serve the airline industry. IATA supports many areas of aviation activity and helps formulate industry policy on critical aviation issues.

Travel Without Plastic (TWP) works predominantly with accommodation providers and tour operators of all sizes to help them to significantly reduce their contribution to waste and plastic pollution. Through a combination of structured programs and tailored support, TWP gives their customers confidence to implement new ways of working that reduce waste without compromising the guest experience or safety standards.

WRAP is a climate action NGO working with governments, businesses, and citizens to create a world in which we use resources sustainably. WRAP's vision is a thriving world in which climate change is no longer a problem. WRAP's experts generate the evidence-based solutions needed to protect the environment, build stronger economies, and support more sustainable societies. WRAP's impact spans the entire life cycle of food, clothes, and products, from production to consumption and beyond.

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EXECUTIVE SUMMARY

SUPP are widely used in aviation due to their strength, lightness, and ability to meet safety and security regulations. However, the airline sector faces challenges associated with improved cabin waste performance and the replacement of SUPP with sustainable alternatives. In addition, airlines face technical and operational obstacles, and the lack of harmonized and risk-based regulations presents a significant barrier to improving recycling and circularity of waste management. The absence of smart regulation continues to constrain airline efforts to improve the sustainability of cabin operations.

Collaboration across the aviation value chain is vital to enable the adoption of circular economy principles and to facilitate the reduction and replacement of SUPP that is necessary for reducing waste and increasing material recovery.

This publication is timely as the United National Environmental Program (UNEP) has convened an intergovernmental negotiating committee (INC) to develop an international legally binding agreement on SUPP use by the end of 2024.

The report advocates for a sectoral approach to managing SUPP in aviation with a clear set of recommendations.

Key recommendations for airlines:

- Reduce waste at source by reviewing standards and procedures through the lens of waste reduction and reuse, and professionally assess the need for SUPP. Set clear targets for the elimination, measurement, and tracking implementation, and disclose progress.
- Introduce reusable items as a strategy to drive circularity. This requires logistical changes that incorporate a closed-loop service, including the impact of potential added weight of reusables on aircraft on fuel burn and carbon emissions.
- To improve waste management and recovery by facilitating onboard and ground waste segregation, and undertaking waste composition audits for passenger and cargo operations.

Key recommendations for regulators:

- Proactively encourage the minimization of SUPP by addressing the need for simple harmonized regulations and legislation. Develop guidance that allows for global common definitions and standards for alternative products that include labelling, integrity and certifications.
- Create the infrastructure and frameworks that will make reuse models possible, while being aware of and responsive to the characteristics of international airline operations.
- Endorse a clear methodology and the sharing of good practices as essential to ensuring that segregation processes are efficient and effective.
- Support the development of infrastructure for waste segregation and recovery at or close to airport premises.

Key recommendations for the supply chain:

- Take part in or organize solution-focused discussions involving key stakeholders, to help identify and implement process changes that prioritize end-to-end solutions that ensure best practices and promote regulatory change.
- Increase public/private sector collaboration and significant investments to implement circular economy principles in the airline sector value chain to enable considerable changes to processes and procedures for stakeholders both upstream and downstream.

1. INTRODUCTION

1.1. Purpose

This report is designed to provide recommendations for airlines, regulators, and other aviation stakeholders about the unique situation faced by the global airline industry regarding the replacement of single-use plastic products (SUPP) with sustainable alternatives. It formulates strategic and practical suggestions for private and public sector actors to reduce unnecessary and problematic SUPP, to divert reusable and recyclable SUPP from landfill and incineration, and to implement more circular models into the airline sector value chain.

Recognizing the work done by the United Nations Environment Programme (UNEP) and the World Travel & Tourism Council (WTTC) in the publication *Rethinking Single-Use Plastic Products in Travel & Tourism*[1] this report explores the needs of upstream and downstream stakeholders including airports, catering companies, cleaning companies, and cargo handlers among others, to enable a more circular approach to material use, product design and innovation, procurement policies, and appropriate waste management.

Practical information on Life Cycle Assessments (LCAs) is included as are decision trees on the replacement of the most frequently used SUPP in passenger and cargo operations. The report also includes case studies that may be replicated across the industry.

1.2. Scope

This report primarily focuses on SUPP used in passenger and cargo operations. Although SUPP in other airline operations (e.g., maintenance, repair and operations, and ground handling) are not specifically considered, the information and tools provided can also be applied to these activities.

The main SUPP identified and analyzed through this report are water bottles; single-use cups for hot and cold drinks; single-use crockery; single-use cutlery; and cargo plastic sheets and stretch wrap.

1.3. Methodology

To better understand the use of SUPP in passenger and cargo operations, the methodology included an initial review of airlines SUPP inventories, targets and initiatives, an airline web survey, and a detailed review of LCAs and SUPP legislation. An additional focus of the research was the identification of "leakage hotspots".

For additional details regarding the methodology in this paper, please see Annex 1.

[1] UNEP and WTTC (2021). Rethinking Single-Use Plastic Products in Travel & Tourism - Impacts, Management Practices and Recommendations.

2. BACKGROUND

2.1. The global scale of plastic pollution

Plastic pollution is seen as a key challenge for our times. UNEP states that plastic pollution "can alter habitats and natural processes, reducing ecosystems' ability to adapt to climate change, directly affecting millions of people's livelihoods, food production capabilities and social well-being"[2]. The impacts of plastic pollution can be seen along the entire plastic life cycle. From exposure to chemicals, plastic particles and additives used in the production phase, leakage of mismanaged plastic that turn into macro and microplastics contributing to air pollution and affecting the marine environment, to the contribution to climate change from plastic production and conversion from fossil fuels.[3]

According to the Organisation for Economic Co-operation and Development (OECD), 430 million metric tons of plastic are produced each year[4], with over one third being discarded after only one use[5]. With only 10% of plastic recycled globally, the remainder is either burned—causing air pollution—or dumped in the open, of which around 2% ultimately ends up in the ocean. Plastic now comprises an estimated 85% of total marine waste.[6][7]

SUPP, designed to be discarded after just one use, are the focus of increasing public concern and regulatory action. The inappropriate disposal of SUPP represents a major risk to ecosystems as they decompose very slowly and break into microplastics, which can damage sea life and enter the marine food chain, posing significant threats to wildlife, and human health.

UNEP recognizes that governments need to find new ways to deal with waste collection and management practices, and implement new policies aimed at eliminating unnecessary and problematic plastics. The SUPP that are necessary should be replaced by reusable, recyclable or compostable options and drive circular models that keep plastics in the economy and out of the environment.[8]

In 2022, 170 nations pledged to significantly reduce the use of plastics by 2030 at the United Nations Environment Assembly (UNEA) and a resolution was adopted to develop an international legally binding instrument on plastic pollution, including in the marine environment (the "Plastics Treaty") by the end of 2024.

As a global agreement the Plastics Treaty "would reflect diverse alternatives to address the full life cycle of plastic, including the design of reusable and recyclable products and materials, and the need for enhanced international collaboration to facilitate access to technology, capacity building and scientific and technical cooperation.[9]"

The initial discussions on the elements of this instrument support a sectoral approach developed at a multilateral level with relevant international organizations[10]. To be successful, the agreement needs to address social and environmental objectives and create an enabling environment that will accelerate a new plastic economy[11].

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[2] UNEP. Plastic Pollution.
[3] UNEP (2022). Plastic Science.
[4] OECD (2022). Global Plastics Outlook.
[5] Landrigan et al. (2023). The Minderoo-Monaco Commission on Plastics and Human Health.
[6] Chemical Pollution (2022). The huge problem of microplastics.
[7] Stoett, P. (2022). Plastic Pollution: A global challenge in need of multi-level justice-centered solutions.
[8] UNEP. The New Plastics Economy Global Commitment.
[9] UN (2022). Nations sign up to end global scourge of plastic pollution.
[10] UNEP/PP/INC.3/4.
[11] UNEP. Intergovernmental Negotiating Committee on Plastic Pollution.

2.2. Single-use plastics and aviation

The SUPP used throughout the aviation value chain and that have played an important role in the delivery of the passenger experience and cargo operations for decades, are under scrutiny as concerns surrounding SUPP continue to grow.

SUPP are widely used in the aviation industry because of their lightweight and hygienic properties. Nevertheless. cabin waste composition audits conducted in 2013-2014[12] and in 2018[13] found that plastic accounted for 17%–20% by weight. Although polyethylene terephthalate (PET) bottles are a highly visible SUPP, they only account for 2% of the waste. Moreover, airline operations are required to use certain SUPP by civil aviation authorities' regulations seeking to ensure safety and security.

Many airlines are accepting the challenge of plastic pollution, and at least 40 airlines have implemented SUPP reduction and replacement programs with some starting as far back as 2018, according to IATA. Although the pandemic reversed the trend in SUPP replacement as many health authorities mandated the sealing of inflight food and beverages, airlines have since reintroduced replacement programs.

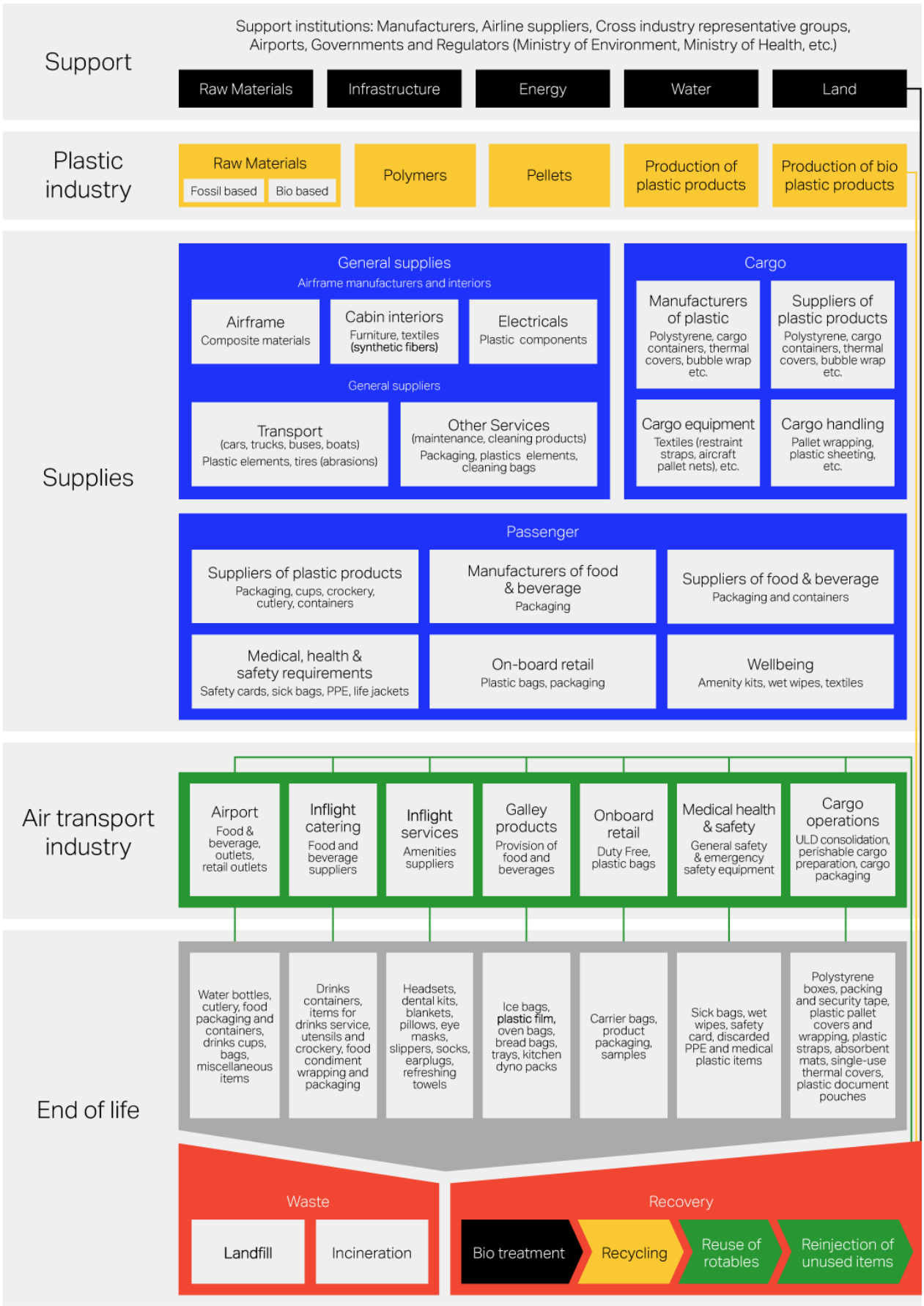
The IATA passenger insights survey conducted in November 2023[14] showed that more than three quarters of passengers would feel better about flying if it did not involve any SUPP, and that they would be happy to support less food and beverage options so that airlines could achieve this.

Cargo operators are also receiving requests from end customers to reduce the associated plastic packaging and wrapping. This has led to the introduction of novel solutions to reduce the use of plastic in cargo operations, though these initiatives are not yet widespread. The IATA Shipper Survey 2022[15] showed that 50% of cargo customers include waste reduction along the supply chain among their top priorities, and more than a third include access to sustainable packaging options.

The complex nature of stakeholders, activities, and processes involved in the creation, distribution, and delivery of SUPP used by airlines to deliver their services to passengers and cargo clients is illustrated in Figure 1.

[12] IATA Cabin Waste Handbook.
[13] Cathay Pacific Airways Limited. Sustainable Development Report 2018.
[14] The IATA passenger insights survey was conducted 31 October-13 November 2023 with a sample of 6,500 recent travelers. It covers 15 markets (Australia, Canada, Chile, China, France, Germany, India, Indonesia, Japan, Singapore, Spain, The Netherlands, UAE, UK, and USA). The sample size in each market was 500, apart from Chile, Japan, Singapore, The Netherlands, and UAE, where it was 300. This Is Motif Ltd prepared the questionnaire and analysis based on data collection and tabulation by Dynata. www.thisismotif.com.
[15] 2022 IATA Global Shipper Survey.

Figure 1. Airline sector value chain where SUPP may be used.



2.3. Leakage pathways of plastic into the environment from the airline sector

Although there is potential for plastic waste from aircraft maintenance, refits and decommissioning to enter the environment, the principal environmental risk from the airline sector is from the inappropriate disposal of SUPP. According to UNEP and WTTC, the risk of leakage of plastic pollution into the environment from the airline sector value chain in medium and high-income countries is categorized as low. This is due to the strict procedures associated with removing and processing cabin waste that prevents it from escaping into the environment.[16] Nevertheless, leakages into the environment can occur.

Airports closely control waste handling and management procedures to ensure that foreign object debris (FOD) does not damage aircraft and that uncontrolled dumping and landfills around the airport do not attract animals, including birds. However, plastic waste discarded around the airport perimeter including car parks and smoking terraces, may be blown into the local environment.

Potential leakage points upstream that are outside of the direct control of airlines include the point of extraction and processing of plastic raw materials, such as spillage of pellets during the manufacture of polymers, or inappropriate handling of plastic waste generated during the manufacture or preparation of products for cabin airframes, cabin interiors, and inflight services products.

Downstream, lightweight plastic products, such as packaging and plastic bottles, can also be blown into the environment if they are transported in open vehicles or if waste management sites are poorly managed, irrespective of the International Catering Waste (ICW) and FOD regulations in place.

Passengers may also carry SUPP onto aircraft or purchase SUPP onboard, and there is potential for them to become pollution if they are improperly disposed of after leaving the aircraft.

Although much of the potential leakage occurs at points outside of the direct control of the airlines, minimizing the use or eliminating SUPP can limit both upstream and downstream sources of pollution, cutting procurement and waste management costs.

Other contributors to plastic pollution that are less commonly noticed by businesses within the airline sector value chain are captured in Table 1 and can also be visualized in Figure 2. Leakage pathway of plastics into the environment in the airline sector value chain..

Table 1. Hidden SUPP in the airline sector that could contribute to plastic pollution.

Hidden SUPP	Rationale	Airline Sector Implication	Leakage from
Wet wipes and sanitary items	These SUPP items are the fifth most commonly found on EU beaches[17], with many incorrectly labelled as “flushable” causing blockages in sewage systems and becoming marine pollution.	These products could end up in aircraft wastewater tanks and be discharged to the airport wastewater system	Passengers and crew
Tire abrasion	Tire abrasion is one of the largest sources of microplastics in the ocean (UNEP 2018).	Research estimates that up to 2% of the microplastics may be generated from aircraft tires[18].	Flight operations

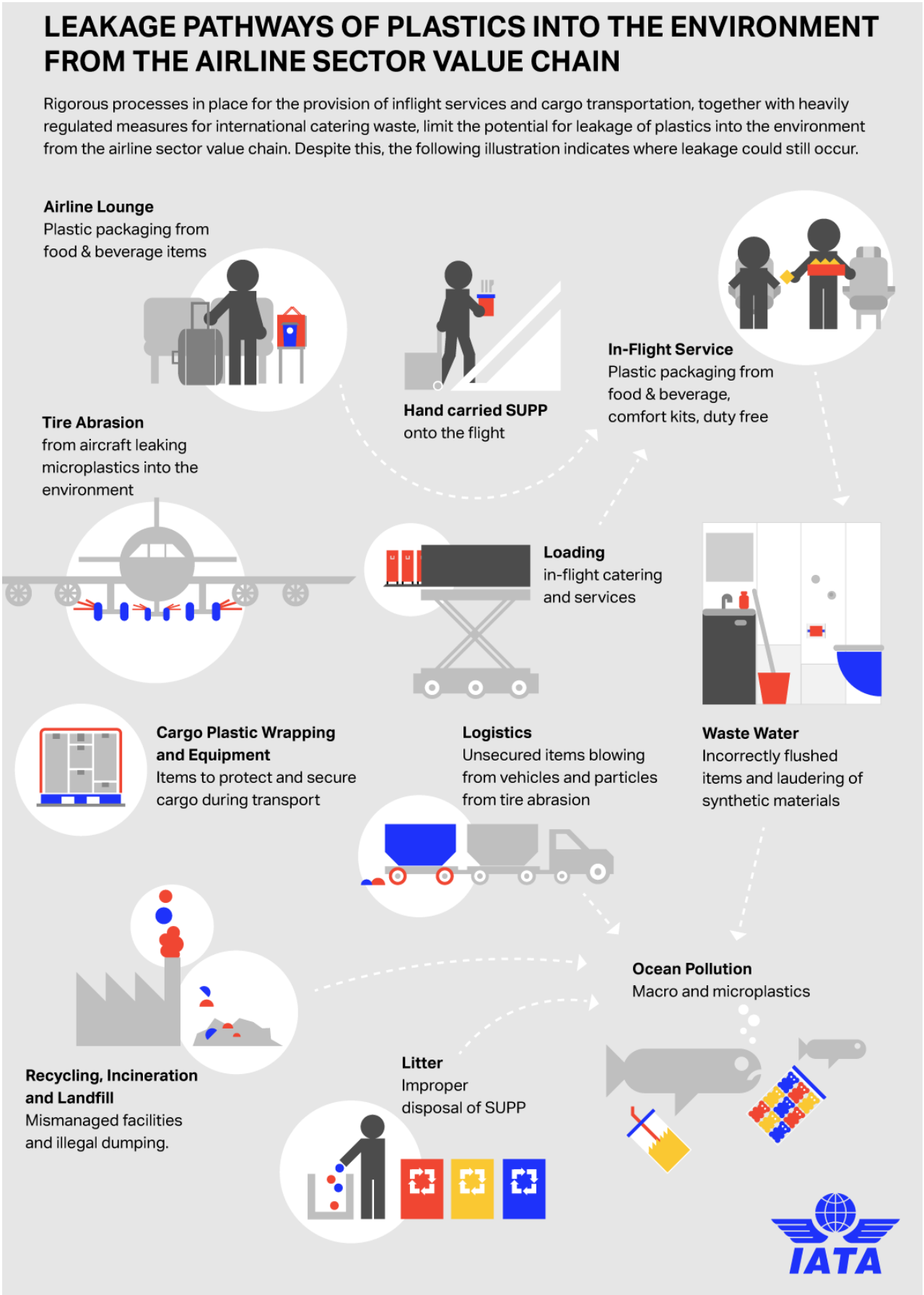
[16] United Nations Environment Programme and World Travel & Tourism Council (2021). Rethinking Single-Use Plastic Products in Travel & Tourism - Impacts, Management Practices and Recommendations. Nairobi.
[17] WWF (2019). Stop the flood of plastic.
[18] Jan Kole et al. (2017). Wear and Tear of Tyres: A Stealthy Source of Microplastics in the Environment.

Textile washing (uniforms, blankets, and pillows)	**Sheds microplastic fibers into wastewater systems if filtration systems are not used during the washing cycle.**	**Airlines should consider reviewing the material of the fabrics and check the washing systems procured.**	**Ground operations**

Source: Adapted from UNEP/WTTC "Rethinking Single-Use Plastic Products in Travel & Tourism"[19].

[19] United Nations Environment Programme and World Travel & Tourism Council (2021). Rethinking Single-Use Plastic Products in Travel & Tourism - Impacts, Management Practices and Recommendations. Nairobi

Figure 2. Leakage pathway of plastics into the environment in the airline sector value chain.



