Switzerland
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# SkyCell Cold Chain Solutions:

## A Comparative Emissions Assessment

A comparative analysis of $CO_2$ emissions of SkyCell's containers and average alternative active cold chains solutions.

## Abstract

This document presents and analyzes the potential carbon emissions associated with transporting pharmaceutical products using SkyCell's hybrid containers (1500X and 6500X), compared to active temperature-controlled alternatives (RAP and RKN). Two calculation approaches are applied: one based on recommendations from an MIT Center for Transportation & Logistics (CTL) study on temperature-sensitive pharma freight, and another derived from a product carbon footprint assessment conducted by the myclimate foundation for SkyCell. Both methodologies are outlined, and the corresponding results are presented across different transport scenarios, including reverse logistics and ocean freight considerations in the first case.

The analysis highlights key methodological challenges in transport emissions accounting, particularly for air freight, where factors such as volumetric weight and reverse transport significantly influence results. Commonly used methods, such as the GLEC/ISO 14083 Framework, do not fully account for tertiary packaging or rented containers, which can lead to incomplete or inaccurate emission estimates.

Hybrid containers capable of both air and ocean freight offer increased flexibility within pharmaceutical supply chains and enable substantial emission reductions, particularly when modal shifts from air to ocean transport are possible.

## Challenges in Decarbonizing Pharmaceutical Logistics

Pharmaceutical products are one of the most logistically demanding products shipped on a global scale. Many pharmaceuticals such as vaccines and biologics require strict temperature control to ensure efficacy and compliance with regulatory standards. As a result, these are mostly shipped via air freight due to speed and reliability.

The healthcare industry is responsible for 4.4% of global emissions, with heavy reliance on carbon-intensive air freight that has a considerable environmental impact with 71% of the healthcare industry's emissions primarily derived from the healthcare supply chain[1].

According to MyGreenLab's 2025 report, while most biotech and pharmaceutical companies have established medium-term Scope 1 and 2 targets and are increasingly aligning with net-zero strategies that include Scope 3 emissions, overall emissions continue to rise with industry growth[2].

Many companies still struggle to identify effective reduction strategies and to accurately measure emissions, particularly as Scope 3 is primarily driven by purchased goods and services, and depends heavily on supply chain actions beyond their direct control.

Emission reduction strategies within the Supply Chain and logistics for the pharma sector include takeback programs, fleet decarbonization, mode mix optimization, freight route and load optimization and cold chain enhancements [3].

1. Healthcare without harm and ARUP (2019). Health Care's Climate Footprint, How the Health Sector Contributes to the Global Climate Crisis and Opportunities for Action.
2. MyGreenLab (2025) The Carbon Impact of Biotech & Pharma.
3. Pharmaceutical Supply Chain Initiative (PSCI). (2024) Decarbonization Paybook for the Pharmaceutical Industry.

SkyCell addresses these challenges by investing in research and strategic partnerships to develop products and services that support the pharmaceutical industry in closing emissions gaps and advancing decarbonization efforts. This includes integrating carbon accounting into lane risk analysis tools, designing packaging with sustainability and circularity principles, and enabling lane optimization and improved inventory management to reduce emissions and increase fuel efficiency.

### Greenhouse Gas Emissions (GHG)

Greenhouse gas inventories are categorized into three scopes according to the Greenhouse Gas Protocol.

**Scope 1. Direct emissions** – stationary/mobile combustion and fugitive emissions

**Scope 2. Indirect emissions** – from purchased electricity and heat.

**Scope 3. Other Indirect Emissions** – occurring in the value chain, incl. transports, waste, purchased goods.

Transport logistics are a major contributor to overall emissions, and optimizing modes and routes, such as shifting from air to ocean freight, offers significant reduction potential. However, a critical challenge remains, emissions in pharma logistics are often substantially underestimated, in some cases by up to a factor of 20, as internal case studies show. This is largely due to the exclusion of key factors such as the weight and volume of the rented containers, their reverse logistics, and non-$CO_2$ impacts. Such underestimation hinders accurate prioritization of reduction measures and delays meaningful climate action.