3. IMPLEMENTING CHANGE

When considering SUPP in aviation, though some items can be avoided, it is impossible to operate passenger and cargo flights without providing services that rely on packaging and infight products. In terms of reducing or eliminating SUPP, this typically means replacing them with a different product or service.

Airlines, suppliers, and regulators need to exercise caution when replacing SUPP with other materials as the alternatives might not always generate the best environmental or social outcomes. Every alternative to SUPP has its own set of corresponding impacts, not all of which are immediately obvious, as they may be hidden elsewhere within the value chain. Attempting to solve plastic pollution could inadvertently contribute to increased emissions and other environmental impacts, demonstrating the complex trade-offs that airlines and regulators must consider. For example, weight is of critical concern to airlines since it links directly to fuel burn and greenhouse gas (GHG) emissions. Furthermore, water and energy would be required for washing and drying reusable products, the impacts of which will vary depending on whether these services are based in destinations with water scarcity and whether installations use renewable energy or fossil fuels.

In addition to the inherent challenge of identifying solutions that are certifiably net beneficial to the environment, airlines and their value chain partners must also navigate a fragmented regulatory context. They also need to consider operational challenges and costs, such as the availability and usability of alternatives, safety, biosecurity, the passenger experience, limited galley space, the role of crew and cargo handling staff, and cargo logistics, and more.

3.1. The regulatory environment

Given the scale of the SUPP challenge, consumers are demanding plastic-free products and, in turn, regulators are implementing local, regional, or national restrictions without always considering the full consequences for the entire supply chain, especially as it applies to the global business of international aviation.

Encouragingly, a large number of countries (127 already in 2018) have introduced bans on SUP bags[20], and over 91 have introduced additional restrictions on manufacture, import, and distribution of SUPP[21], with the EU Plastics Strategy being the first on introducing bans on specific products, including straws, crockery, cutlery, cups, and materials such as polystyrene.[22]

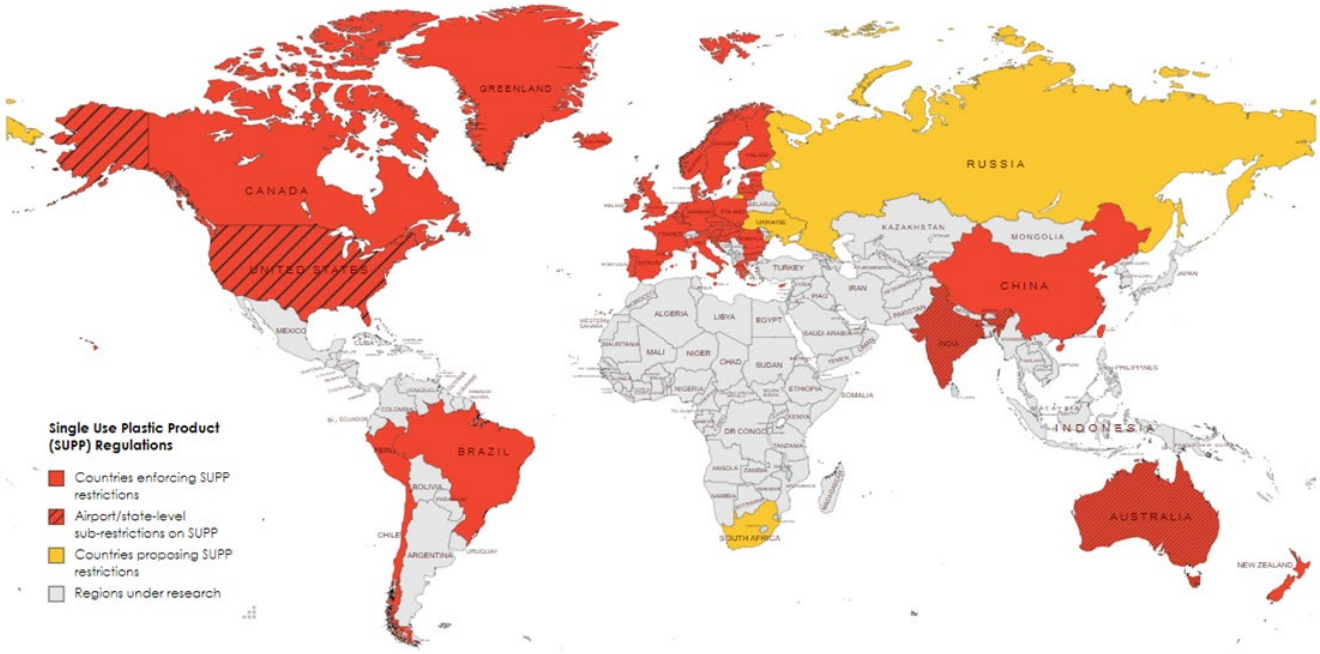
However, the resulting regulatory environment is complex because an international consensus on the definition of SUPP has not been reached, nor there is a common framework to identify acceptable substitutes and alternatives. Although the Plastics Treaty is currently being negotiated and is expected to take a life cycle approach, agreement on the level of implementation and harmonization of asymmetric regulations still needs to be reached.

In May 2021, the 27 Member States of the European Union transposed the EU Directive on SUPP into national legislation and bans on certain SUPP took effect in July 2021.[23] This has not prevented the emergence of multiple different regulations across countries, such as the new rules for disposable plastic cups and containers in the Netherlands[24]. In China, the Civil Aviation Administration banned in 2022 a range of plastic items specifically in airports that have an annual passenger throughput of 200 million or more passengers and

[20] United Nations Environment Program (2018). Legal Limits on Single-Use Plastics and Microplastics.
[21] Patrício Silva et al. (2020). Rethinking and optimising plastic waste management under COVID-19 pandemic.
[22] European Commission. EU restrictions on certain single-use plastics.
[23] Ibid.
[24] Ministerie van Infrastructuur en Waterstaat. Zo past u de regels voor plastic wegwerpbekers en -bakjes toe.

for domestic flights.[25] There is no evidence, however, that any LCAs have been undertaken to identify the impacts of implementing these changes in the aviation sector.

Figure 3. Map of current SUPP regulations in place.



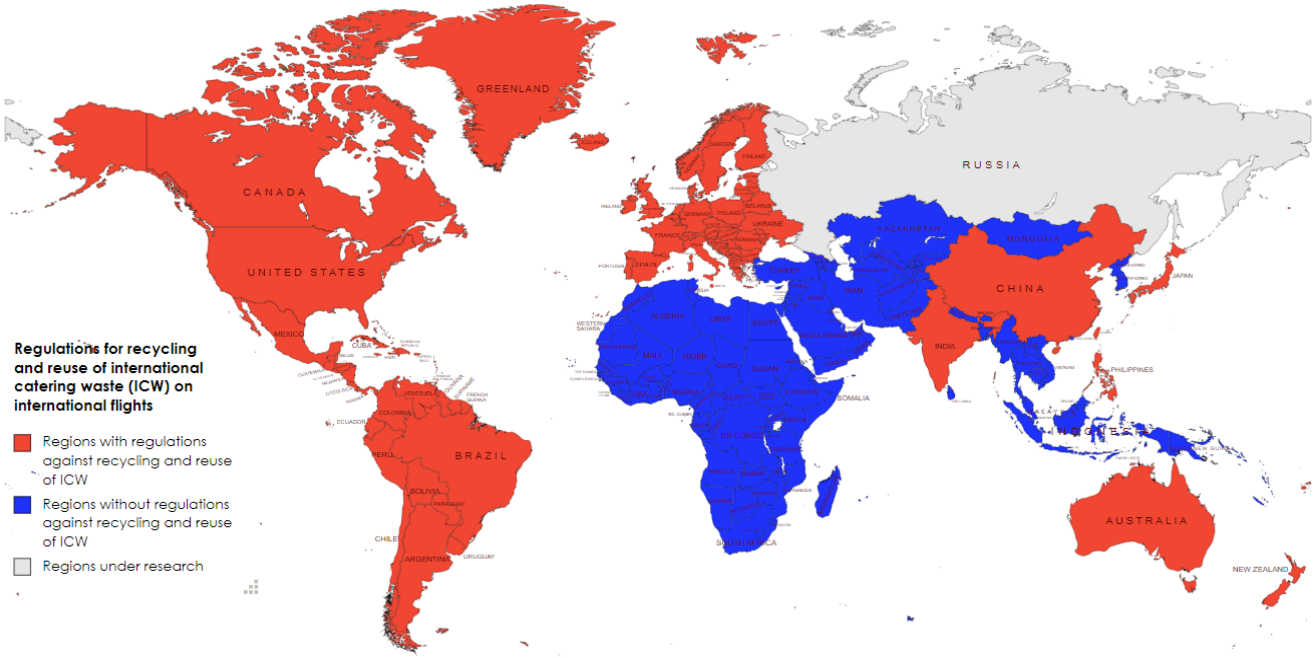
Source: IATA.

Complicating the situation further for airlines, ICW legislation precludes the recycling and reuse of items that contain or that have been in contact with animal-based foodstuffs, with the objective of minimizing risks to animal health. For example, EU's Animal By-Products legislation[26] classifies ICW as biohazardous waste (Category 1). This regulation requires that ICW is subject to strict control and treatment by incineration or disposal by deep burial in an authorized landfill.

Although risk to animal health is a valid concern, there is no evidence that quantitative risk assessments of animal disease outbreaks from ICW have been undertaken. With food safety being of critical concern, following the Hazard Analysis and Critical Control Point (HACCP) food safety protocols, this biohazardous classification seems disproportionate.[27]

[25] Civil Aviation Administration of China. Plan for Civil Aviation Plastic Pollution Control Measures 2021–2025.
[26] Regulation (EC) No 1069/2009 laying down health rules as regards animal by-products and derived products not intended for human consumption.
[27] IATA et al. (2023). Towards Smarter Regulation of International Catering Waste (Category 1) in Aviation.

Figure 4. Map of current ICW regulations in place.



Source: IATA.

SUPP regulations often fail to recognize that alternatives to SUPP in aviation must meet strict safety and hygiene requirements. A lack of aviation specific standardized LCAs means that considerations regarding how to ensure that the introduction of alternatives does not displace pollution from the marine environment to the atmosphere, or how the lack of infrastructure required to support reuse models within the global aviation value chain can be addressed, are left unanswered. Particularly for international airlines that can fly up to 120 different countries.

Furthermore, as airlines have long supply chains and purchase inflight products in bulk, often pre-positioning branded products at outstations for the return journey, they could be procuring alternatives to SUPP that do not comply with all regulators' restrictions across an international flight. Without significant and timely public/private sector investment in reusable infrastructure or exemptions for the sector, compliance with upcoming regulation will be challenging.

It is already a complex task to comply with current regulations. In some cases, there is no definitive list of exact product types that would fall under a particular definition, such as 'tableware' or 'foodware', making it uncertain for instance if products such as single-use hot drink cups that are lined with plastic would be included within the prohibition or restriction. In other cases, it is the interpretation of "use" that is complex. The definition of "take-away" and "dine-in" options are clear for restaurants and cafes, but it is unclear how they apply to airline catering.

In some countries, there are lists of exempt types of business, but often airlines are neither listed as exempted nor as directly affected by the legislation. Where there are nationwide restrictions, domestic airlines will be affected as they will not be able to source prohibited products, but the impact on international airlines is not clear.

Table 2 provides a general overview of the legislation around SUPP in the five countries that were reviewed. [28] Further detail on how these restrictions and bans affect the problematic SUPP used by the airline sector can be found in Annex 2.

Table 2. SUPP regulations review and implications for the airline industry.

Country	Dates	Implications
Australia	From 2021 to 2025 (proposed) depending on the state.	Phase out the use and sale of problematic single-use plastics by 2025, with different regulations per state and comply with the National Packaging Targets by 2025.Airlines will not be able to procure packaging that is made, used, and sold in Australia.[29,30,31]
Canada	December 2022: purchase or import. June 2024: sale of flexible straws. December 2025: import for purposes of export.	Prohibition of the manufacture, import and sale of SUPP checkout bags, cutlery, foodservice ware[32], ring carriers, stir sticks, and straws. Restricted items can be removed as waste. Restricted items can remain onboard during turnaround at Canadian airports. Restricted items cannot be used in Canadian airspace.[33]
European Union	July 2021.	Single-use plastic plates and cutlery cannot be placed on the markets of the EU Member States.[34] Airlines operating in the EU need to comply with the labeling of certain SUPP, such as cups.[35]
India	July 2022.	Airlines and catering companies will not be able to source or use restricted items in India.[36]
People's Republic of China	2022: items banned in airports over 2 million passengers and domestic flights. 2023: items banned in international flights.	These are restrictions on the use, but there is no clarity on how the Work Plan is being enforced.[37]

The review of these 5 jurisdictions indicates that all place bans on SUP straws, stirrers, crockery and cutlery. Other SUPP items restrictions are less harmonized, reflecting the current lack of available, sustainable alternatives. A total of 4 out of the 5 jurisdictions have banned SUP cups with the EU and India restricting beverage cups made from polystyrene and imposing a strict labelling scheme. Indian states apply differing volume restrictions on PET with the EU specifying minimum recycled plastic content for new PET bottles. China is the only country that includes restrictions on cargo sheets.

[28] **Legislation around plastic waste management and international catering waste from international flights has not been identified.**
[29] Australian Marine Conservation Society (2023). Which Australian states are banning single-use plastics?
[30] APCO. Australia's 2025 national packaging targets.
[31] Australian Retailers Association. Phase-out of unnecessary and problematic single-use plastics.
[32] **Made from or containing problematic plastics.**
[33] Government of Canada. Single-use Plastics Prohibition Regulations – Overview.
[34] European Commission. EU restrictions on certain single-use plastics.
[35] European Commission. Marking specifications for single-use plastic products.
[36] Plastic Waste Management Amendment Rules.
[37] Civil Aviation Administration of China. Plan for Civil Aviation Plastic Pollution Control Measures 2021–2025.

There is still a lack of consistency and regulation around labeling. The EU has introduced rules that beverage cups made partly from plastic (even those only lined with a plastic coating) need to have a specific printed marking[38]. Although the Canadian government is considering the development of labeling rules for plastic packaging and SUPP, it is unclear if they will be aligned with the EU or any other national scheme[39].

A UNEP report published in 2020 recommended that there "should be global consistency of definitions regarding the content and reusability of plastic packaging in standards. Labels and claims should be updated to reflect these"[40]. In the absence of a globally recognized plastic labelling system, passengers will continue to be confused and airlines will have to purchase differing alternative inflight products based on requirements per route and not necessarily on the environmental benefits.

Although airlines are replacing SUPP with bio-based alternatives, globally consistent use of terminology or definitions are absent for "recyclable", "compostable", "biodegradable", and "eco-friendly". The environmental value of the move to bio-based products is also undermined by ICW regulations that require these materials to be incinerated, steam sterilized or landfilled and the lack of biotreatment infrastructure at airports.

Despite the good intentions of policymakers, this inconsistency / lack of policy cohesion / patchwork creates additional costs and complexity for the airlines while not necessarily delivering the environmental benefits expected.

3.2. Operational challenges and mitigation

Every alternative to SUPP has its own set of corresponding impacts, not all of which are immediately obvious. As a simplified example, reducing SUPP cuts waste, but if lightweight SUPP are replaced with heavier alternatives that later require washing and drying, such as reusable crockery, this could have a negative impact in terms of greenhouse gas emissions emitted during the flight, and on water and energy consumption during the washing process.

To make informed decisions about the best options, businesses in the airline sector value chain and regulators need to consider all the potential consequences. Doing this requires knowledge of airline operations and access to information that clearly and consistently outlines the environmental advantages and disadvantages of alternatives. The following are potential solutions for overcoming some of the challenges of replacing SUPP.

Define problematic and unnecessary SUPP

Problematic and unnecessary SUPP is defined by the Global Tourism Plastics Initiative (GTPI) as plastic that is not reusable, recyclable, or compostable; that contains, or is manufactured with hazardous chemicals; that can be avoided; that disrupts the recyclability or compostability of other items; that has a high likelihood of becoming litter. Examples in aviation could be items such as:

- Small packets (e.g., condiments).
- Thin plastic bags provided as part of the meal service for facilitation of disposal of used mixed meal items.
- Individually wrapped items (e.g., wet wipes, toothpicks, pillows, and blankets).
- Excessive amenities (e.g., mini dental kits).
- Excessive cargo protection (e.g., extra plastic sheets, overpacking of goods).

[38] Regulation (EU) No 2020/2151 laying down rules on harmonised marking specifications on single-use plastic products.
[39] Government of Canada. Developing labelling rules for plastic packaging and single-use plastics.
[40] UNEP (2020). Can I recycle this?

Recommendations:

- Undertake an inventory and identify any items that are predominantly used out of habit or because of legacy brand standards but could be considered unnecessary or of no real value to the passenger experience.
- Undertake a brand survey to determine if passenger views have changed.
- For each item, follow a waste reduction hierarchy approach to ascertain which items could be eliminated completely, and which could be replaced with reusable alternatives or alternatives made from different materials.

Review company standards and customers' requirements for packaging to determine the necessity of non-essential cargo protection items.

Cost

The cost associated with implementing change was highlighted as the biggest problem (by 83% of 37 responses) in the IATA survey. Many single-use alternatives that offer the same functionality as SUPP are not yet available at scale, making them more expensive per unit. The cost of reusable products is not limited to the product itself, as they can incur additional costs such as the service required to remove them from the aircraft to a washing and drying facility and their subsequent return. Additional stock is required to substitute products that are in service or at washing facilities. This may also incur additional storage costs. Reusable products have a finite lifespan and will ultimately need to be replaced due to wear and tear and due to loss or breakage.

Recommendations:

- Earmark any savings that are generated by reducing waste and eliminating unnecessary SUPP for investment in alternatives.
- Return on Investment calculations need to consider the break-even point at which the reusable product outperforms the single-use product it is replacing in terms of cost.
- Assuming that waste contracts are based on (or could be renegotiated to be based on) the volume of waste generated, waste handling costs should also be reduced and go some way to compensating the additional costs associated with keeping reusable in service.

Facilitating the role of cabin crew

Cabin waste problems will not be solved without a change in processes and procedures.

Recommendations:

- Involve cabin crew in decision making. They will be able to provide insight into whether a proposal that sounds good in theory will work in the practical day-to-day demands of their role.
- Consider the option of having a crew member that is responsible for waste recycling.
- Implement regular training for cabin crew so that processes are implemented consistently.
- Work with suppliers who can provide suitable solutions that are already compatible with standard cabin layouts and crew processes.

Facilitating the role of cargo handling staff

Cargo handling staff work in a complex and time-sensitive environment where they need to adhere not only to detailed shipper requirements, but also to local and national requirements for cargo preparation, such as using the correct quantity of SUPP, as well sourcing and disposal. Due to high turnover rates and inadequate standard procedures, staff members may unintentionally damage or misuse single-use and reusable items. Improved collaboration and awareness across the supply chain are necessary to address these challenges.

Recommendations:

- Raise awareness and promote the involvement of cargo handling staff in decision-making. Provide training and encouragement to reduce, reuse, recycle SUPP in operations and adopt/investigate alternative procedures. Extend educational efforts to shippers, especially those who transport perishable products.
- Engage with suppliers who can provide alternative solutions tailored to the airline's needs, location, operations, and strategy. Foster industry collaboration and common best practices.

Functionality of alternatives

The airline SUPP web survey showed that many respondents were concerned that alternatives to SUPP would not have the same level of functionality and product integrity, potentially affecting customer safety. This includes whether alternative materials would be able to hold hot or alcoholic liquids for a certain period, withstand oven heating and prevent contamination of food.

In cargo operations, alternatives to stretch wrap and plastic sheets need to ensure that pallets are tightly and securely wrapped, and that cargo is protected against adverse weather.

Recommendations:

- Keep up to date with innovations in alternatives and appropriate certification standards. Proactively search for suppliers that consider operational requirements when they are creating alternative processes and products.
- Provision of pre-cut plastic sheets adapted to the contour of pallets and replacing stretch wrap with lighter plastic alternatives.

Cabin layout / galley space

Airline galleys need to maximize utility, functionality, convenience, and the passenger experience. Historically, little attention has been paid to waste management, but this is now an area where innovative ideas are emerging.

Recommendations:

- Use existing space differently, e.g., offer duty free items for sale that can be collected at the airport of return, minimizing the impact on sales, and freeing up space to store reusable items or waste that has been separated for recycling.
- Consider what the "cabin of the future" might look like and what functionality is needed to meet service expectations. Reduce, segregate, and better manage cabin waste and facilitate the role of the crew when procuring new aircraft or retrofitting. Examples include innovations such as the Airbus Retrolley, trash compactors, and new design features, such as waste chutes directly into the hold of the aircraft for waste / recycling storage. Design features should also optimize space utilization in the galley for waste sorting and storage.

Safety and security

Certain SUPPs are necessary for safe and secure flying and cargo operations. Examples of necessary SUPP include:

- Medical items to ensure the health and safety of crew.
- Security Tamper Evident Bags (STEBs) and Liquid and Gels (LAGs) bags.
- Washroom, static bin, cabin cleaning and biohazardous waste bags.
- Cabin sickness bags (lined with plastic).
- IATA Dangerous Goods Regulations (DGR), specify requirements for packaging, labelling, and documentation, which may include restrictions or guidelines for plastic wrapping used in air cargo.

Recommendations:

- Medical items are outside the scope of plastic reduction legislation. STEBS and LAGs are enforced by civil aviation legislation over which airlines have no direct control. Trade associations such as IATA could encourage a move to more sustainable bags with higher recycled content.
- Washroom bins contain a variety of mixed, non-recyclable and potentially hazardous wastes, and are subsequently disposed of to landfill or incineration as are cabin sickness bags for obvious reasons. The decision in this case is about the impacts associated with plastic bags or linings made from fossil fuels versus those made from plants. The important operational consideration for such bags is that they are fit for purpose. Alternatives must be strong—there cannot be leaks in the galley or washroom as they can cause crew or passengers to slip plus there is the potential for corrosion of the airframe.

ICW regulations

Current ICW rules based on animal health concerns undermine the ability of the aviation sector to make a positive contribution to the circular economy through cabin waste prevention, reuse, and recycling initiatives. Although waste generated on flights operating within some territorial borders or within the EU can be efficiently processed, recycled, and reused, the same is not true for waste from international flights originating outside of those borders.

Recommendations:

- Reuse and recycling on flights should not be restricted by ICW regulations. For ICW flights, engage with the regulator to determine the potential for reuse and recycling of uncontaminated products and develop appropriate operating procedures.
- Advocate for a quantitative risk assessment concerning health risks that ICW represents to animal health, with a view to a revision of the ICW provisions so that the aviation sector can contribute to circular economy goals.

Availability of alternatives

Many alternatives that offer the same functionality as SUPP are not yet available at the scale required by airlines.

Recommendations:

- If the SUPP is necessary for the safe functioning of the operation and neither reusable nor single-use alternatives are available, take steps to ensure that decision-making considers the range of pros and cons from all the perspectives highlighted in this section. Where appropriate, follow this with a holistic LCA, particularly when comparing a switch from single use to reusable alternatives.
- Keep up to date with developments in the Hospitality, Restaurants and Catering (HORECA) sector (for passenger operations) and e-Commerce (for cargo operations) sectors where innovation is often more dynamic.

End-of-life treatment for sustainable alternatives

One of the limitations of compostable and biodegradable products are the end-of-life treatment options, as these can be environmentally detrimental if appropriate infrastructure is not in place for the specific requirements of the disposal method, otherwise these items would be landfilled.

Recommendations:

- Not only is important that sustainable alternatives are available, including compostables and bio-based items, but when using these products airlines need to reflect on different implications for key stakeholders. For example, treatment facilities need to be in place, such as industrial composting plants.
- Quality of composting is key, as it cannot be mixed with plastics or glass, therefore segregation and appropriate controls need to be in place.

Recognized global certification scheme for sustainable alternatives

With several countries introducing targets on the reduction of SUPP, including recycled content, there is a proliferation of standards and certifications that differ in definitions, methodology and labelling systems, creating confusion for manufactures and consumers.

Recommendations:

- Use product-based certifications that that are globally recognized to make informed choices.
- Engage with stakeholders to advocate for a unified framework of certifications for sustainable alternatives, including certifications that focus on individual products, with labels that are easily recognized by consumers.

Brand standards

Brand standards may currently require the use of SUPP.

Recommendations:

- Rethink brand standards through the lens of waste reduction. Critique your business, accepting that change is necessary and that passengers are generally willing to support it.
- Undertake a brand survey to determine if passenger and/or frequent flyer views on plastic have changed.
- Engage high level management, marketing teams, catering services, crew, and other key stakeholders in collaborative discussions about how to maintain the passenger experience while reducing waste and SUPP.

4. TOOLS FOR SUPP REDUCTION

With different alternatives to SUPP available, it's challenging to find a product in the market that can be consider as a sustainable alternative. The direct replacement of SUPP might generate unexpected environmental and social outcomes. It is important to introduce practices and tools that inform and support decision-making processes.

4.1. Life cycle assessments

LCA is a technique developed to better understand and address the results associated with the manufacture and use of different products.[41] LCAs consider the impact at each stage of a product's life cycle (cradle-to-grave), from the natural resources extracted from the Earth and its processing, through each subsequent stage of manufacturing, transportation, product use, reuse, recycling, and, ultimately, disposal.

LCAs can be expensive and time consuming but they estimate the environmental effects of various products in a transparent, replicable, and comparable manner. However, it is important to understand the comparison between different LCA scopes and boundaries since variations in assumptions can lead to very diverse outcomes.

To ensure that an LCA is robust, it should be a peer reviewed, independent study that respects the steps laid out in recognized standards and frameworks (e.g., ISO 14040 and 14044). The highest possible number of indicators should be included, and the exclusion of any indicators should be clearly justified. The study should also be cradle-to-grave, with upstream and downstream impacts being assessed, clear hypotheses being addressed, and different business model configurations for the use and end of life phases considered. Importantly, at the interpretation stage, it is proposed to consider the formulation of recommendations to improve the environmental performance of the system under study.[42]

Research indicates that an internationally recognized impact assessment method to consider marine plastic pollution in LCA has yet to be developed.[43] Other environmental impact categories therefore tend be used in LCAs, including greenhouse gas emissions, eutrophication, toxicity, acidification, and natural resource depletion.[44]

4.1.1 Challenges of adopting LCAs in the airline sector

In the case of the airline sector, there are very few LCAs on SUPP in the public domain that cover the five prioritized items (Annex 3). With this being an under-researched area, what does exist cannot therefore establish an agreed best practice, nor recommend a harmonized approach to setting out study scope.

This lack of harmonization of LCA approaches can affect the decision-making of many airlines. Of the 14 airlines that responded to the SUPP web survey as having conducted LCAs to support decision making for their SUPP replacement program, nine had used their own methodologies and five used information provided by manufacturers on alternative products.

Consequently, it is likely that decisions on SUPP in aviation are not being based on published and transparent LCA evidence or on wider holistic considerations, and therefore may result in negligible or negative impacts on the environment.

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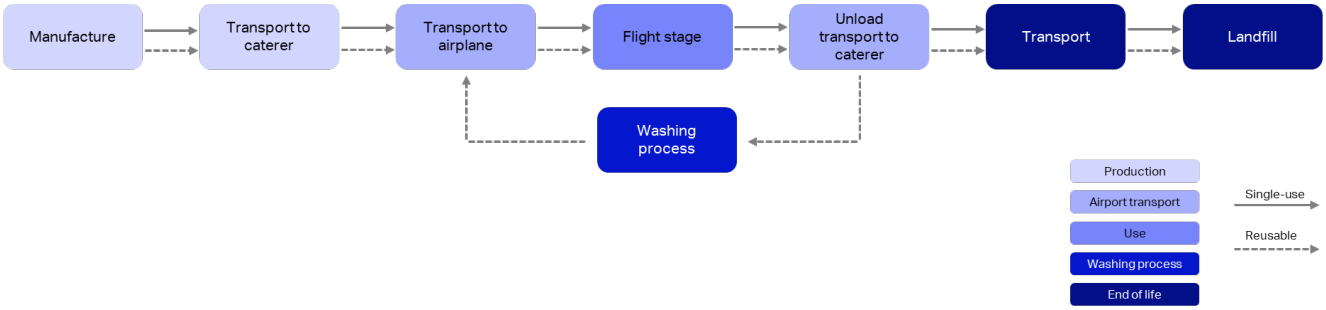
[41] ISO 14040:2006. Environmental management — Life cycle assessment — Principles and framework.
[42] Life cycle assessment scientists urge EU policy makers to treat some packaging environmental impact assessments with caution.
[43] Woods et al. (2021). A framework for the assessment of marine litter impacts in life cycle impact assessment.
[44] Miller, S. (2022). The capabilities and deficiencies of life cycle assessment to address the plastic problem.

Illustrations of the differences in LCA approaches can be found in Figure 5 and Figure 6 below.

Figure 5 highlights a cradle-to-grave study that considers life cycle stages from the manufacture of the inflight product through to associated transport, fuel burn, washing processes of reusables and ultimate end of life treatment (landfill).

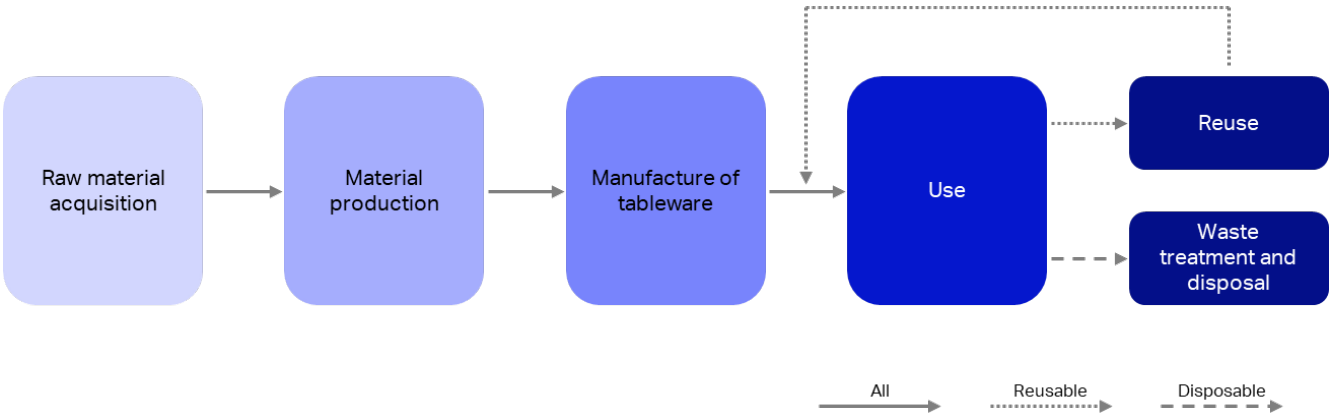
Figure 5. Life cycle system boundary of tableware, including flight stage.



Source: Adapted from Blanca-Alcubilla et al. (2020).[45]

Figure 6 shows a different approach which focuses on the stages of impact that could be considered more as the cradle-to-gate part of the life cycle. It does not include the repercussions that would occur during the flight stage, but it does include more than one end of life option, which the previous study did not.

Figure 6. Life cycle system boundary of tableware, only considering cradle-to-gate.



Source: Wei et al. (2022)[46].

As these diagrams demonstrate, it is challenging for airlines to commission an LCA on the consequences of switching from SUPP to reusable alternatives, as they could end up implementing completely different actions depending on the LCA results.

[45] Blanca-Alcubilla et al. (2020). Is the reusable tableware the best option? Analysis of the aviation catering sector with a life cycle approach.
[46] Wei et al. (2022). Revealing the feasibility and environmental benefits of replacing disposable plastic tableware in aviation catering: An AHP-LCA integrated study.

4.1.2 Recommendations for commissioning and interpreting an LCA

Although more research is needed in LCAs specific to aviation, there are several key recommendations for airlines wishing to commission their own LCA or to interpret the results of an LCA from suppliers or manufacturers of alternative products (see Box 1).

Box 1. LCA commissioning guidance for the airline sector.

It is important that the starting point of any SUPP replacement program should be focused on preventing and minimizing waste at source, and when replacements are required, an LCA can help to compare different options.

Guidance

- Undertake a cradle-to-grave study, including all the life cycle stages so that comparisons between studies are more straightforward.
- Be extremely clear on what is included in the scope, such as functional units, environmental impact categories and systems boundaries (see definitions below).
- Be aware that environmental impact categories are chosen at the discretion of the researchers and their commissioners, so the same topics might not be included in all assessments.
- It is essential that the emissions from jet fuel consumption are included in the scope, but it should not be the only focus. Including other impact categories will enable an airline to make more informed decisions.
- An LCA should include the results associated with different end of life scenarios, including landfill and incineration, and not solely focus on one.
- Remember that the consequences on biodiversity and of plastics in the environment are not fully understood, nor is there a consensus on how to measure them, so LCAs are not likely to be able to consider these issues.

Definitions and scope

- A functional unit is the reference unit for the study, covering the service being provided (what), the extent to which it is provided (how much), its quality (how well) and its duration (how long). For airlines, this means comparing the same amount of single use items with the number of uses for the reusable alternative (e.g., 300 SUP cups versus 300 uses of a reusable cup).
- An example of a functional unit could be: The safe provision of cups for 300 drinks of 250ml per flight over 200 medium-haul flights.
- In this example, safe refers to how well, provision of cups is what, the number and size of drinks refers to how much and the number of flights covers how long.
- Environmental impact categories can range from global warming potential (the potential for a product or process to contribute to climate change by quantifying GHG emissions), through to eutrophication (the potential for a product or process to lead to excessive nutrient levels in bodies of water causing algal blooms) and soil acidification (by emitting harmful substances that contribute to acid rain). The choice of environmental impact categories is at the discretion of the researchers and/or their commissioners/clients, and not all will be included in the assessment.
- System boundaries define the beginning and end points of the life cycle that is being assessed. Using plastic products as an example, this might start with raw material extraction of fossil fuels through to end of life disposal such as incineration. The many processes and activities between these two points can also be at the discretion of researchers, commissioners and/or clients.

Airlines will rarely encounter LCAs developed by the manufacturers of SUPP alternatives that include transport emissions in their calculations. In this case, as airlines are aware of the trade-offs due to fuel costs and variations in weight, they can estimate the additional or reduced impact by using the marginal fuel burn rate (0.02 to 0.03 kilograms of fuel per 1,000 km for every kilogram of weight added)[47].

Although LCAs may determine that different options, such as sustainable bio-based disposable products, represent an optimal environmental solution for air transport, airlines are likely to see procurement options diminish as manufacturers move out of the market driven by consumer demand and regulatory initiatives that favor reusables.

4.2. Decision trees

As previously highlighted, the outcomes of LCAs are not the only deciding factors influencing decisions on SUPP replacement. Despite the complexity, airlines need to make choices to eliminate, reduce or replace SUPP.

Five SUPP (water bottles; single-use cups for hot and cold drinks; single-use crockery; single-use cutlery; and cargo plastic sheets and stretch wrap) have been identified as the most problematic products to replace and are prioritized for replacement.

Simplified decision trees for the products listed above are presented in Annex 5. These have been created to support more informed decision-making and consider environmental and operational trade-offs. Each tree focuses on the potential for eliminating waste at its source, subsequent steps follow a logical path through the waste reduction hierarchy and provide some insight into the advantages and disadvantages of alternative products and materials.

Figure 7. Waste Reduction Hierarchy.

Source: EU Waste Framework Directive (2008/98/EC)

[47] Steinegger, R. (2017). Fuel Economy as Function of Weight and Distance.

As a precursor to all decision trees, airlines should question first if there are possibilities to prevent the use of SUPP—is there a possibility to change procedures or customer expectations[48], are the processes efficient in terms of use and load and is there space onboard and on the ground support for reusable items to be stored? Airlines should then look for the most suitable replacement options, such as those that might be from highly recyclable through to less plastic content.

Where steps to eliminate or reduce waste are not possible, the minimum desired outcome is to divert recyclable and recoverable waste from landfill and incineration, where regulations allow, and to advocate to for smarter regulations if they are not allowed.

[48] **See IATA Cabin Waste Handbook for examples related to these initiatives.**

5. ACTIONS AND INITIATIVES

5.1. Actions and initiatives within the airline sector

Taking action requires planning and consideration of how SUPP are used, purchased, and removed.

The SUPP web survey responses were mixed but encouraging overall, with 90% of airlines already taking proactive steps to eliminate unnecessary products or to switch to more circular systems. Airlines also show a clear inclination to adopt changes, such as only offering amenity kits on demand, eliminating miniature condiments, changing menus to reduce packaging, and switching from disposable to reusable products. Airlines not currently considering changes were predominantly concerned with passenger expectations and service quality.

Furthermore, IATA research indicates that there have been initiatives implemented by at least 40 airlines to reduce and replace SUPP (a list of illustrative examples can be found in Box 2). These include actions such as setting targets for discontinuing use to upcycling projects. Scaling these initiatives is imperative to achieving meaningful change.

Box 2. Illustrative good practices from the airline sector.

Airline	Initiative
Air Baltic	Allows passengers to submit inflight meal selections up to one hour before departure at the airline's hub in Riga, avoiding unnecessary SUPP, waste, and fuel burn.[49]
ANA	Reusable items and alternative solutions will be used where possible to reduce the amount of disposable plastic waste.[50]
Delta Air Lines	Testing a reusable cup system and new paper cups.[51]
Emirates	In addition to several initiatives to reduce plastic waste, the closed loop recycling initiative allows for millions of onboard items (such as plastic trays, bowls, snack, and casserole dishes) to be recycled in a local facility and remade into fresh, ready-to-use Emirates meal service products.[52]
Lufthansa Cargo	Uses a new type of wrap that consists of 10% recycled plastic and is also one micrometer (one µ) thinner than previous wraps. This means that about two kilograms less wrap is needed on each cargo flight. The plastic is then collected and processed into granules to be incorporated into new recycled wrap.[53]
Malaysia Airlines	Biodegradable materials are used for inflight catering and merchandise.[54]
Qantas	Under Project Bowerbird, initiatives such as premium economy blankets made with 20 recycled plastic bottles or water bottles that are 100% recycled PET.[55]

[49] airBaltic. Pre-order onboard meal.
[50] ANA (2022). A New Style of Premium Class Meals on Domestic Flights.
[51] Delta Air Lines (2023). Delta participates in SkyTeam's Sustainable Flight Challenge, showcases sustainability strategy in action.
[52] Emirates (2023). Emirates unveils new closed loop recycling initiative to reduce plastic.
[53] Lufthansa Group. Cleantech Hub. More environmentally friendly plastic film.
[54] Malaysia Airlines. Environmentally Responsible.
[55] Qantas Sustainability Report 2023.

Also, unnecessary waste can be avoided where ICW regulations allow (Box 3), such as on domestic flights (including intra-European routes) by recovering SUPP and other recyclable products through proactive segregation. Where ICW regulations allow, unopened, uncontaminated products with a long shelf life, such as condiment sachets, confectionery, and drinks can be returned to the catering company, reducing waste and the number of new items that need to be purchased.

Box 3. Air New Zealand case on international waste reclassification project.
In 2017, Air New Zealand (ANZ) launched a major international waste reclassification project, the Project Green initiative, in conjunction with the Ministry for Primary Industries and catering partner LSG Sky Chefs. It enabled ANZ to reclassify 40 types of inflight products so that if removed from aircraft sealed and untouched, they can be reused on future flights. In 2023, Project Green diverted approximately 70 metric tons from landfill, made up of 3.4 million units of products such as cutlery packs and sugar sachets, and recycled 215 metric tons of glass. More than 1,500 metric tons of reinjected product and recycled glass have now been diverted from landfill since the Project's inception. The airline also has a large number of other waste reduction initiatives in place.[56]

5.2. Actions and initiatives in the travel and tourism industry

Industry-wide initiatives can provide effective platforms to align and enhance international and cross-sectoral efforts to address plastic pollution (examples provided in Box 4). The Global Tourism Plastics Initiative (GTPI), led by UNEP and the World Tourism Organization (UN Tourism) is a voluntary commitment initiative uniting over 200 organizations (of which 70% are businesses). The objective of the GTPI is to get commitment on the elimination of problematic or unnecessary plastic packaging and items, the implementation of reuse models, and public, annual reports on progress. It also works in a collaborative manner across the tourism value chain on the collective development of solutions. It is a cross-sectoral initiative with signatories comprising accommodation providers, tour operators, business associations, national and local governments, and academia.

A GTPI progress report demonstrates encouraging developments but also highlights several challenges including data collection, identification of suitable alternatives to plastic in kitchens, which do not result in unintended consequences, such as increasing food waste, and limited updates on the implementation of commitments by many signatories.[57]

Box 4. Illustrative good practices from outside the airline sector.	
Sector	**Initiative**
Airports	The Green Airports Recognition (GAR) objective is to promote environmental best practices to minimize aviation's impacts on the environment. Within this initiative, several airports in Asia Pacific presented submissions that focus on SUPP elimination.[58]
Tour operators and travel agents	Send packing lists to their customers, encouraging them to travel with reusable bags and refillable water bottles, and informing them about locations of water refill stations in airports and at destinations.[59,60,61]
Destinations	Many destinations are implementing drinking water dispensers in city centers, at tourist attractions, and in popular resorts so that

[56] Air New Zealand. Driving towards a circular economy.
[57] GTPI (2022). 2022 Annual Progress Report.
[58] ACI (2023). Green Airports Recognition 2023.
[59] SNP Natuurreizen.
[60] Odysseia-In. Responsible Policy.
[61] Weltweit Wandern. Nachhaltig reisen.

	visitors can easily refill their reusable bottles when traveling. The Cleanwave Movement in Mallorca is a good example.[62] In Cyprus, five beaches have now been awarded the Plastic Free Beach certificate and the program is expected to extend to other destinations.[63]
Hotels	Many hotels are working collaboratively with suppliers to increase reusable and returnable business models. An example is refilling dispensers from larger containers which are returned to the supplier who can then wash and reuse them, keeping plastic in the economy and out of the environment.[64]

5.3. Role of passengers

Throughout the entire journey, passengers have an essential role as they can contribute to minimizing SUPP use and waste generation. Passengers have been accustomed to inflight food and beverages, amenities, and retail opportunities in a specific way, however, and it is important to highlight what people say they will do versus what they in fact do or are willing to do (the so-called 'intention-action gap').