## Product Carbon Footprint Assessment Method

Cradle-to-grave emissions aligned with a product carbon footprint (PCF) pathway were calculated by external partner *Stiftung myclimate* for the SkyCell 1500X container and a comparable active RKN container, conducted in 2022 and 2018 respectively. Results are normalized to a functional unit of **1 m³ of effective pharmaceutical product volume transported** within a 2–8 °C temperature range.

**Life cycle stages and data sources:** The assessment covers manufacturing, preconditioning, packaging, transport, and end-of-life (EoL). Primary data on SkyCell containers was collected internally, complemented by publicly available information where relevant. Emission factors were sourced from the EcoInvent database.

**Effective volume and filling rate:** For each container type, an effective internal volume was calculated based on the usable interior volume and an assumed filling rate of approximately 0.7, reflecting containers are not expected to be fully loaded during shipments. Results are therefore normalized per transported volume contemplating these assumptions.

### Product Carbon Footprint (PCF)

Analysis of the greenhouse gas emissions of a product/service entire life cycle.

Covers all stages: raw material extraction, production, transport, use, and end-of-life.

**Container lifetime:** Both container types are assumed to have a lifetime of 100 shipments. Manufacturing and EoL emissions are therefore allocated across 100 cycles to determine the proportional impact per shipment.

**Exclusions:** Reverse or repositioning shipments back to the sender are not included. Lorry transport from the airport to service centres and back is also excluded.

### CONTAINER SPECIFICATIONS AND CONSIDERATIONS

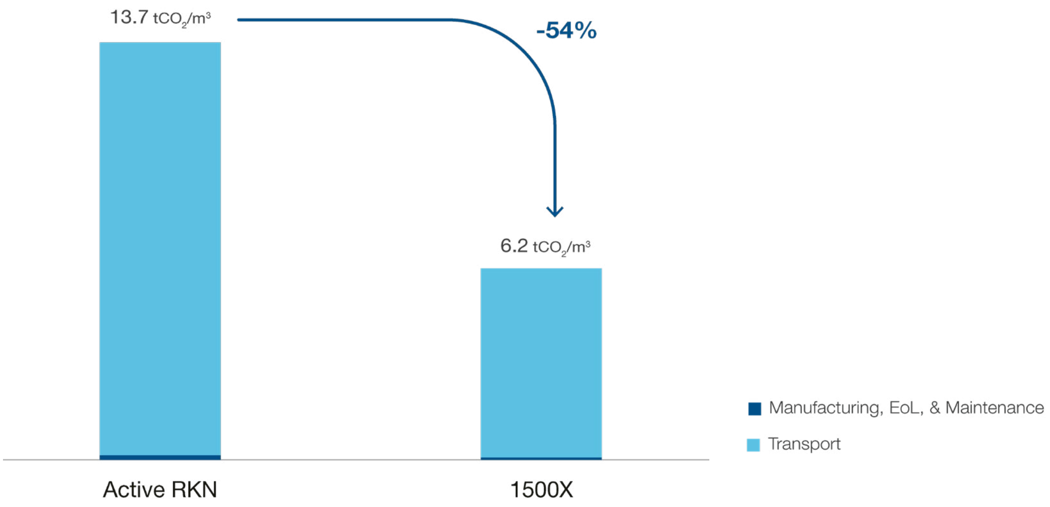
| | 1500X | Active RKN |
|---|---|---|
| Outer volume [m3] | 2.70 | 4.80 |
| Usable interior volume [m3] | 1.66 | 2.30 |
| Weight container empty [kg] | 379 | 635 |
| Specific weight pharma product | 0.1 t/m3 | 0.1 t/m3 |
| Weight of pallet [ kg] | 22 | 22 |