Any changes in passenger services, particularly on airlines with a high percentage of frequent flyers, requires a strong, strategic communications plan with consistent messages across all touchpoints and aligned with brand identity.

Public awareness of the negative impacts of SUPP continues to increase and more people are prepared to take action to support businesses that are reducing them. In fact, 23% of the airlines that responded to the SUPP web survey said that they had received complaints from customers due to the use of SUPP onboard.

It is important to understand customer behavior and develop initiatives accordingly. As mentioned previously, passengers may carry SUPP onto the aircraft or purchase products that comprise SUPP on board, which are then improperly disposed of after leaving the aircraft. Airlines could provide SUPP on discretionary or "buy-on-board" basis reducing both procurement and waste costs. Finally, passengers can help to increase recycling if they are given clear instructions on how to separate waste. Although these are not definitive drivers of behavior change, passengers should be involved in SUPP prevention, reuse, and recycling solutions.

This report has established that potential leakage of SUPP from the airline sector into the environment is low and is primarily restricted to the inappropriate disposal of plastic products (bags and bottles) by passengers. Airlines can raise awareness of the challenges of plastic pollution with passengers with a focus on routes to regions with less developed waste and recycling infrastructure.

[62] Fundación Cleanwave.
[63] The Travel Foundation. Cyprus launches first plastic free beach.
[64] Maritim Hotels. Great body care, less plastic, short transport routes.

5.4. Other voluntary commitments

A large number of organisations have made voluntary pledges to reduce plastic use and contribute to the circular economy. In 2018, the Ellen MacArthur Foundation (EMF) launched the Global Commitment as a global voluntary effort to tackle plastic waste. Over 1,000 organisations including businesses representing 20% of all plastic packaging used globally and 55 government signatories, have become signatories. Five years on a progress report acknowledges that the significant progress has been made in reducing plastic waste but also recognizes that the Global Commitment and its signatories will likely not realise all the 2025 ambitions. [65] The report identifies three main challenges that are currently hindering progress including scaling reuse, flexible plastic packaging in high-leakage countries, and lack of infrastructure to collect and circulate packaging. It also recognizes the international legally binding instrument on plastic pollution presents the greatest opportunity for rapid global action on plastic waste.

[65] EMF (2023). The global commitment five years in.

6. RECOMMENDATIONS FOR AIRLINES, THE VALUE CHAIN, AND POLICYMAKERS

Based on the key findings of this report and previous research by IATA, SUPP replacement is a clear priority for passengers and airlines. Although strict regulations on the handling of airline waste reduces the risk of SUPP leaking into the environment and becoming pollution, significant volumes of cabin waste, including plastics, are required to be incinerated or landfilled by ICW regulations.

Inconsistent policies at airport, national, and regional levels requiring airlines to reduce or eliminate certain SUPP will result in different alternative products being introduced on separate legs of a journey. This will continue to confuse passengers, crew, and handling staff, increase compliance costs, generate more waste, and potentially shift the burden from plastic reduction to emission increases so that as one problem is solved, another is created.

The following recommendations are therefore intended to be strategic and practical, with consideration given to short-, medium- and long-term solutions for airlines, the airline sector value chain, and policymakers. They focus on reducing waste at source, facilitating informed decision-making around SUPP replacement programs, and increasing opportunities for material recovery where ICW regulations allow. They also facilitate collaboration with suppliers for increasing the circularity of plastics at design and manufacturing level and for the implementation of globally harmonized regulations so that collective steps can be taken to reduce and reuse models in line with circularity principles.

6.1. Reducing SUPP use at source

It is estimated that over 20% of cabin waste is unused and unconsumed food and drink.[66] Eliminating this waste at source would not only yield significant environmental benefits but also be a key source of funding to support waste reduction and SUPP replacement programs. IATA's Cabin Waste Handbook[67] contains 22 actions an airline and its service partners can initiate to reduce, reuse, and recycle cabin waste including SUPP.

To reduce waste at source, airlines are encouraged to review brand standards and operating procedures through the lens of waste reduction and reuse, and to professionally critique the need for SUPP versus the legacy brand standards, learned habits and passenger expectations that have encouraged the usage of SUPP to date.

Responses to the SUPP web survey showed that 9 out of 11 airlines are already or would consider taking action to change inflight menus to avoid individually packaged items and to eliminate or reduce amenity kit offerings. A total of 10 out of 11 are already or would consider eliminating packaging from blankets, pillows, and headsets.

In response to the continued concerns of passengers showed in the IATA passenger insights survey[68], projects to reduce cabin waste at source could be accelerated, with the added advantage that this provides new opportunities for communications that focus on passenger benefits.

[66] IATA Cabin Waste Handbook.
[67] Ibid.
[68] The IATA passenger insights survey was conducted 31 October-13 November 2023 with a sample of 6,500 recent travelers. It covers 15 markets (Australia, Canada, Chile, China, France, Germany, India, Indonesia, Japan, Singapore, Spain, The Netherlands, UAE, UK, and USA). The sample size in each market was 500, apart from Chile, Japan, Singapore, The Netherlands, and UAE, where it was 300. This Is Motif Ltd prepared the questionnaire and analysis based on data collection and tabulation by Dynata. www.thisismotif.com

Collaboration along the value chain in support of waste reduction at source is a critical component of success. Solution-focused discussions involving key stakeholders such as catering companies, suppliers of food and beverage containers, packaging and amenity kits, and cargo handlers, can help to identify previously unconsidered opportunities.

Regulators could proactively encourage the separation of unused, sealed food and beverage items by developing guidance, thus reducing procurement requirements, and diverting waste from landfill or incineration. Airlines, galley equipment suppliers, catering companies and cleaners could then co-create procedures to make onboard waste segregation efficient for all those involved.

Key recommendations for airlines

- Review brand standards and operating procedures through the lens of waste reduction and reuse.
- Integrate end-of-life/waste disposal considerations into material/product procurement decisions.
- Identify unnecessary and problematic SUPP and prioritize their removal or replacement.
- Set clear targets for elimination, measure, and track implementation, and disclose progress.
- Introduce positive messages and calls to action at key communications touchpoints along the passenger journey to galvanize increasing support. These include, but are not limited to, information on websites, messages within reservation confirmation emails, information in mobile applications, reminders prior to departure, and information on the day of departure through in-app messaging.
- Facilitate open dialogue with key stakeholders in the value chain to identify and overcome logistical changes that will lead to waste reduction initiatives.
- When communicating SUPP replacement goals and initiatives, appreciate that certain SUPP are required by civil aviation or public health authorities.

A review of existing global SUPP regulations indicates that the following products should be targeted by airlines for removal or replacement by bio-based disposable or reusable options depending on LCA results:

- Straws
- Drink stirrers
- Crockery
- Cutlery

The replacement of SUP cups is more problematic as bio-based disposable alternatives that can hold hot liquids and alcohol are still at research and development stage. At least 28 countries have recognized this conflict and have not included bans on SUP cups in their regulations, at this stage. In addition, there also seems to be little or no practical alternative to PET bottles for passengers on long-haul flights. Until an alternative becomes clear, airlines should focus on recycling these bottles and increasing the recycled content of new bottles.

Key recommendations for the airline sector value chain

- All value chain actors can participate in multi-stakeholder working groups to identify and implement process changes that prioritize end-to-end solutions that ensure best practices are adopted to minimize waste generation at every stage of a product's life cycle.
- Airlines and their service providers need to coordinate actions to promote regulatory change; provide demand signals to market; and encourage development of appropriate recycling, reuse and recovery systems / infrastructure.
- Cleaning and catering companies can encourage the development of new contract models with airlines that incentivize recycling and waste reduction (e.g., new contracts to financially reward airlines for reducing volumes of waste).

Key recommendations for policymakers

- Urgently agree on a globally consistent definition of SUPP.
- Implement harmonized SUPP restrictions, including labeling that is based on a LCA approach and ensure they reflect the safety and security constraints of civil aviation.
- Develop sustainability guidance and certification for alternatives to SUPP.

6.2. Interventions to drive circularity

A circular economy is a sustainable model in which products and materials are designed in such a way that they can be reused, remanufactured, or recovered and thus maintained in the economy for as long as possible.[69]

The focus on continued reuse of the same product is what differentiates the circular economy from the recycling economy. Within a recycling economy (and using plastic as an example), products are collected, sorted, shredded, and turned into different products depending on the quality of processed material. With each downcycling process, plastic degrades to the point where, for example, it is eventually only suitable to be turned into yarn for synthetic textiles, filling for furniture and soft toys or building aggregate.

Implementing circular economy principles into the airline sector value chain will require considerable changes to processes and procedures for stakeholders both upstream and downstream, and it will not be possible without public/private sector collaboration and significant investment.

As most SUPP regulations still allow a linear economy model approach (exceptions include new legislation in the Netherlands[70] and the agreed Proposal for a Regulation on Packaging and Packaging Waste[71]), the airline sector could consider developing a sectoral approach to replace SUPP with sustainable alternatives or joining an existing industry initiative, such as the Global Tourism Plastics Initiative (GTPI).

The principal strategy that airlines can employ to drive circularity is the introduction of reusable items. Reusable items will play a significant role in supporting circular economy principles. Their introduction will require logistical changes that incorporate a closed-loop service, and onboard procedural changes for crew as well as efficient returns and inspection for air cargo operations. Trolleys and/or galleys may also require a re-design depending on the aircraft and where possible, catering facilities will need to be adapted to fit more washing lines. Collaboration with catering companies, suppliers, aircraft manufacturers, crew, and other key stakeholders will be necessary to conceptualize the processes that are required to optimize reuse models.

A key concern regarding reusables on aircraft is the impact of added weight on fuel burn and carbon emissions. A well-structured LCA that incorporates suitable functional units, impact categories, and systems boundaries (section 4.1 and Annex 4), together with oversight of operational considerations, should enable airlines and other key value chain actors to make more informed decisions about the introduction of reusable items onboard.

Policymakers need to act swiftly to create the infrastructure and frameworks that will make reuse models possible. Encouraging the switch from disposal consumption patterns requires reusable products and systems to be more financially competitive than single-use alternatives and cross-sectoral collaboration at regional and global levels. Although these circumstances do not yet exist, airlines are nevertheless advised to prepare and ensure that their voice is heard in relevant public/private sector discussions. Policymakers, in turn, need to be aware of and responsive to the characteristics of international airline operations.

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[69] UNEP (2023). Turning off the Tap.
[70] Ministerie van Infrastructuur en Waterstaat. Zo past u de regels voor plastic wegwerpbekers en -bakjes toe.
[71] European Council (2024). Provisional agreement on packaging and packaging waste.

Key recommendations for airlines

- Strengthen engagement with industry peers, trade associations, and other key stakeholders in the value chain to conceptualize processes that would reduce the burden of individual responses to the same challenges, particularly in countries where compliance to act on waste reduction and circular economy models will be mandated, such as the agreed Proposal for a Regulation on Packaging and Packaging Waste in the EU.
- When reuse infrastructure is in place, and when feasible within current operational limitations and a robust LCA has indicated that reusable alternatives are a better solution, give contractual preference to suppliers of reusable products.
- When commissioning an LCA on SUPP, follow the detailed guidance set out in Annex 4.
- Understand and comprehensively assess manufacturers' LCAs.
- Where reuse infrastructure is not in place, advocate for this.
- Regularly review policies and standards with reusability and circularity principles in mind.
- Build capacity among cabin crew and equip them with the necessary tools and knowledge to identify and achieve more circular solutions.

Key recommendations for the airline sector value chain

- Develop further industry capability regarding the development of LCA methodology.
- Inflight product manufacturers could contribute to the creation of standardized LCA methodology frameworks that consider the specific needs of airlines.
- Inflight product manufacturers could present well-structured cradle-to-grave LCAs that incorporate suitable functional units, impact categories, and systems boundaries so that procurement teams can make more informed decisions around the pros and cons of switching to reusable alternatives. This should also include certifications and credible documentation throughout the value chain.

Key recommendations for policymakers

- Implement cohesive policies that enable reusable products and systems to be more financially competitive than single-use alternatives and test their suitability through pilot programs.
- Provide finance and incentives for investment in the significant infrastructure and systems changes that will be required to support a circular economy in the airline sector value chain.
- Prioritize a unified approach to SUPP legislation that considers trade-offs and burden shifting that are particularly prevalent in the airline industry.

6.3. Interventions to drive waste segregation and recycling

Animal health rules in many global territories undermine the ability of the airline sector value chain to make a positive contribution to the circular economy through reuse and recycling initiatives. Airlines fully support regulations that minimize the spread of animal diseases but consider the ICW biohazardous classification to be disproportionate.

The ICW regulations further limit the accuracy of LCAs conducted specifically for airlines, as different waste recovery options cannot be included in the scope as an end-of-life scenario.

Two main strategies that airlines can start applying to improve waste management and recovery are the recovery and reinjection of sealed unconsumed food and beverage products, and onboard waste segregation to divert recyclable and reusable materials from landfill or incineration.

With the approval of the regulating authority, it is possible to develop food product reinjection processes to subsequent flights and to recycle, as a minimum, aluminum cans, paper/cardboard, glass, and plastic from both domestic and international flights if they are collected separately and have not come into contact with food that comprises animal products. Even where there are no ICW regulations in place, such as domestic and intra-

European flights, it is good practice to keep recyclables clean by avoiding food contamination. Airlines are encouraged to segregate reusable and recyclable products if not already doing so. Furthermore, regulators should encourage this practice by issuing supporting guidance that gives animal health inspectors and waste contractors confidence in this approach.

Collaboration between equipment suppliers, catering companies, and cleaners will ensure that cabin interiors, equipment, and operational procedures are designed to facilitate quick and easy segregation of items for recovery and reuse and recycling onboard, with minimal or no repercussions on either the time required to perform the task by crew members or the quality of waste segregation.

Aircraft being manufactured today will be in service for the next 20 to 30 years and therefore need to be designed with efficient waste management in mind. Airlines, manufacturers, and suppliers are encouraged to use cabin configurations, onboard stowage space, and trolley designs that facilitate the segregation of recoverable items and recyclables. Where this may require additional expenditure, costs could potentially be offset against recyclable revenues and cost reductions associated with reducing mixed waste collection. It should be noted that SUPP regulations and their subsequent impact on the supply chain will change the nature of cabin waste, and this must be reflected in future cabin and galley design.

A clear methodology and the sharing of good practice endorsed by the regulators, together with the engagement of crew and passengers, is essential to ensure that segregation processes are efficient and effective.

The supporting infrastructure for waste segregation and recovery in the sector needs to be ambitious, such as the development of materials recovery facilities (MRF) at or close to airport premises. It is recognized that international airports can generate the same amount of waste as a "small city" and considering the high proportion of organic waste generated from airport restaurants, kitchens and sewage, the concept of integrated biotreatment could be viable.

Anaerobic digestion of these wastes would generate biogas for electricity production. As SUPP regulations force a move to reusables and bio-based SUPP alternatives the organic fraction of the waste will increase in the future. If regulations allow, combining both the liquid and solid waste-streams from aircraft and airports could yield the economies of scale necessary to make biotreatment a commercial solution, reducing emissions and contributing to circularity.

As an alternative, the installation of industrial composting plants at airports could be considered which would be able to treat both industrially and home compostable materials, opening the opportunity for catering companies to provide meal services based on certified compostable crockery, cutlery, and packaging. This would relieve the cabin crew of time-consuming onboard waste segregation procedures and divert waste from landfill. Unfortunately, at present, ICW regulations do not allow biotreatment.

Key recommendations for airlines

- Facilitate onboard waste segregation if not already doing so by implementing new operating procedures, particularly in destinations where ICW regulations do not apply.
- Undertake waste composition audits to identify waste streams characteristics.
- Evaluate waste management costs and build a business case for intervention.
- Support the advocacy efforts for revised ICW regulations that would enable airlines to divert recyclable and recoverable waste from landfill and incineration, facilitate biotreatment and for the creation of suitable waste materials recovery facilities at airports.
- Proactively engage with aircraft and trolley cart manufacturers to drive demand for solutions that facilitate segregation of waste streams, waste compaction, and liquid disposal units.
- Convene all relevant stakeholders in discussions to consider end-to-end solutions to ensure that practices are adopted that minimize waste generation at every stage of a product's life cycle.

- Conduct regular waste segregation training with crew to ensure consistency.
- Implement proactive staff and passenger engagement campaigns.
- Renegotiate waste collection contracts that incentivize segregation.
- Invest in LCA research that considers the differences in policy and legislation toward SUPP around the world and their impact on aviation.
- Consider the SUPP restrictions enforced at destination airports and countries prior to making alternative product procurement choices.

Key recommendations for the airline sector value chain

- Cleaning and catering companies can encourage the development of new contract models with airlines that incentivize waste segregation and recycling.
- Aircraft manufacturers and cabin interior designers and suppliers can be more proactive in promoting cabin configurations that facilitate onboard waste management and segregation.
- Suppliers of consumable products must provide clarity on the material composition of products and the requirements for disposal after use, through valid certifications, test results and credible documented evidence.
- Support research and development to identify and promote alternative sustainable materials for the aviation sector.
- Having a holistic approach to waste management and coordination amongst the total waste processing chain to improve and develop recycling infrastructure making use of the economies of scales for different end-of-life processes.

Key recommendations for policymakers

- Undertake a quantitative risk assessment of ICW and its threat to animal health, using the results as the basis for the revision of the ICW regulations.
- Support the development of harmonized guidance on the reuse and recycling of waste for international flights.
- Urgently agree on a globally consistent definition of SUPP and acceptable alternatives that consider the characteristics of the international transport sector.
- Standardize labels and green claims to better reflect actual conditions rather than theoretical application.
- Proactively support the investment in material recycling facilities (MRF) at airports and explore the potential for airport integrated biotreatment facilities.
- Implement subsidies / incentives for research and development into more sustainable materials for the aviation sector and create demand for reusable and recycled products.

7. CONCLUSION

There is a genuine willingness among most key players in the aviation value chain to eliminate, reduce, and replace SUPP. Achieving this at scale while operating within current asymmetric SUPP frameworks and adhering to ICW regulations is extremely challenging. Compliance with differing rules for international airlines that can fly to up to 120 countries is impractical within current global economic models and supply chain logistics.

A comprehensive review of SUPP regulation that considers the unique position of international airline logistics and operations, together with a quantitative risk assessment concerning the risks that ICW represents to animal health, would be a valuable starting point. Airlines can then make a more positive contribution to circular economy principles and meet their ambitions and passenger expectations on sustainability.

Airlines are acutely aware of their contribution to climate change and although SUPP reduction is important, switching to alternatives that would increase emissions appears illogical, especially given the low risk of plastic leakage from the sector. This is a key point that appears to have been often overlooked by regulators. To avoid displacing pollution, it is imperative that the LCAs developed are specific to the needs of the airline sector, respecting the strict hygiene, safety, and security concerns, and that include environmental impact categories, like climate change, and various end-of-life scenarios as a default. More research is needed to understand the overall environmental impact of different choices. It is not known, for example, whether a life cycle perspective would make it beneficial for airlines to switch to bio-based alternatives that would facilitate biotreatment of food waste and its service ware.

If SUPP regulations are globally harmonized, airlines and their stakeholders must collaborate to be properly prepared. Airlines need to start or accelerate initiatives to review their operating procedures, particularly in countries where ICW regulations are not enforced and where many items could already be recovered for reuse. They are also encouraged to review brand standards and consider that the provision of an excellent passenger experience and achieving waste reduction are not mutually exclusive.

Meaningful change cannot be achieved in isolation or without due appreciation for the complexities of the airline sector value chain. Awareness of the environmental impact of plastic pollution and the cost of inaction is at an all-time high. Leaving a positive legacy is a key reason why people are motivated to act, and this is a useful communications approach to increase passenger engagement.

Regulators must also be aware of the nuanced decisions faced by airlines. There is no simple answer to the question of global plastic pollution. Solutions are context dependent and may have unintended consequences. Finding SUPP replacements involves numerous interconnected elements that make it challenging to understand the full complexity and scope of the issue.

Although a voluntary plastic commitment by the airline sector would raise awareness and stimulate additional action on plastic waste, it would likely encounter similar challenges, as faced by the Global Commitment and GTPI. These include data collection, identifying suitable alternatives and a lack of reuse and recycling infrastructure.

IATA and its member airlines remain committed to collaborating across the value chain to realize a more cohesive approach to SUPP reduction and circular economy principles in the aviation sector. To replace SUPP with sustainable alternatives, policymakers must urgently engage in discussions with airlines and representative organizations from within the value chain to seek a sectoral solution.

8. GLOSSARY

8.1. Acronyms

CAA - Civil Aviation Authority

EMF - Ellen MacArthur Foundation

FOD - Foreign Object Debris

GHG - Greenhouse Gas Emissions

GTPI - The Global Tourism Plastics Initiative

HACCP - Hazard Analysis and Critical Control Point

HORECA - Hospitality, Restaurants and Catering sector

ICW - International Catering Waste

LAGs - Liquids, Aerosols and Gels

LCA - Life Cycle Assessment

MRF - Material Recovery Facility

OECD - Organisation for Economic Co-operation and Development

PEF - Product Environmental Footprint

PET - Polyethylene terephthalate

STEBs - Security Tamper-Evident Bags

SUP - Single-Use Plastics

SUPP - Single-Use Plastic Products

ULD - Unit Load Device

UNEA - United Nations Environment Assembly

UNEP – United Nations Environment Programme

UN Tourism - World Tourism Organization

WTTC - World Travel and Tourism Council

8.2. Definitions

Airline sector value chain - Wide variety of stakeholders that are involved in the creation, distribution, and delivery of airline passenger and cargo services.

Animal by-products (ABPs) - Materials obtained from animals which are not intended for human consumption.

Asymmetric SUPP legislation - A lack of cohesion in the content and approaches of national and international bans on the use of single-use plastic products.

Bio-based products - Products that are composed in whole, or in considerable part, of biological products, renewable agricultural materials, or forestry materials (biomass).

Biodegradable products- Products designed to decompose at the end of their life by the conversion of all their organic constituents.

Biotreatment – Process which removes dissolved and suspended organic chemical constituents through biodegradation, as well as suspended matter through physical separation.

Cabin waste - All waste generated within the aircraft cabin, including cleaning, catering/galley, and items brought on board by passengers.

Circular economy - Alternative to a traditional linear economy (make, use, disposal) in which resources are kept in use for as long as possible, extracting the maximum value from them whilst in use, then recover and regenerate products and materials at the end of each service life.

Composite packaging - Products or packaging made from two or more layers of different materials that cannot be separated by hand, for example paper coffee cups lined with a plastic liner.

Compostable product - Subset of biodegradable products designed to biodegrade under controlled conditions.

Composting - Process that breaks down organic materials using bacteria in an oxygen-rich environment. The resulting product can be used as a soil conditioner.

Cradle-to-gate - Assessment of a partial product life cycle from resource extraction (cradle) to the aircraft gate (before it is transported to the consumer).

Cradle-to-grave - Assessment that considers impacts at each stage of a product life cycle from resource extraction to disposal.

Downcycling – The process in which a recycled product is not as structurally strong as the original product made from virgin materials.

Eco-friendly – Product designed to have little or no damaging effect on the environment.

Ecotoxicity - Potential for damage to ecosystems and species within them through the release of toxic materials.

Eutrophication - A gradual increase in phosphorous, nitrogen and other plant nutrients in an aging aquatic ecosystem which can cause large concentrations of algae and microscopic organisms which in turn means fewer animals such as fish and birds can be supported by these aquatic systems.

Functional unit - A functional unit is the reference unit for the study, covering the service being provided (what), the extent to which it is provided (how much), its quality (how well) and its duration (how long).

Global commitment - Launched in 2018, by the Ellen MacArthur Foundation (EMF) in collaboration with UNEP, unites businesses and governments behind a common vision to commit to change how they produce, use, and reuse plastic.

Global Tourism Plastics Initiative (GTPI) - Voluntary commitment initiative uniting over 200 organizations in the elimination and reduction of single-use plastic products from travel and tourism.

Global warming potential (GWP) - Relative potency of a greenhouse gas (GHG), taking account of how long it remains active in the atmosphere.

Home compostable packaging - Packaging/products that are made of components and materials that fully decompose into soil without intervention from industrial processes.

Industrially compostable products - Products where 90% of the product disintegrates within 12 weeks and breaks down completely to carbon dioxide in six months, in specialist machinery that can achieve the required heat and humidity for this breakdown to take place.

International Catering Waste (ICW) - Animal (meat) derived component of food waste generated on international flights and is subject to regulation in several countries. Some jurisdictions extend the definition to include waste comprising fruit and vegetables.

Ionizing radiation - Form of energy that acts by removing electrons from atoms and molecules of materials that include air, water, and living tissue.

Landfill - The disposal of waste by burying it in a site that is specifically designed and built to receive waste.

Leakage hotspot - A component of the system that, directly or indirectly, significantly contributes to plastic leakage and its associated impacts, which can be acted upon to mitigate this leakage.

Leakage pathway - The different ways and means that single-use plastic products may find their way into the environment as plastic pollution, such as being littered or being blown into natural environments from open air waste management sites.

Life Cycle Assessment (LCA) - A technique developed to better understand and address the environmental impacts at each stage of a product's life cycle (cradle-to-grave).

Linear economy - An economy that follows the "take, make, dispose" approach which does not contribute to circular economy principles.

Microplastics - Small pieces of plastic, less than 5 mm (0.2 inch) in length.

New plastic economy - An economy that prioritizes keeping plastics from becoming pollution.

Ocean acidification - A reduction in the pH of seawater due to absorption of carbon dioxide.

Photochemical ozone formation - Accounts for the formation of ozone at the ground level of the troposphere, which in high concentrations damages vegetation, human respiratory tracts and manmade materials through reaction with organic materials.

Plastic pollution - Negative effects and emissions resulting from the production and consumption of plastic materials and products across their entire life cycle.

Plastic sheets for cargo operations - Type of unite load device (ULD) cover, typically 0.03 to 0.05 mm thick polyethylene film with fire retardant additives, used to protect the cargo against the weather, prevent leakage and/or secure loads.

Plastics Treaty - Legally binding instrument, which would reflect diverse alternatives to address the full life cycle of plastics, the design of reusable and recyclable products and materials, and the need for enhanced international collaboration to facilitate access to technology, capacity building and scientific and technical cooperation.

Product integrity - Ability of a product to meet or exceed expectations for performance, quality, and durability.

Recyclable products – Products whose recycling is proven to work in practice and at scale.

Recycling - Treatment or processing of waste materials into new products for further use.

Recycling economy - An economy where products are collected, sorted, shredded, and turned into different products depending on the quality of processed material.

Reinjection - Transfer of packaged, safe to eat food and drink back into in-flight service.

Reusable products - Products that have been designed for numerous uses.

Single-use plastic products (SUPP) – Products made from plastic that are only used once and then disposed of, either during the provision of goods and services to airlines, or items that are used on board by passengers and/or crew.

Soil acidification - Process where the soil pH decreases over time.

Soil acidification - The emission of harmful substances that contribute to acid rain.

Sterilization - Process of making something free from bacteria or other living microorganisms.

Sustainable alternatives to SUPP - Disposable or reusable products that represent a net environmental benefit over commonly used SUPP, considering key aspects such as safety and integrity.

System boundaries - System boundaries define the beginning and end points of the life cycle that is being assessed.

Trade-offs - A compromise, or in other words, the exchange of one thing for another and a balancing of factors, all of which cannot usually be achieved at the same time.

Unnecessary and Problematic Plastics - Defined by the Global Tourism Plastics Initiative (GTPI) as plastics that:

- Are not reusable, recyclable, or compostable.
- Contains, or its manufacturing requires, hazardous chemicals that pose a significant risk to human health or the environment.
- Can be avoided, or replaced by a reuse model, while maintaining utility.
- Hinder or disrupt the recyclability or compostability of other items.
- Have a high likelihood of being littered or ending up in the natural environment.

Unit Load Device (ULD) - An aircraft pallet or pallet net combination, or an aircraft container.

Upcycling - The process of reusing old materials to make something new and more valuable.

Waste reduction hierarchy - Usually presented in the form of a pyramid, the waste reduction hierarchy indicates an order of preference for actions to eliminate waste at source, reduce waste through re-use models, recover waste by recycling and the different types of waste disposal from least to most harmful.

9. Annexes

Annex 1: Methodology

SUPP inventory

To identify the nature and scale of SUPP use, airlines need to develop a list of product types and corresponding quantities (such as number, weight, or area). Following a review of publicly disclosed targets and initiatives in 2022, six airlines with the most proactive SUPP reduction and replacement programs were interviewed to create a general SUPP list that would inform harmonized analysis across airlines.

Based on these findings, a simplified SUPP list for the airline sector has been created and presented in Table 3, considering 63 items organized into five categories: food & beverage (F&B); medical, hygiene & safety; amenities; operational; and cargo.

Table 3. SUPP List.

Food & Beverage	**SUPP**
Drink containers	Polyethylene terephthalate (PET) drinks bottles (water, wine, soft drinks, etc.)
	Multilayered or composite packaging
Drink service ware	Plastic cups and lids for hot beverages
	Plastics cups for cold beverages
	Cardboard/paper cups lined with plastic
	Plastic straws
	Drink stirrers
Food service ware	Cutlery (knife, fork, spoon, chopsticks)
	Bowls
	Plates
	Casseroles dishes
	Lids
Packaging	Plastic wrapping for cutleries and utensils
	Food wrapping film
	Pre-packaged food
	Bulk packaging for several products
Dairy product containers	Yogurt / Ice Cream container
	Individual butter pots
	Milk pot/jiggers
Kitchen / galley	Oven Bag
	Kitchen dyno packs (containers for food production and storage)
	Ice bag
	Bread bags
	Trays
Condiment and seasoning containers	Salt & pepper shakers
	Plastic packets for sauce and oil
Medical, hygiene & safety	**SUPP**
Medical	Medical supplies and packaging
	Personal protective equipment (PPE) (e.g., face masks, gloves, etc.)
Hygiene	Sick bags
	Wet wipes
Safety[72]	Safety card

[72] **For the purposes of this report safety items are will not be considered in the analysis for replacement options because they are required to meet regulations and due to their infrequent use.**

	Life jacket
	Plastic bags for retail purchase (Security tamper-evident bags [STEBs] and liquids, aerosols, and gels, [LAGs])
	Emergency air supply equipment
Amenities	**SUPP**
General Items	Headphones
	Refreshing towels
Amenity kit items	Amenity kits
	Toothbrushes + toothpaste
	Ear plugs
	Toothpick
	Socks
	Cotton bud sticks
	Eye mask wrappers
	Plastic wrap for amenity items
Operational	**SUPP**
General	Waste bags (e.g., liners for washroom and static bins, cleaners' bags)
	Disposable gloves
	Cling film
	Bulk packaging used for laundry transportation of service textiles
	Dry Ice bag
	Head rest cover
	Plastic bags for retail purchase (non-liquids)
Cargo	**SUPP**
Packaging	Styrofoam containers
	Tape / security tape
	Plastic envelopes & pouches for documentation
	Bubble wrap
Cargo Build Up	Plastic sheets / covers
	Plastic straps
	Absorbent sheets / pads
	Stretch wrap
	Single-use thermal blankets
	Styrofoam for padding
	Plastic labels
	Plastic skid / pallet

IATA research indicates that the majority of the 40 airline SUPP elimination and replacement initiatives include quantifiable reduction or replacement goals. However, a number have gone further by committing to replacing all on-board SUPP or to plastic-free flights. Given that many of the 63 SUPP items listed in Table 3 are mandated by civil aviation or public health authorities, airlines must be cautious about making such commitments.

As regulation around the nature of admissible statements with respect to airlines' and other organizations' environmental achievements and commitments is becoming more stringent, great restraint must be exercised in the use of terms such as plastic-free, 100% recyclable, 100% compostable or 100% recycled.

Airline web survey

An airline sector-specific SUPP web survey was issued to 69 airlines in August 2023 and 56 responses were received from 47 different airline operators[73]. A total of 54 respondents represented airlines with mixed passenger and cargo operations and two respondents operate dedicated cargo aircraft.

The survey responses provide a global representation from across all IATA's regions (Africa and the Middle East, the Americas, Europe, Asia Pacific and North Asia).

The survey aimed to provide an understanding of the level of airline experience in SUPP replacement including the motivations for taking action, as well as of SUPP inventories and data availability.

The survey also sought to identify the most problematic products and the key challenges that are preventing airlines from achieving successful SUPP replacement.

Based on the items listed in Table 3, a priority list of the five most problematic SUPP used by airlines globally was derived that includes PET bottles, cutlery, crockery, cups for cold and hot drinks, and cargo plastic sheets and stretch wrap. These items were used to scope the LCA and policy research.

Life cycle assessments

A comprehensive review was carried out to identify the existence of LCAs for the five SUPP identified above.

Drawing on the findings of the literature review, guidance on commissioning and interpreting LCAs was created to help airlines make more informed decisions by understanding the different environmental trade-offs involved. The LCA guidance is complemented by a series of decision trees that take into account operational and regulatory considerations into account to facilitate balanced decision-making.

Legislation

A major complication facing the airline sector value chain is the lack of global consistency relating to SUPP legislation. The legislation in five territories (Australia, Canada, Europe, India, and the People's Republic of China) was analyzed and compared across the five problematic items. The findings not only illustrate the range of challenges the industry faces but also the potential for harmonized global actions and the need for a consistent global approach.

[73] Some airlines responded to cargo and passenger surveys separately.

Annex 2: Regulatory restrictions per problematic SUPP used by the airline sector

Table 4. Overview of SUPP legislation in five key territories for five key items used by airlines.

	Australia	Canada	Europe	India	P.R.China
PET Plastic Bottles	Not restricted.	Not restricted.	Not restricted but requires incorporating recycled plastic (25% from 2025, and 30% from 2030).	Restrictions are state dependent.[74]	Not restricted.
SUP Cups (and paper lined with plastic)	Mixed restrictions depending on the state and applied only to specific business types but no obvious exemptions for airlines.	Assumed prohibited as legislation refers to "food service ware made from or containing problematic plastics that are hard to recycle".	Restricted, including oxo-degradable and bio-based plastics. Labeling requirements.	Prohibited.[75]	Prohibited in domestic airports and on domestic flights. Unclear if legislation applies to international flights.
Plastic Cutlery	Mixed restrictions depending on the state, including some exemptions for aircraft.	Assumed prohibited as legislation refers to "food service ware made from or containing problematic plastics that are hard to recycle".	Prohibited, including oxo-degradable and bio-based plastics.	Prohibited.	Assumed prohibited on aircraft as CAAC (Civil Aviation Administration of China) legislation bans SUP "tableware" and cutlery would likely fall under this definition.
Plastic Crockery	Mixed restrictions depending on the state, including some exemptions for aircraft.	Assumed prohibited as legislation refers to "food service ware made from or containing problematic plastics that are hard to recycle".	Restricted, including oxo-degradable and bio-based plastics.	Unclear as legislation refers to plates and trays.	Prohibited. Single-use crockery is expressly covered by the CAAC legislation and is already banned at airports and on domestic flights, with the ban being extended to international flights in 2023.
Cargo plastic sheets and stretch wrap	Not restricted.	Not restricted.	Not restricted.	Not restricted.	Restricted in domestic airports. Unclear if restricted from incoming aircraft.

[74] **Certain Indian states do impose minimum volumes for PET bottles including Kerala and Maharashtra.**
[75] **The Print (2023). 'Laminated paper cups' are 95% paper. They still come under single-use plastic ban, rules HC.**

Annex 3: Life Cycle Assessment Literature Review

Life Cycle Assessment (LCA) is an established methodology framework to estimate environmental impacts in a transparent, replicable, and comparable manner. Specific impact categories are chosen by the researchers and/or their commissioners/clients and can range from the global warming potential of GHGs through eutrophication to soil acidification. Choices about the scope of the study and what is included and excluded determine how comparable it might be to a similar study. With harmonized approaches to establishing study scope, LCA studies can be ideal for understanding the effects of SUPP and their alternatives in aviation.

A literature review was conducted to synthesize the findings of LCA on SUPP in aviation, specifically for five key products of interest:

- Bottles
- Cutlery
- Crockery
- Cups
- Cargo packaging wrap

This synthesis intends to present the established research and provide input to recommendations for the aviation industry when conducting their own LCA. With enough information, it could form the basis of the harmonized approach needed to make LCA studies replicable and comparable.

The review aimed to answer the following questions:

- Which relevant LCAs exist for SUPP on aircraft?
- What is common to these LCAs in terms of:
  - functional unit?
  - scope and boundary?
  - anything else upon review?
- What additional research is called for?
- What are the challenges experienced in conducting relevant LCAs?

Method

The search took place using the SCOPUS engine with key words aimed at the industry, LCA studies, plastic, and the key products. There were no geographical exclusions but only results from 2018 and later were included due to the changing aviation industry and the shift in focus on SUPP since 2018. The search returned 1,240 results and WRAP sourced one additional unpublished paper through contacts. Only four ended up in scope for review.

Table 5. Literature search results and filtering in two screenings.

Search results	1st screening	2nd screening
1,240 published	6 relevant 34 unclear 1,200 irrelevant	3 in scope 1,237 not in scope
1* unpublished	1 relevant	1 in scope

*WRAP obtained one unpublished study; this is not a comment on how many unpublished studies there are.

These four papers are:

1. Blanca-Alcubilla et al. (2020).Is the reusable tableware the best option? Analysis of the aviation catering sector with a life cycle approach.
2. Blanca-Alcubilla G. (2021). Life Cycle Assessment of the cabin waste management in the aviation sector.
3. Keiser et al. (2023). Life cycle assessment in aviation: A systematic literature review of applications, methodological approaches and challenges.
4. Wei et al. (2022). Revealing the feasibility and environmental benefits of replacing disposable plastic tableware in aviation catering: An AHP-LCA integrated study.

The search and subsequent screening results likely show that this is an under-researched area. Two of the four results have the same lead author. Consequently, it is likely decisions on SUPP in aviation are not being made based on published and transparent LCA evidence and therefore may not have the greatest impact on environmental protection.

Findings

LCA papers

Table 6. Papers reviewed against type of paper and SUPP products included in the paper.

Paper reference	Type		Products included				
	LCA study	Review paper	Cutlery	Crockery	Cups	Bottles	Cargo wrap
Blanca-Alcubilla et al. (2020).	x		x	x	x		
Blanca-Alcubilla, G. (2021).	x	x	All but only as a fraction of total on-board catering waste				
Keiser et al. (2023).		x					
Wei et al. (2022).	x		x	x			

Three papers (Blanca-Alcubilla et al. (2020); Blanca-Alcubilla, G. (2021); Wei et al. (2022)) comprised LCA themselves, of which only Blanca-Alcubilla et al. (2020) and Wei et al. (2022) focused on the priority products. Keiser et al. (2023) comprises a review and analysis of relevant LCA, while Blanca-Alcubilla, G. (2021) also contains a brief review of relevant LCA. Some of the LCA reviewed in those papers are outside of the date range of this review.

Functional unit

It is established to use number of meals (1,000) for the SUPP products reviewed but this only applies to those items (Wei et al. (2022); Blanca-Alcubilla et al. (2020)). In other words, LCAs are only available for SUPP used in meal packaging/provision and not bottles or cargo wrap.

Overall, LCAs in aviation most commonly uses a functional unit of passenger kilometers (Keiser et al. (2023)).

Scope

Differences in scope have a significant bearing on conclusions.

Impact categories

Wei et al. (2022) considers 11 different impact categories. However, Blanca-Alcubilla et al. (2020), only considers the impact of global warming potential (100-year timeframe) in the study. Blanca-Alcubilla, G. (2021) considers six impact categories.

Considering more than one impact category allows for better information about the potential for trade-offs and the unintended consequences of changes. In the case of SUPP, products made from alternative materials or alternative ways SUPP can be made, used, and disposed of, might have better impacts on the environment in some ways but worse in others. In Wei et al. (2022) for example, bamboo tableware is shown to have a lower global warming potential than a bioplastic blend (polylactic acid and polypropylene) but a higher acidification potential.

Transport and use phase

- Wei et al. (2022) assumes transport emissions and fuel consumption of the aircraft is out of scope since as a comparative LCA between similar items, the impacts of alternatives will be negligibly different.
- Blanca-Alcubilla et al. (2020) states that the fuel consumption from weight differences make the greatest contribution to overall impact.
- Blanca-Alcubilla, G. (2021) does not consider impacts before and during use of products.

Waste management

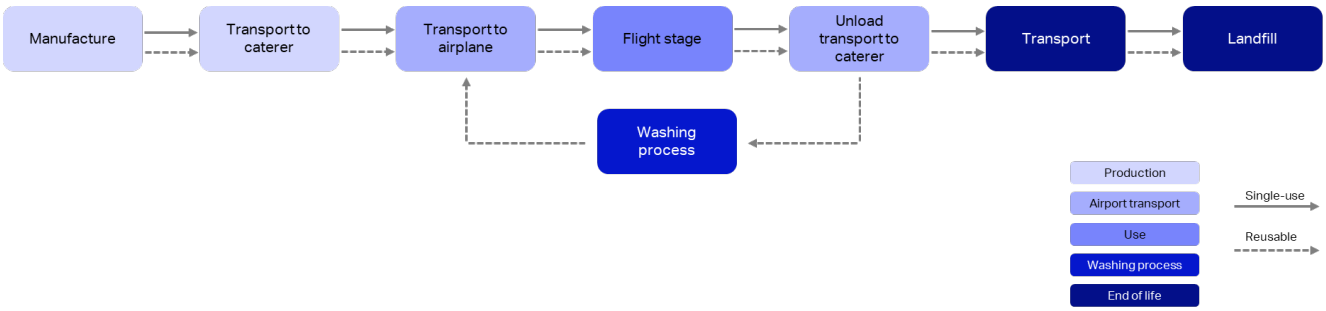
- Blanca-Alcubilla,G. (2021) includes recycling in different waste management scenarios for cabin waste.
- Wei et al. (2022) considers incineration in scope, whereas Blanca-Alcubilla et al. (2020) only considers landfill as an end-of-life destination due to the specific airline and airports of the different studies.