## DESCRIPTION PER LIFE CYCLE STAGE

| Stage | Description |
|---|---|
| **Manufacturing** | Emissions for SkyCell products are based on the bill of materials as well as supplier distances and transport modes. In the case of the RKN, this information was assumed by myclimate by desk research and contacting the provider. |
| **Preconditioning** | For the lane analyzed, both containers are assumed to be preconditioned in Germany. The RKN is presumed to be charged for an average of 8 hours, while the 1500X undergoes 20-30 hours of chilled storage at lower temperatures, followed by 7 days of chilled storage. |
| **Transport** | Only transport during the use phase is considered (Leg 2), meaning when the pharmaceutical product is inside the container. The analysis includes only the airfreight segment from the airport of origin to the destination airport. Distances are calculated using the Great Circle Distance (GCD) method, with 6,420 km assumed for the Frankfurt–Toronto exemplary route. For consistency, identical origin and destination points are applied to both container types, and no layovers are considered.<br><br>Optimal weight-volume ratio is considered for both containers, comparing to the air cargo volume ratio and the actual transported weight.<br><br>Emission factors reflect full life cycle impacts, from fuel combustion to aircraft manufacturing, and are adjusted with a radiative forcing index (RFI) of two to account for additional climate effects such as contrails. |
| **Disposal** | At the end of their lifecycle, container components from both types are assumed to be either reused, recycled, or thermally treated. Where reuse or recycling occurs, primarily for metals, electronics, and certain plastics, the cut-off approach is applied. Any remaining components are assumed to be incinerated with energy recovery. |

## RESULTS

The 1500X's low weight and high capacity enable more pharmaceutical product to be transported per shipment, helping reduce flight frequency, costs, and emissions by up to **54%** compared with the RKN in the analyzed scenario. Its durable and reusable design supports a circular model based on leasing, return, refurbishment, and reuse, extending the container's lifespan and reducing waste. Across the assessed shipment, transport remains the dominant emissions driver, accounting for over 90% of total emissions per shipment.




## Application to Other Transport Lanes

Using these results, the average emissions per transported kilometre can be estimated and used to assess the potential emissions of other lanes by adjusting the variable emissions by the transport distance and by adding the fixed emissions (manufacturing, preconditioning & EoL). For example, for the Amsterdam – Sydney (AMS–SYD) route with an estimated distance of 16,900 km, emissions are valued at approximately 16.4 $tCO_2/m^3$ for the 1500X and 35.8 $tCO_2/m^3$ for the RKN. This corresponds to an emission reduction of around 54% per shipment when comparing the 1500X to the RKN with the considerations mentioned in this section.

## Transport Scenario Assessments Using the MIT CTL Methodology

To further assess emissions across different shipment scenarios and container types, including reverse logistics, SkyCell applies the methodology proposed by Lehmann, Winkenbach, and Janjevic (2023)[4] from the MIT's Centre for Transport and Logistics on pharmaceutical cold chain logistics and the data available from the Network for Transport Measures (NTM) emissions calculation tool.

Considering the standard set by the study, the calculations included the volumetric weight approach for air freight. This means that the weight of the pharma product and the packaging is considered and compared to the volumetric weight of the pharma container. The greater of the two is then used to calculate the emissions.

In addition, the secondary climate effects of air travel are also included, describing the global warming of non-$CO_2$ effects, such as cloud formation. The afore mentioned study recommends a value of two. IATA currently uses a factor of one, whereas other studies recommend a factor of three[5].

### Volumetric Weight

A way to account for how much space a shipment uses during transport, not just its physical mass. In air freight, carriers compare the actual weight with the volumetric weight, calculated from the shipment's dimensions, and charge based on whichever is higher. This ensures that large but lightweight goods still reflect the space they use on the aircraft and their respective emissions.

## METHOD

To facilitate comparison, the same origin and destination locations were assumed for all container types, and no layover air transport was considered. In addition, the final values are adjusted to a comparable unit of 1 pallet of pharma product transported per 1000 km. The analysis compares four container types, two active (RKN, RAP) and two hybrids (1500X, 6500X). It also includes both reverse transports and ocean freight scenarios.

Pallet size and weight are assumed to be consistent across all container types. The 1500X and RKN each carry one pallet, while the 6500X and RAP are assumed to carry an average of 4.5 pallets, reflecting their capacity for either four US-sized pallets or five EU pallets. Each pallet is assumed to include 150 kg of pharmaceutical product plus 22 kg for the pallet itself.

For reverse logistics, all active containers are assumed to be transported back by air, whereas hybrid containers are modelled with both air and ocean return scenarios. As a dual-mode solution, the 6500X is also assessed under a full ocean freight scenario. In all return cases, containers are assumed to be empty.

4. Lehmann J., Winkenbach M., Janjevic M. (2023). Operational and tactical levers to reduce carbon emissions in temperature-sensitive freight transportation for pharmaceuticals. MIT CTL

5. Lee et al., (2021). The contribution of global aviation to anthropogenic climate forcing for 2000 to 2018. Atmospheric Environment, 244.