System boundary

The reviewed literature provided a couple of useful diagrams for system boundaries of SUPP in aviation.

Blanca-Alcubilla et al. (2020) highlight that transport and flight impacts are included, using shading to differentiate stages in the life cycle.

Figure 5. Life cycle system boundary of tableware, including flight stage.

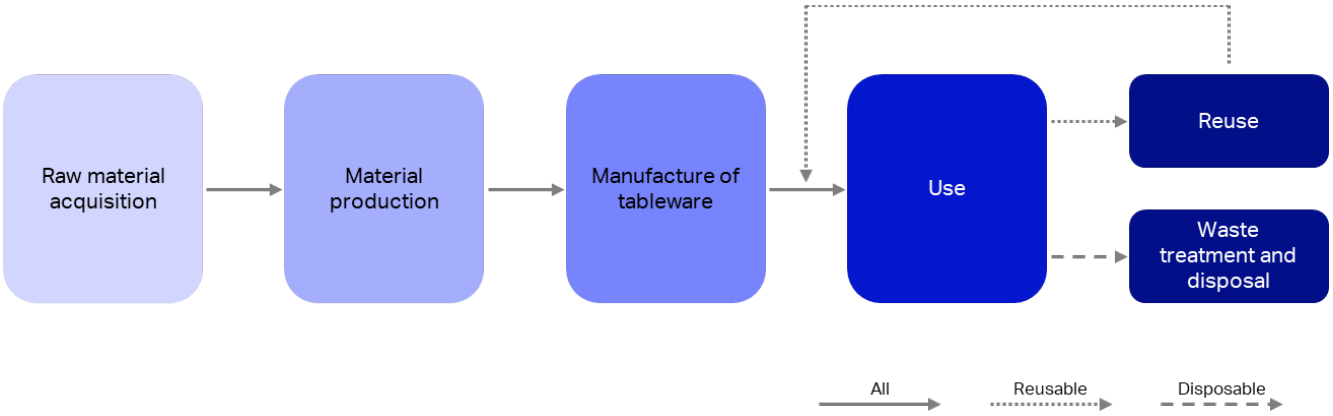


Source: Adapted from Blanca-Alcubilla et al. (2020).[76]

[76] Blanca-Alcubilla et al. (2020).Is the reusable tableware the best option? Analysis of the aviation catering sector with a life cycle approach.

Wei et al. (2022) provides a clear and simple system boundary diagram, focusing on the different stages of impact in the cradle to the gate part of the life cycle.

Figure 6. Life cycle system boundary of tableware, only considering cradle-to-gate.



Source: Wei et al. (2022)[77].

The two figures demonstrate the difference in approach to the scope of the studies and how, with small decisions on assumptions, a different picture emerges with drastically different results and conclusions.

Both studies are cradle-to-grave yet have opposing conclusions, which would not be expected of supposedly comparable studies in terms of their system boundaries. Blanca-Alcubilla et al. (2020) include the impact of weight of cutlery on aircraft fuel consumption as part of the use phase and highlight the separation of stages in the reuse part of the life cycle. Wei et al. (2022) focuses on the detail of the production of both disposable and reusable tableware. Conclusions from Wei et al. (2022) mention that the preferred option is tableware with the least impact on the production phase, whereas Blanca-Alcubilla et al. (2020) highlights as a better option tableware that has less impact in aircraft fuel consumption.

Blanca-Alcubilla, G. (2021) compares different end-of-life phase scenarios in its LCA, gate to grave, and therefore is less useful to consider for full life cycle studies. Despite this, there are important conclusions to be drawn from this study on the role of recycling in end-of-life treatment and disposal of SUPP In aviation. The study looked at the relative environmental impact of disposal of on-board aviation catering waste to landfill alone and a scenario where recyclable waste is separated for recycling. This recycling scenario accounted for EU legislation on hazardous waste of animal origin from outside the bloc; it was a practical/real-world scenario based on waste composition data from Madrid airport and Iberia flights. The study concluded that "selective collection of waste on airplane cabins and the correct management of recoverable waste would considerably reduce the environmental impacts of the aviation catering waste management systems"[78]. In other words, recycling and recovery of separated aviation catering waste is much better for the environment than landfilling it. This conclusion should be treated with caution when applied to SUPP in that it applies to all catering waste (including non-SUPP waste). The author did not show the contribution to the results by waste type.

[77] Wei et al. (2022). Revealing the feasibility and environmental benefits of replacing disposable plastic tableware in aviation catering: An AHP-LCA integrated study.
[78] Blanca-Alcubilla G. (2021). Life Cycle Assessment of the cabin waste management in the aviation sector.

Calls for additional research

As research in this area is limited, additional research is needed. Of papers reviewed, Keiser et al. (2023) specifically calls for: "first, the methodological specification of LCA methodology to the aviation industry and second, an organizational research agenda for operationalizing LCA in the aviation industry". The wider report attempts to address these calls.

Although not a call for additional research as such, Blanca-Alcubilla, G. (2021) states the importance of EU legislation on SUPP and the impact on the waste treatment options. In other words, recycling from international flights is precluded by law in this jurisdiction. The environmental impact of different waste treatment options cannot be included in the scope of any airline affected by this legislation. This would indicate the importance of research on differences in policy and legislation toward SUPP around the world and their impact on aviation.

Challenges

Keiser et al. (2023) identify and summarize four key challenges, albeit including LCA out of scope of this study:

- Representation accuracy.
- Comparability.
- Data availability and quality.
- Uncertainty.

Representation and comparability refer to the scope and boundary differences of LCA. The former is a challenge of representing the full picture when some LCA exclude areas from scope and/or system boundaries. The latter is a challenge of comparing studies of different scopes and boundaries with each other. For example, Wei et al. (2022) and Blanca-Alcubilla et al. (2020) have opposite conclusions on the whole but incomparable scopes and boundaries.

None of the LCA identified as relevant for this review published a summary of the data quality used in their studies. The lack of relevant LCA identified may indicate an issue of data availability and/or quality.

Wei et al. (2022) presented a sensitivity analysis to assess the impact of any uncertainty in their data but not an assessment of the uncertainty itself. In other words, those authors did not say how likely changes (from inaccuracy/error) in some of the underlying data might be. However, they did show the effect of changes in data that might result from correcting any hypothetical inaccuracy/errors. Blanca-Alcubilla et al. (2020) and Blanca-Alcubilla, G. (2021) presented neither a sensitivity analysis nor an assessment of uncertainty in their data.

Annex 4: Guidelines on commissioning and interpreting LCA

Drawing on the findings of the literature review, this section provides an overview of some of the issues that are specific to commissioning LCAs in the context of the aviation industry, supplementing existing guidance on LCA from sources such as the International Organization for Standardization and the European Commission.

Goal

At inception, the goal should be a statement that sets out the rationale for the study. The goal should outline: What is the context for commissioning the work? How does the commissioning body intend to use it? Who will be the audience for the work, and who will provide an independent critical review of the findings?

For the aviation industry, it is important to understand at the outset whether the study is to inform internal decision making or for making public statements on environmental impacts. Where comparative assertions are to be made in public (e.g., option X has a lower carbon footprint than option Y) the international standards on LCA (ISO14040 and ISO14044 require a peer review panel to be appointed.

Where the objective is to be able to communicate publicly, the organization commissioning the LCA should also consider any requirements relating to green claims in the country / countries in which those claims will be made. This may also affect the type of study commissioned. For example, green claims in the EU[79] or the Loi anti-gaspillage économie circulaire in France.[80]

Scope

Functional unit

When starting an LCA, the first issue is to define the functional unit. This is the reference unit for the study covering the service being provided (what) the extent to which it is provided (how much), quality (how well), and the duration (how long). For the aviation industry, comparing single use and reusable alternatives requires a functional unit that covers multiple uses. This needs to be sufficiently large to recognize the number of single use items replaced by reusable items, loss rates, and so forth.

An example functional unit could be: *The safe provision of cups for 300 drinks of 250ml per flight over 200 medium-haul flights, where safe refers to how well, provision of cups is what, the number of drinks and size of drink refers to how much and the number of flights covers how long.*

Alternatively, a passenger-centric approach might allow different carriers to compare single-use and reusable plastic products for their specific operations: *The safe provision of cups to contain the drinks of one passenger per kilometer flown.* This could be further specified with information on the general drinking habits of an average passenger (e.g., ml per passenger per flight/flight distance). There would be a need to further define issues, such as flight distance.

Thought should be given to commissioning a study which covers short, medium, and long-haul flights to understand whether there are differences due to distance travelled. Also, functional units should be appropriate to incorporate the different stages of the life cycle of the product.

[79] European Commission. Green Claims.
[80] Ministere de la Transition Ecologique et de la Cohesión des Territoires. La loi anti-gaspillage pour une économie circulaire.

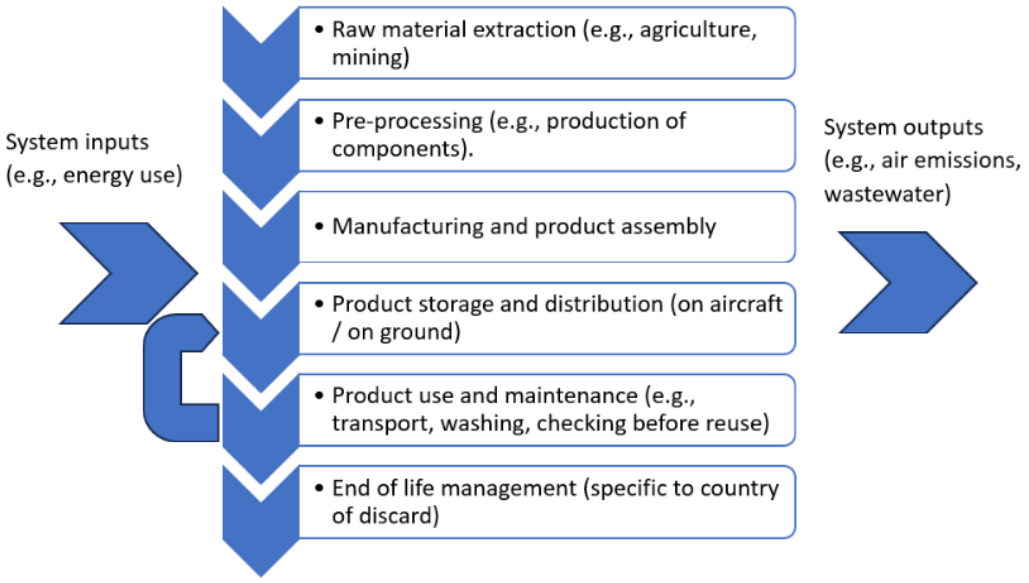
Boundary

The boundaries of a LCA should be clearly defined, and this is most easily shown through a system boundary diagram. Core requirements are shown in the diagram below. Where an element of the life cycle is equal in all scenarios, it need not be included in the assessment. This could include, for example, the construction of the aircraft itself, luggage which is being wrapped, or the quality of service provided to a customer.

Key issues for the aviation industry to consider regarding the boundary and the functional unit are:

- Impacts from raw material extraction should only account those driven by airline demand.
- Product storage and distribution. For example, would a flight take off and land on each leg of the journey with the exact quantity of an item required or would additional items be carried? What inflight infrastructure is required to store the items?
- What maintenance activities are required for a reusable item? For example, a visual check, or hot washing. Further information on reusable items is given in the following section.
- End of life should be process specific. In which country or countries would products be disposed of, or prepared for reuse? What resources are required for disposal, or to collect items to prepare them for reuse?

Figure 8. System boundaries.



Primary data should be gathered for each stage of the life cycle, relating to the functional unit specified. This will include, for example, the materials used, product packaging, energy use, direct emissions to air, and information waste management destinations by country. Secondary data sets may also be used, including environmental impacts associated with electricity generation in a specific country.

Limitations

In preparing the LCA, assumptions and limitations must be identified at the earliest opportunity. Where a scenario is based on a small-scale pilot or hypothetical situation, this should be clearly stated.

Where primary data is not available, secondary, often average, data (e.g., from trade associations) may be available. In some cases, neither primary nor secondary data may be available (e.g., information on distance travelled by an item as part of distribution). In this example, default assumptions may be used. The implications of using secondary data and assumptions should be discussed and may be reviewed as part of a sensitivity analysis.

Life cycle inventory and allocation

In line with the agreed system boundary, primary data should be gathered for each of the following life cycle stages. The data should be specific to the materials and products being used by the aviation industry.

1. Raw material acquisition and pre-processing (including production of parts and components).
2. Manufacturing (production of the main product).
3. Distribution (product packaging, distribution and storage).
4. Use (including transport component).
5. End of life (including product recovery or recycling).

Key issues for the aviation industry

Use phase: allocation of impact during flight

The impact of transport emissions can be allocated to items being transported in two different ways. The first is where transport capacity is limited by volume. The second is where transport capacity is limited by mass. The GHG protocol[81] and Life Cycle Inventories of Air Transport Services[82] both recommend use of mass allocation in aviation. Mass allocation is right now the only one accepted by IATA's recommended practices on CO2 emissions calculation for air segments (PAX - RP1726 / Cargo - RP1678). The EU Product Environmental Footprint method does not specifically address air transport. Mass allocation for single use and reusable items is therefore recommended, measured in ton-kilometers. So, for example, to allocate fuel use to cups carried on an aircraft, the fuel use would be divided by the payload, multiplied by the weight of the cups in metric tons, then divided by kilometers travelled to give fuel use per ton-kilometer. If a passenger-centric function is defined, the impact may be quantified per passenger-kilometer. Please also see IATA's Passenger CO2 Standard Methodology[83] for further information.

Reuse rates and activities

Reusable items will have a finite life due to losses, breakages, and wear over time. The number of reusable items required to provide a service must therefore be considered and justified, and the functional unit sufficiently large to allow for modelling to incorporate losses / replacements.

Activities specific to reuse must also be included. This may include inspections to ensure that the items continue to be fit for purpose, washing, and cleaning. Consideration should also be given to whether the reusable items are for the use of one airline, or if pooling (sharing) items for reuse among airlines is to be assessed. This could bring potential efficiencies of scale. For more guidance on reuse please see the EU Product Environmental Footprint Methodology[84].

End-of-life

One of the challenges for LCAs for items brought onto and off aircraft is the number of countries in which single use and reusable items will be discarded at the end of their life. The choice is therefore to commission an LCA that considers a specific country of loading / unloading, or to commission a study which considers multiple end-of-life destinations as alternative scenarios. In each case, it is important that the LCA discusses the results in this context.

Many databases exist that contain standard waste management data for common materials. For example, ecoinvent[85] includes country specific solid waste management data for Europe, Brazil, Colombia, Peru, India,

[81] GHG Protocol. Technical Guidance for Calculating Scope 3 Emissions. Category 4: Upstream Transportation and Distribution.
[82] Treeze (2016). Life Cycle Inventories of Air Transport Services.
[83] IATA. Passenger CO2 Standard Methodology.
[84] European Commission. Recommendation on the use of Environmental Footprint methods.
[85] Ecoinvent (2024). Waste Management and Recycling.

and South Africa. ecoinvent also includes default combinations of waste treatment processes (e.g., x% to recycling, y% to landfill, z% to energy recovery). Those mixes offer the possibility to users to model country specific burdens that arise from waste management. The mixes include different treatment processes based on the regional availability of them, including plastics. The LCA database[86] managed by Sphera includes information on the management of materials and chemicals in different countries by a variety of waste management routes. The European Platform on LCAs[87] also contains some standard factors. For GHG emissions associated with landfill, the Intergovernmental Panel on Climate Change has produced a simple spreadsheet model that allows the modelling of change in waste emission factors by geography[88] and the Emission Factor Database[89].

In considering the end of life, the study should be clear whether an average disposal mix for a country will be used, or if specific treatment routes are anticipated. Where known, the specific treatment route should be modelled. It is likely to be of use to consider an alternative treatment route to understand the effect this has on the outcome of the LCA.

Environmental impact categories

A range of environmental indicators may be considered relevant. The EU Product Environmental Footprint Methodology recommends 14 impact categories for general inclusion, summarized in Table 7 below. Further guidance on each impact category is available in the Product Environmental Footprint (PEF) Methodology[90].

Two key gaps to be aware of are scientific understanding of the impact of plastics that become marine litter, and biodiversity. Woods et al[91] identify that their impact is not adequately understood or incorporated into the above indicators. Although biodiversity is important, there is not yet consensus on the measurement of this in LCAs. Until characterization factors for their impacts are agreed, this will remain a gap.

Table 7. PEF environmental impact categories.

Categories	
Climate change, total	Eutrophication, terrestrial
Ozone depletion	Eutrophication, freshwater
Human toxicity, cancer	Eutrophication, marine
Human toxicity, non-cancer	Ecotoxicity, freshwater
Particulate matter	Land use
Ionizing radiation, human health	Water use
Photochemical ozone formation, human health	Resource use, minerals and metals
Acidification	Resource use, fossils

This guidance focusses on areas of common interest for the aviation industry. It is desirable that any study considers multiple criteria, rather than focus on a single issue. This is to ensure that a holistic view of the impact on the environment is considered, and to ensure that material or relevant issues are considered in making and communicating changes. Defining materiality or relevance is a combination of the functional unit and global issues, for example where planetary boundaries are being exceeded.

[86] Sphera. Managed LCA Content (GaBi Databases).
[87] European Commission. ILCD International Life Cycle Data system.
[88] IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 5. Waste.
[89] IPCC. EFDB. Emission factor database.
[90] European Commission. Environmental Footprint methods. Annexes 1 to 2.
[91] Woods et al. (2021). A framework for the assessment of marine litter impacts in life cycle impact assessment.

Five impact categories which are likely to be material and with potential for variation between single use and reusable systems are:

- Climate change. Climate change is a ubiquitous issue, considering all inputs and outputs that result in greenhouse gas emissions. It calculates global warming potential, measured in carbon dioxide.
- Ecotoxicity, freshwater. This considers the potential for damage to ecosystems and species within them through the release of toxic materials. It is measured in Comparative Toxic Units for ecosystems.
- Eutrophication considers the impact of nutrients (e.g., nitrogen and phosphorus) that accelerate the growth of algae and other vegetation in water. This may be a relevant issue when considering biodegradable and fossil based alternative materials and is measured through a range of criteria.
- Resource use (minerals, metals, and fossil) considers the use of non-renewable natural resources and is measured through abiotic resource depletion.
- Water use is a location specific impact factor, requiring knowledge of the location of processes across the life cycle. It considers the potential for water deprivation and may be affected where activities change water demand in primary production or washing items for reuse. It is measured in cubic meters water equivalent of deprived water.

Conclusion and summarized recommendations

Although the intention of an LCA is to facilitate decision making, LCAs are extremely complex, and since they are an under-researched area in aviation, it is important to understand that decisions around scope will determine how comparable one study will be to another. There are not many LCAs on SUPP in aviation. What does exist cannot therefore establish an agreed best practice, nor recommend a harmonized approach to setting out study scope.

Nevertheless, there are a few key recommendations that can be made from the literature, especially for those looking to commission their own LCA or interpret results of those provided by suppliers or manufacturers.

Given the lack of product specific information and any studies on cargo wrap, conclusions should be assumed to apply to all SUPP used by passengers.

When commissioning an LCA on SUPP replacement in aviation:

- As a starting point, ensure that all possible steps have been taken to reduce waste at source by preventing and minimizing consumption of single-use products.
- Ask for a cradle-to-grave study, which allows for better comparability between studies without excluding life cycle stages. A caveat is that certain stages may not be relevant to the objective of the study and therefore including them has cost/resource implications.
- Include aviation fuel in the scope, as excluding it appears to affect conclusions. This is due to the correlation between weight transported by air and fuel use, and consequently environmental impact. Even small weight changes between items make a difference over time and when comparing the provision of thousands of meals or kilometers travelled. This recommendation may change as the industry moves to sustainable aviation fuel (SAF) in line with the sectors net zero carbon emissions target. Transport emissions of moving SUPP between stages of the life cycle should be included at least for stages from manufacturing gate to disposal to accommodate changes in fuel use for reusable alternatives and/or heavier alternatives.
- Bear in mind that though the lightest alternatives to SUPP may perform well when considering impacts on fuel burn, they may not necessarily perform well in other impact indicator categories.
- Although global warming potential (GWP) over a 100-year timeframe is common, ensure that other indicators that go beyond global warming potential such as water use, land use and ozone depletion—which are also relevant issues—are also considered when making and communicating changes. The EU Product Environmental Footprint (PEF) indicators are a useful guide.

- Require an assessment of uncertainty in data and analysis. This is not satisfied solely with a contribution and sensitivity analysis. Researchers should assess the uncertainty in the underlying data. This can be qualitative in nature where a quantitative assessment cannot be made.
- Use established functional units such as thousands of meals for catering SUPP or provision of SUPP for a passenger kilometer traveled.
- Specify more than one end-of-life scenario, so that decision making can also consider available waste infrastructures, particularly in territories where recyclable waste is able to be segregated for recycling. Evidence suggests recycling of materials from onboard waste has better environmental outcomes than landfilling or incineration. This is likely to apply to SUPP but there may be nuance for certain impact indicators that were lost when aggregating the results for all waste in the study in question. Therefore, different options in a study will give results relevant to SUPP and airline circumstances.

When interpreting the results of an LCA on SUPP replacement in aviation:

- Check the scopes to understand exactly which life cycle stages and impact indicators have been included in the assessments so that you can understand the comparability of multiple assessments for the same or similar products and circumstances.
- Check that the end-of-life scenarios in the LCA are representative of the waste infrastructures and regulations in the territories to which the airline flies.

Annex 5: Decision Trees

The information provided in the decision trees is not exhaustive and its main purpose is to inspire thinking.

The additional information on different materials is for reference. When considering a replacement option, several aspects should be taken into account, such as operational considerations, sourcing of materials, end of life treatments, recycled content included, product integrity, etc.

Airlines would benefit from carrying out a similar exercise relevant to their own specific situations and incorporating LCA on the different items considered.

Plastic water bottles

Figure 9. Plastic water bottle decision tree.

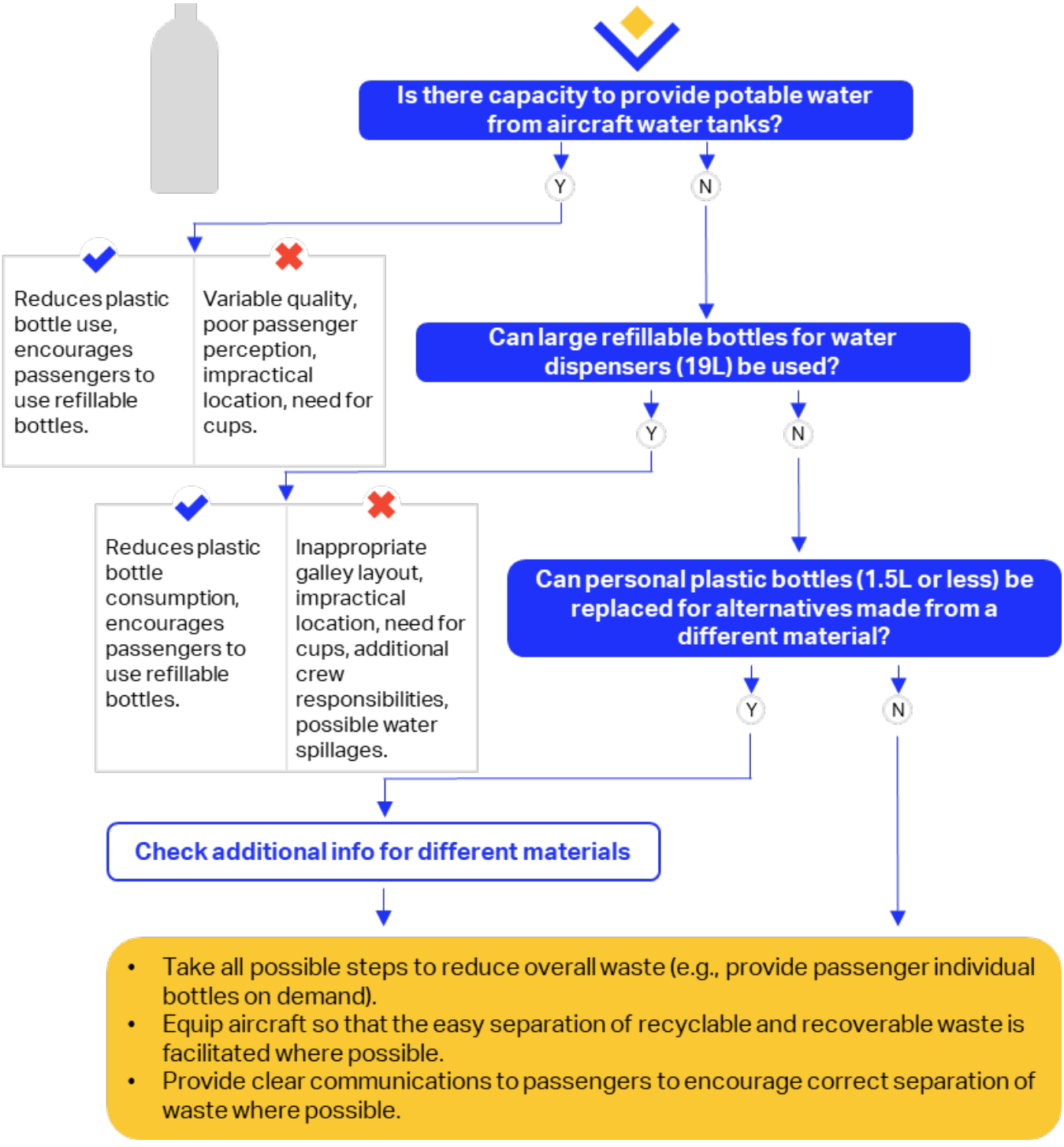
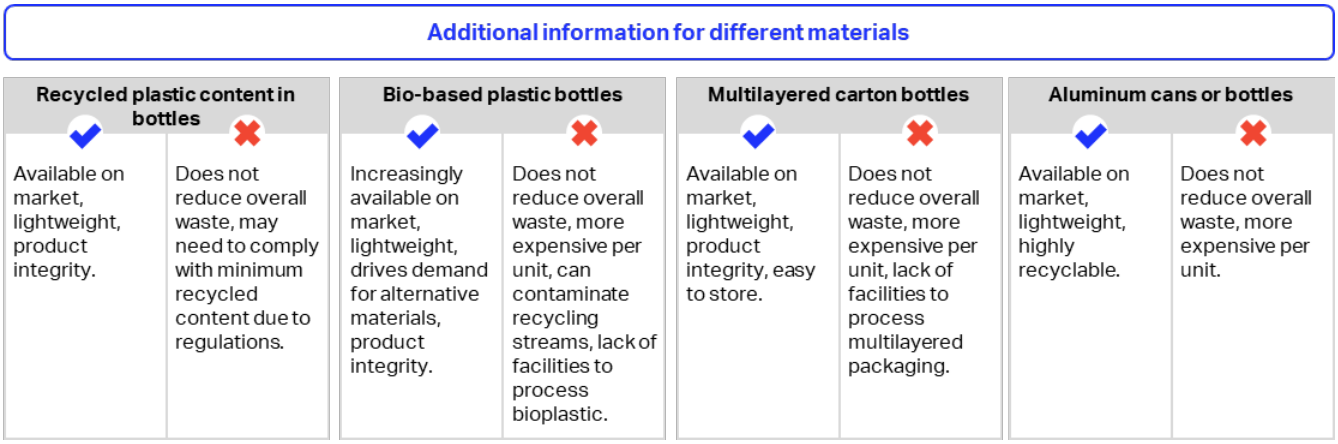


Figure 10. Additional information for different materials for water bottles.



Single-use cups

Figure 11. Single-use cups decision tree.

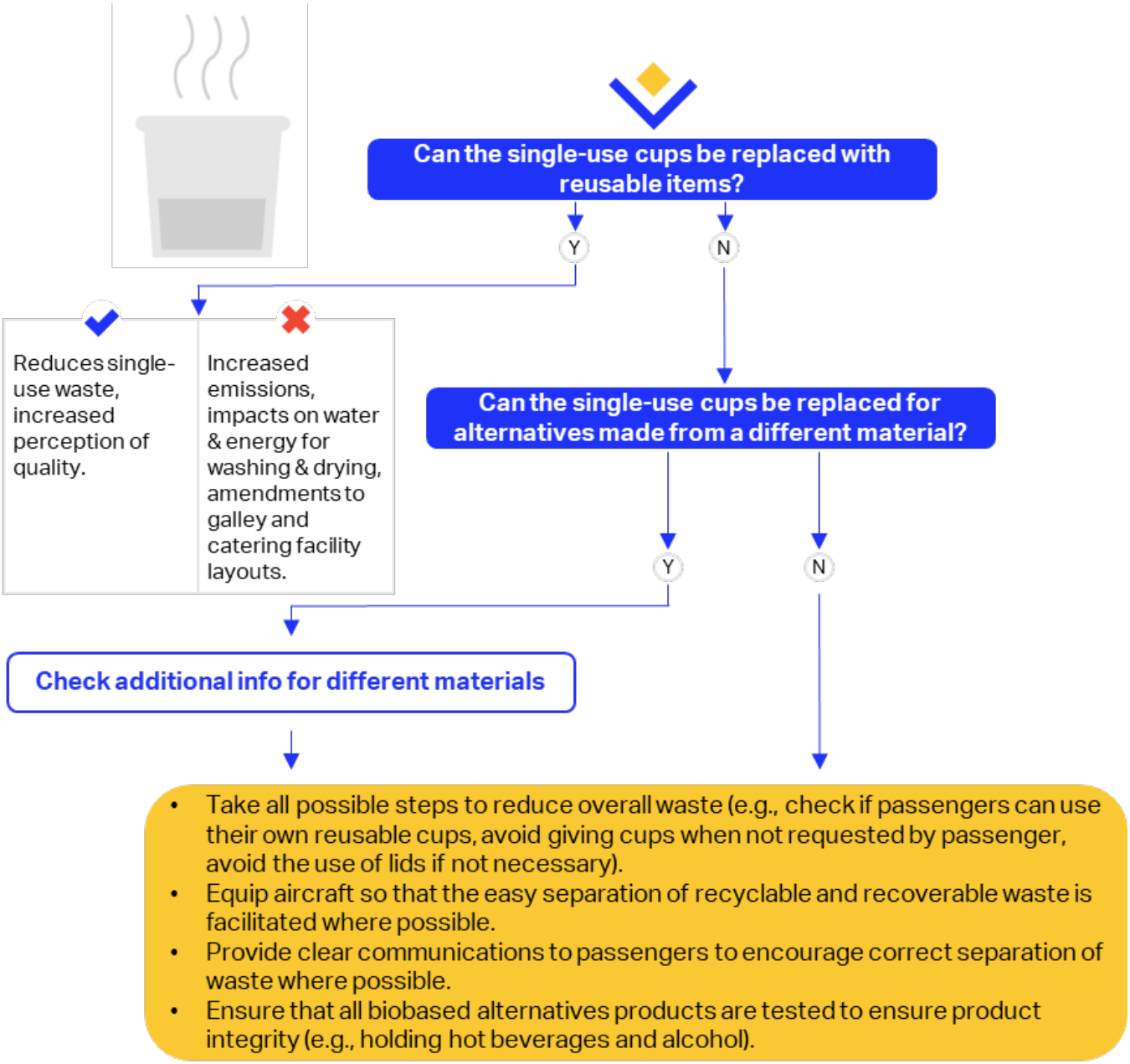
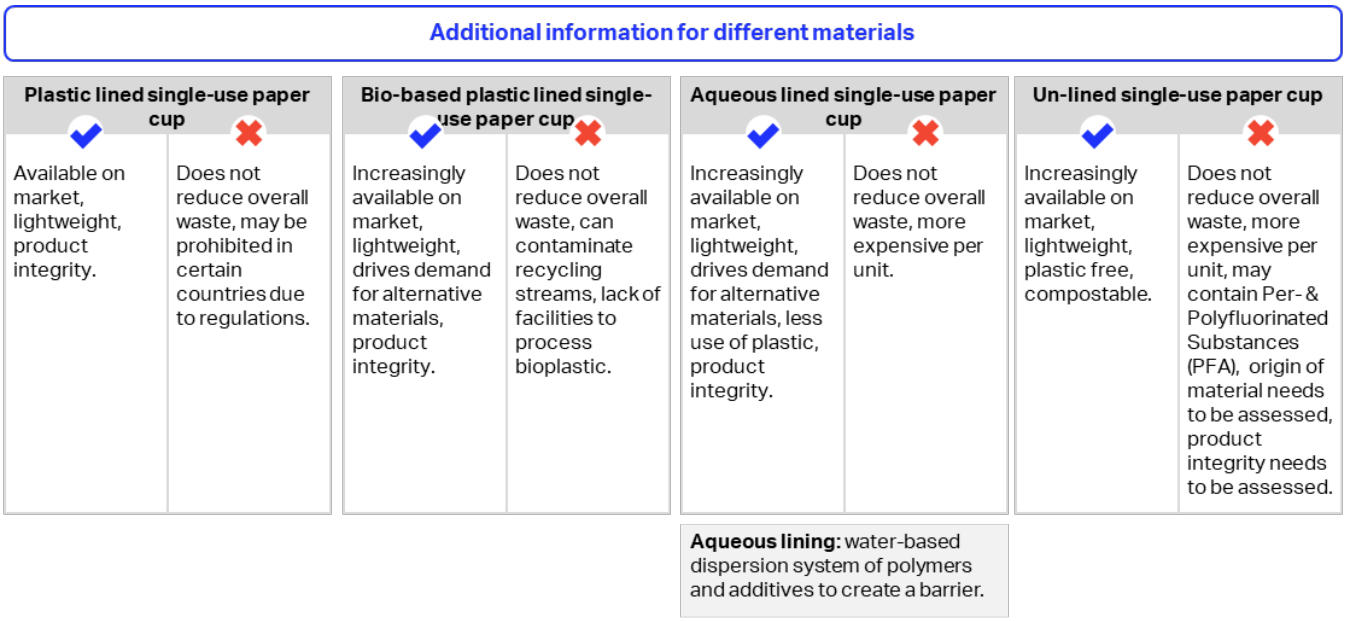


Figure 12. Additional information for different materials for single-use cups.



Single-use crockery

Figure 13. Single-use crockery decision tree.

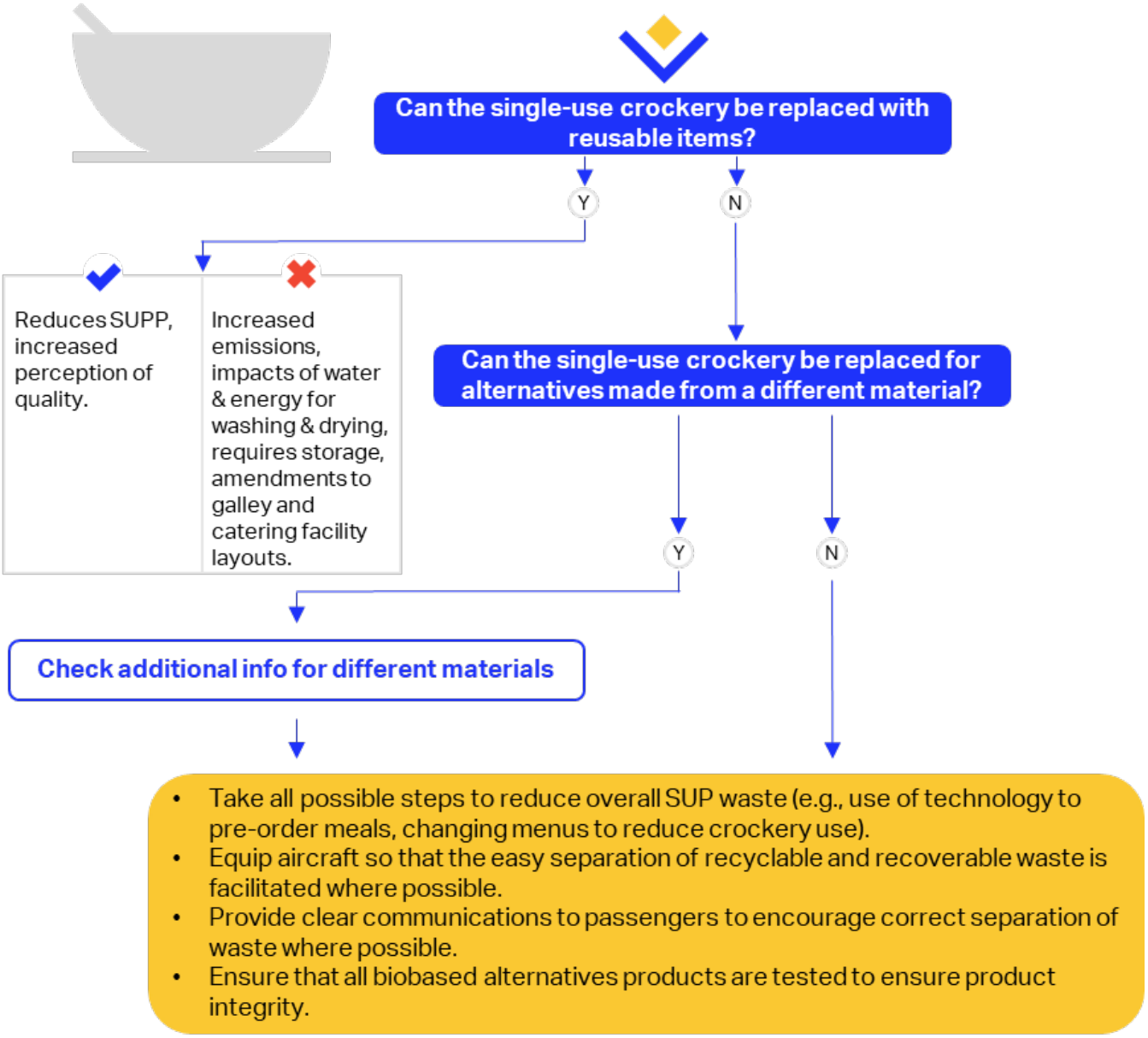
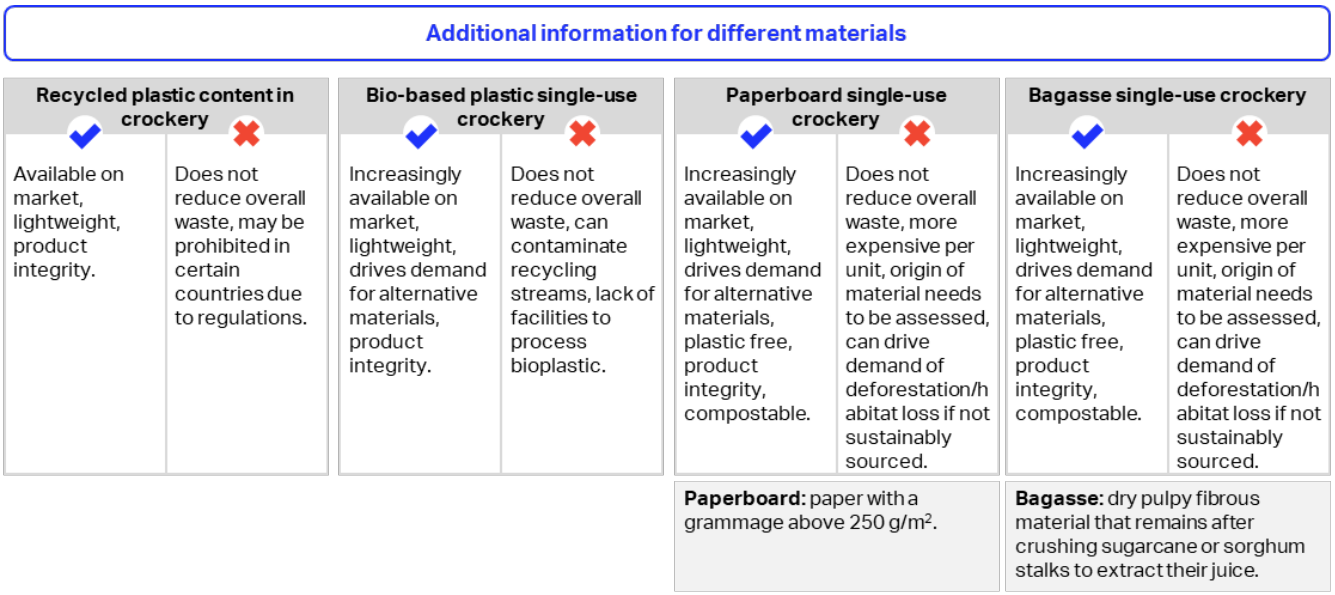


Figure 14. Additional information for different materials for single-use crockery.



Single-use cutlery

Figure 15. Single-use cutlery decision tree.

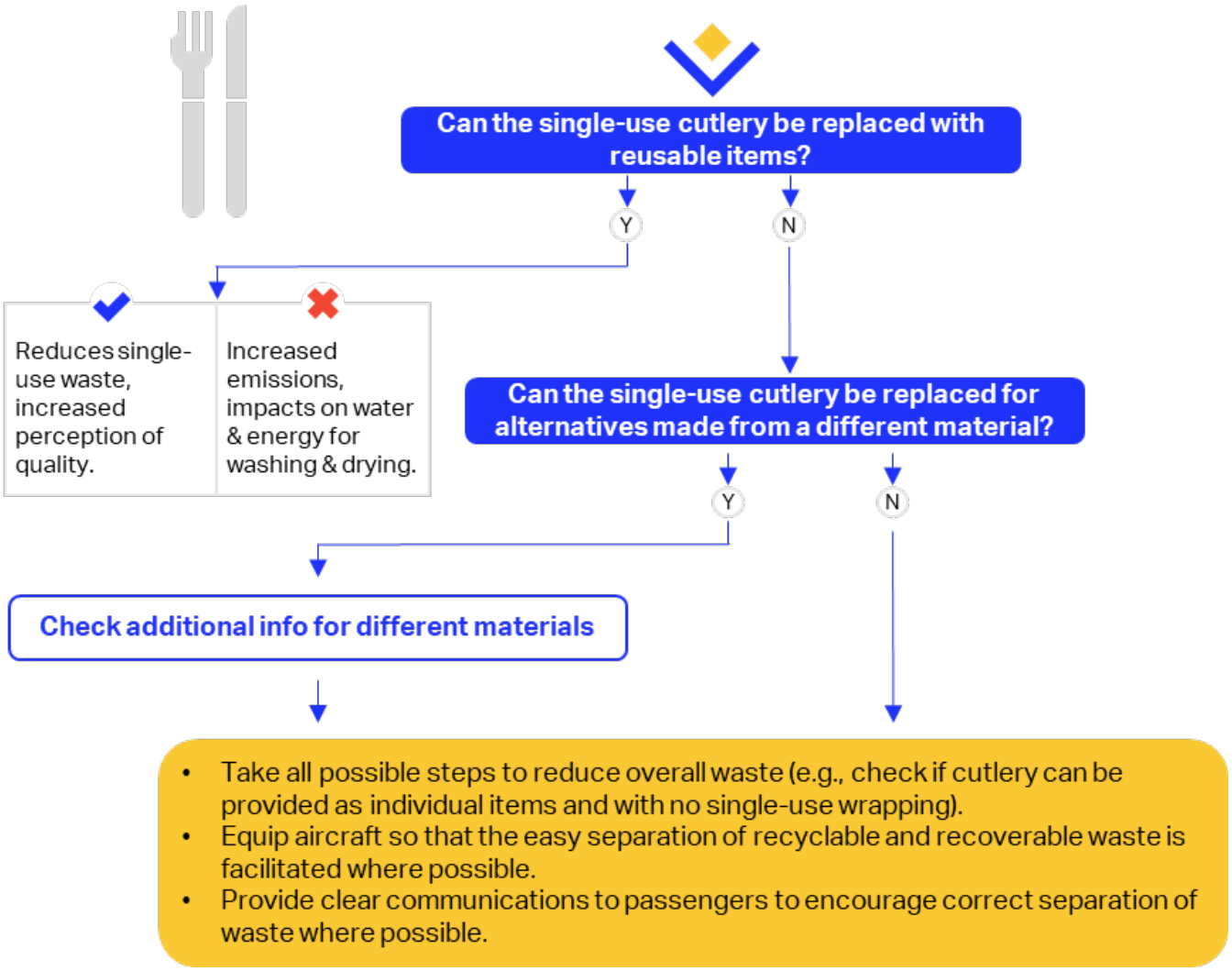
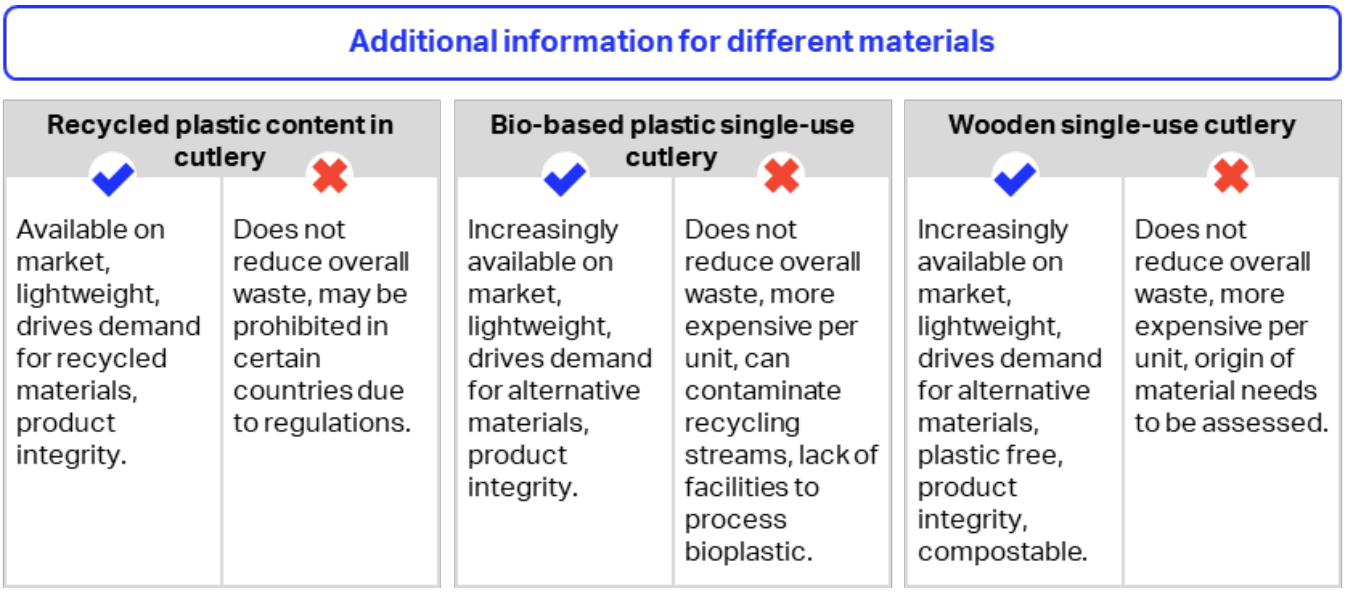


Figure 16. Additional information for different materials for single-use cutlery.



Cargo plastic sheets and stretch wrap

Figure 17. Cargo plastic sheets and stretch wrap decision tree.

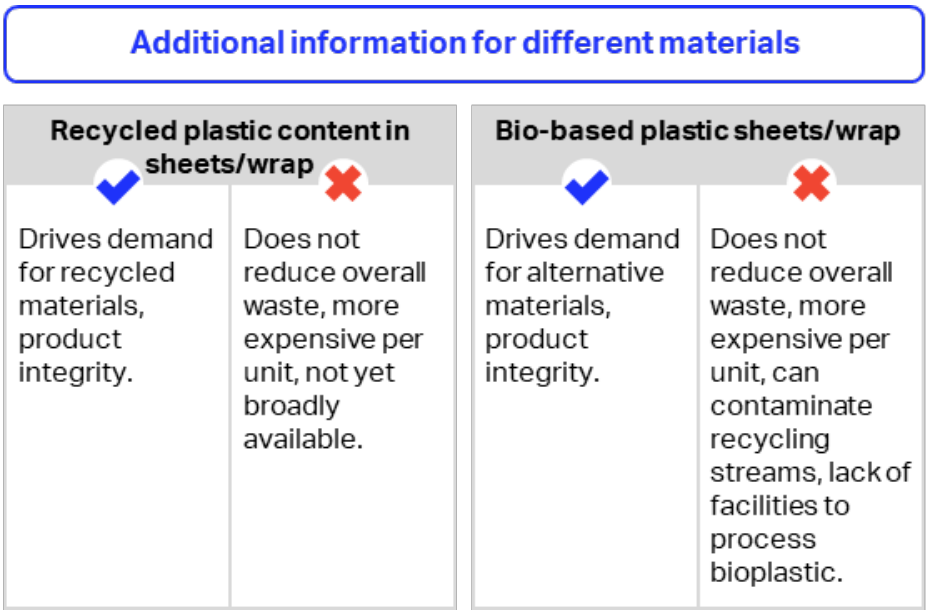
Can the use of plastic sheets and stretch wrap be avoided?

- Y → **Favor the use of ULD containers, reusable temporary covers for ramp movement and storage, reusable blankets for pallet consolidation & weather protection**
  - ✓ Reduces plastic volume, cost reduction, drives efficient operations.
  - ✗ Requires additional inspection & repair, proper returns management and storage, collaboration in the airport environment
- N → **Can plastic sheets be reused?**
  - Y
    - ✓ Reduces plastic volume, reduces costs, could create partnerships to exchange plastic sheets.
    - ✗ Requires inspection and potential repair, requires proper storage, may generate rejection from stakeholders.
  - N → **Can the use of plastic sheets and stretch wrap be reduced with other alternatives*?**
    - Y
      - **Pre-cut plastic sheets**
        - ✓ Reduces plastic volume, increasingly available on the market.
        - ✗ May be more expensive than regular rolls, not available in all destinations, size may vary.
      - **Use of lighter plastic alternatives**
        - ✓ Significant reduction in plastic volume, cost effective, easy to implement.
        - ✗ May require investment in equipment, not broadly available.
      - → **Check additional info for different materials***
    - N → **Can plastic sheets and stretch wrap be made from a different material*?**
      - Y → **Check additional info for different materials***
      - N

* Different materials and alternatives need to take into account the flammability test requirements for safety reasons.

- Take all possible steps to reduce overall plastic use (e.g., review customers requirements, review operating procedures).
- Equip cargo facilities so that the easy separation of recyclable and recoverable plastic is facilitated where possible.
- Provide clear communications to personnel to encourage correct separation of plastic where possible.

Figure 18. Additional information for different materials for cargo plastic sheets and stretch wrap.



Annex 6: Case Studies

Iberia

BACKGROUND

Iberia has been focused on waste reduction since 2016 when they partnered with Ecoembes, Gate Gourmet, Ferrovial, and ESCI-UPF to develop the Life+ "Zero Cabin Waste" project. As part of this 40-month project, the airline achieved a 12% reduction in waste per passenger, recovered 42% of the waste generated on flights, and reduced waste to landfill by 2,049 metric tons. The Zero Cabin Waste project was transitioned into "business as usual" within Iberia and actions to support it continue as part of an overall corporate sustainability program.

THE STRATEGY

In terms of SUPP reduction, the airline's strategy has been to first focus on the elimination of unnecessary products and subsequently a replacement plan that includes switching from SUPP to other single-use materials and procuring items made with recycled content. The initiative also extends to airport lounges in Adolfo Suárez Madrid-Barajas Airport.

To divert as much cabin waste as possible from landfill and incineration in Spain, this procedure has been applied across the company fleet:

Short and medium haul: Bi-compartmentalized carts where waste is separated in recyclables (transparent bag with Iberia logo in orange) and non-recyclables (transparent bag with Iberia logo in black) are used on short and medium haul flights.

Long haul: Non-recyclable waste goes to an assigned trolley and the recyclable waste goes into the trash compactor. This procedure facilitates the segregation of waste onboard for recycling so that it can be removed by the waste manager and recycled at appropriate facilities. Unfortunately, since April 2023, Spanish law is forcing the airline to incinerate all waste from long haul flights, as it does in outstations.

IMPACTS

Several actions were executed to reduce SUPP:

- Replacement of plastic packaging for earplugs provided in business class and premium economy class with paper packaging: 3,269 kg plastic reduction annually.
- Replacement of biodegradable plastic with paper band: 53,000 kg less plastic per year.
- Elimination of small waste bags for the customer (offered during the COVID period to avoid contact): 3,882 kg plastic reduction per year.
- Replacement of disposable soap bottles with reusable alternatives, the benefits of which are still being calculated.
- Elimination of salt and pepper kits in short and medium haul: 7,560 kg less plastic per year.
- Replacement of plastic packaging with a compostable alternative for individual butter packs: 885 kg plastic reduction annually.
- Lids for crockery have been replaced by lids made from 100% recycled plastic and birchwood cutlery has been replaced with metal cutlery.

In the premium lounges, aluminum cans and plastic containers have been replaced with returnable glass, resulting in a reduction of close to 1 million cans and 200,000 plastic containers per year.

Other initiatives designed to reduce food waste and weight, such as identifying and removing unpopular foods, offering a spare meal in economy, and being able to adjust the number of meals loaded onto flights based on check in information has also cut packaging waste.

Continued waste segregation, where ICW regulations allow, has facilitated a total of 1,694 metric tons of onboard waste being sent for recycling in 2022.

Overall, these initiatives have been welcomed by catering companies, cabin crew, and passengers.

CHALLENGES

Challenges arose when waste reduction actions had the potential to affect the role of cabin crew, particularly on shorter flights where time is limited. For example, meal trays served to passengers in long haul flights include a pack containing sugar, a wooden drink stirrer and a napkin offered as default. Clearly not all passengers want a hot drink or do not want sugar, however, although offering these items on demand would reduce waste it would require a new and slightly more time-consuming process for crew.

One initiative trialed to reduce SUPP glasses was to simply offer a paper straw with canned drinks, however, many passengers expressed a preference for plastic glass meaning that aircraft needed to stock both products and the use of straws increased.

Additional difficulties were linked to a lack of space for storing separated waste in galleys although the installation of trash compactors helped to overcome this issue.

The customer service teams are tackling the challenge of how to incentivize passengers to travel with their own reusable coffee cups so that use of single-use hot drinks cups can be minimized. Similar discussions are considering the logistics of being able to offer water refills to passengers in a way that does not negatively impact on the crew role or the passenger experience.

LESSONS LEARNED

It has been extremely important to include all value chain stakeholders in the waste reduction program to maximize efficiency and positive impacts. Involving key stakeholders from within the airline sector value chain has been a key contributor to the ongoing success of the program, but it requires a constant reinforcement of communication with stakeholders, cabin crew, and passengers to maintain momentum.

In future, when considering alternatives to SUPP, the airline would envisage using LCA methodologies to help with more informed decision making.

Japan Airlines

BACKGROUND

Japan has been reported as being the second highest generator of plastic packaging waste per capita, and so the country has set a goal to reduce SUPP production 25% by 2030.

THE STRATEGY

The JAL Group is addressing this issue by establishing its own "Priorities for Resource Circulation," based on the JAL Group environmental policy. With expert advice from the World Wide Fund for Nature (WWF) Japan, the airline has developed guidelines for alternative packaging material solutions that take into account sustainability, biodiversity, recyclability, resource efficiency, and greenhouse gas emissions during recycling. Cross-organizational plastics subcommittee meetings are also held regularly within the company to share progress.

With the cooperation of customers, and through the promotion of the 3R (Reduce/Reuse/Recycle) +1R (Redesign), they have set a goal of eliminating all new petroleum-derived SUPP in cabins and lounges and changing 100% of SUPP used in airport and cargo operations to environmentally friendly materials by the 2025 financial year.

Actions so far have included the elimination of wet towel dispensers and individually packaged snacks in airline lounges, the replacement of glasses made of SUPP for welcome drinks in business class to reusable plastic glasses, and a switch from single-use non-woven fabric headrests to reusable alternatives. As a result, some 630,000 fewer wet towels have been used at lounges at Haneda and Narita airports equivalent to six metric tons. Moreover,1.6 million headrest covers are being replaced by reusable headrest covers made of synthetic leather.

JAL has also redesigned various items of the passenger service, such as switching to certified paper cups and lids, which have been separated for recycling since December 2022 on some routes in collaboration with Nippon Paper Industries Co., Ltd. Recycled paper cups were initially collected on Osaka-Haneda flights at a rate of 500 kg/month, but the number of routes covered is being expanded and the amount collected will increase.

Food waste reduction initiatives, such as the JAL Meal Skip Option, also have the added benefit of reducing packaging waste and contributing to social actions around lunch programs for children in developing countries.

Hard to replace SUPP including bottled water are purchased from suppliers that meet JAL's priorities for resource circulation. With the cooperation of Clear Water Tsunan Co. Ltd, the JAL Group also has implemented 100% recycled plastic bottles for mineral water and the salad cups served in economy class.

In airports, plastic bags to protect cabin baggage are no longer offered and the use of polyethylene cargo plastic wrapping is being switched to materials containing environmentally friendly materials.

In the absence of aviation specific LCAs, the current methods for decision making are based on the effectiveness of plastic reduction, weight (petroleum usage), and number of items.

IMPACTS

The JAL Group reduced its SUPP service items for cabins and lounges by 45% by the end of FY2022 vs FY2019 and aims to eliminate all new petroleum-derived SUPP by FY2025.

It also reduced the use of petroleum-derived SUPP in cargo and at airports by 91% by the end of FY2022 by switching to a blend of biomass materials and recycled plastics. The objective is to achieve 100% by FY2025.

CHALLENGES

There were a number of challenges identified with the recycled paper cups. The JAL Group created a unique recycle chain whereby paper cups used for inflight services were sorted and collected by the JAL Group, and then transported, accumulated, baled, and recycled by the Nippon Paper Group using advanced technology. However, it has proved challenging to identify suitable paper lids and extensive testing was required to identify alternatives lids that are safe, sealable and recyclable.

Another challenge was the priority of cabin crews and customer awareness. Flight times on domestic routes in Japan are short and cabin crews are busy. Cabin crews needed to separate paper items, which required the cooperation and understanding of customers. The JAL Group will continue to work with stakeholders to accelerate the promotion of resource recycling.

LESSONS LEARNED

JAL acknowledges that, although their strategy for SUPP reduction and replacement has been successful, it would have benefited from appropriate LCA tools that would have provided a better understanding of the potential impacts of the changes being made.

LATAM Airlines

BACKGROUND

LATAM's sustainability actions and decisions have formed part of the merged company strategy since 2012 and the airline has been committed to the UN Sustainable Development Goals since they were launched in 2015.

The company has made a public commitment to be a zero waste to landfill group by 2027 and to eliminate SUPP by 2023.

THE STRATEGY

Based on the results of a waste baseline study in 2019, which identified that the airline generated around 11,000 metric tons of solid waste every year, two workstreams on zero waste to landfill and the elimination of SUPP were implemented.

For SUPP, this involved a review of global legislation in Latin America, North America, and Europe, leading to the creation of a restricted product list was created. The first step in the strategy was to review the most commonly generated SUPP and to establish a plan. This included, for example, replacing drink stirrers, food containers, and soft elements protections; eliminating unnecessary SUPP, including the plastic packaging on galley trolleys that were used to hold tea bags and sugar packs. Additionally, simple new processes were implemented, such as providing lids for hot drinks only upon request.

On international routes, meals are now served in lightweight, reusable plastic trays with an aluminum foil lid. Cutlery sets have been switched to bamboo alternatives, which are wrapped in kraft paper. Hot and cold drinks are served in paper cups with an aqueous lining meaning they are completely free from plastic. Passenger soft elements are now wrapped with a paper band instead of a SUPP cover.

Cargo plastic sheets and stretch wrap were also among the SUPP items under investigation. The airline recently received the IATA Air Cargo Innovation Award[92] in the corporate category for its plastic reduction projects in its cargo operations in Chile and Brazil.

IMPACTS

In response to ideas suggested by employees, LATAM cargo operations in Chile have replaced stretch wrap with a 3M tape and a reusable blanket[93]. The use of 3M tape resulted in an 80% reduction of stretch wrap (24 metric tons) per year. The reusable blanket, used to safely transport cargo from the hold to the aircraft's feet, contributed to a reduction of 45 metric tons of stretch wrap per year. In Brazil, the airline is transitioning to reusable, waterproof pallet covers, with an expected reduction of 13 metric tons of stretch wrap per year.

In terms of impact in the passenger cabin, 49 metric tons of plastic bags have been eliminated. The use of lightweight reusable plastic crockery is estimated to have prevented the use of 254 metric tons of SUPP. Waste segregation onboard ensured that 120 metric tons of recyclable waste were diverted from landfill via the "recicla tu viaje" program on domestic routes.

The reusable blankets used in cargo operations have proven particularly successful as they are quicker to fit than stretch wrap. Both, the crew and passengers have welcomed initiatives in the passenger cabins.

[92] IATA Pressroom (2023). LATAM Cargo and Swiss Airtainer Win 2023 IATA Air Cargo Innovation Awards.
[93] LinkedIn. LATAM Cargo.

CHALLENGES

As with any change, LATAM reports that not every initiative was straightforward to implement. The reusable cargo blankets went through multiple product iterations before being deemed fit for purpose. In addition, the lack of return logistics limits their use to protecting cargo during transportation from the warehouse to the aircraft.

In the passenger cabin, aqueous lined paper cups are approximately five times more expensive than the traditional plastic cups. Moreover, recyclers are also refusing to accept them due to their past liquid content. The airline continues to work with relevant stakeholders to address these challenges.

Differing international SUPP regulations and their alternatives remain a significant barrier to scalable change. In the absence of harmonization, LATAM will continue to use some SUPP even though this does not align with the LATAM strategy. In these cases, proactive passenger communications are in place to explain why certain SUPP are still onboard.

LESSONS LEARNED

The success of the LATAM zero-waste and SUPP removal strategies has been attributed to the incorporation of waste reduction targets in senior management objectives. This was particularly essential when the costs for alternatives were higher.

Active involvement of cargo handlers and cabin crew in the exploration of new ideas has also played a vital part in the initiatives' success. Their practical perspective ensured that, in addition to SUPP reduction, alternatives also facilitate the roles of staff.

In the absence of harmonized SUPP legislation, airlines need to adopt a flexible approach to replacing SUPP, making decisions based on what is available on the market at a reasonable cost. This is essential for implementing solutions at scale.