## CONTAINER SPECIFICATIONS AND CONSIDERATIONS

| | 1500X | 6500X | Active RKN | Active RAP |
|---|---|---|---|---|
| Outer volume [m3] | 2.70 | 10.10 | 4.80 | 11.50 |
| Usable interior volume [ m3] | 1.66 | 6.60 | 2.30 | 6.38 |
| Weight container empty [kg] | 379 | 877 | 635 | 1100 |
| Weight container full [kg] | 551 | 1651 | 807 | 1874 |
| Pallet capacity per unit | 1 | 4.5 | 1 | 4.5 |

### Production, End-of-Life, and Preconditioning Emissions

Fixed container emissions for the 1500X and RKN containers are directly extracted from the MIT CTL study. This includes Manufacturing, Preconditioning and EoL. As no publicly available PCF data exists for the active RAP, its fixed emissions are assumed to be approximately twice those of the active RKN.

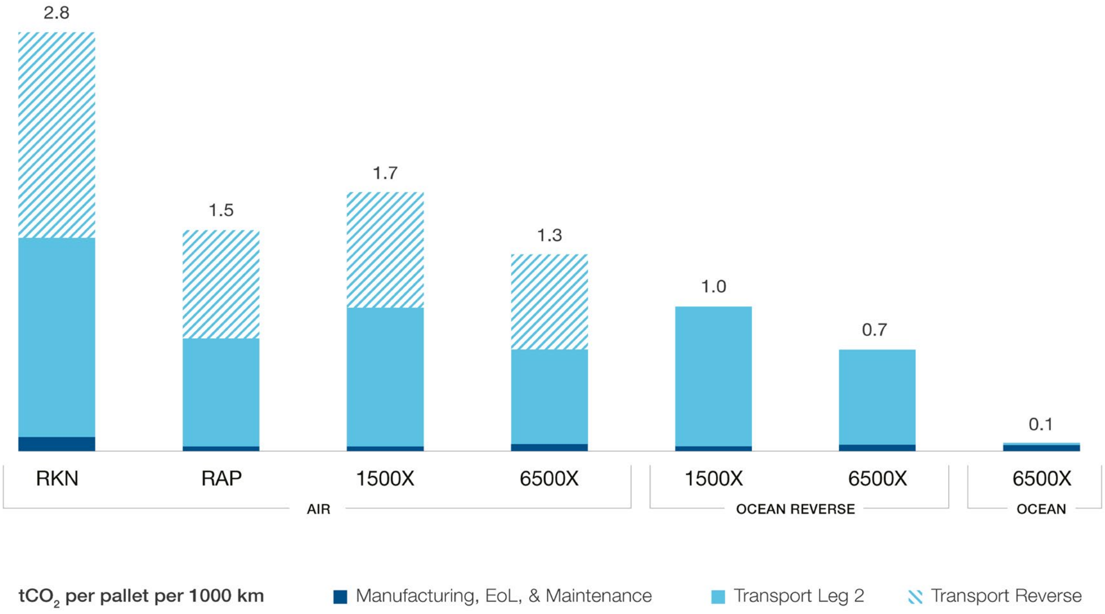
For SkyCell's 6500X container, an internal product carbon footprint (PCF) assessment was conducted, following industry guidelines. Adjustments were made for repair and reuse processes as well as preconditioning, reflecting the 6500X's integrated temperature-control design. The container is assumed to be reused for 100 shipments, with results normalized per shipment.

### Transport Emissions

To analyze emissions, the Frankfurt–Toronto Lane was used as an exemplary long-haul shipment. Transport emissions were calculated with the Network for Transport Measures (NTM) tool, which is also applied in the MIT CTL scenarios and enables the integration of volumetric weight and route-specific distances for air freight. Results were multiplied by a factor of 2 to account for secondary climate effects and normalised to $tCO_2$ per pallet per 1,000 km, based on the distance defined in NTM for the mentioned lane.

Transport is modelled in two legs: outbound transport (Leg 2), where the container is loaded with pharmaceutical products, and return transport (Leg 3), where the empty container is assumed to return to its origin. A belly freighter aircraft (B77-200 Belly) is used for air freight, while an average large container ship is assumed for ocean freight.

# RESULTS

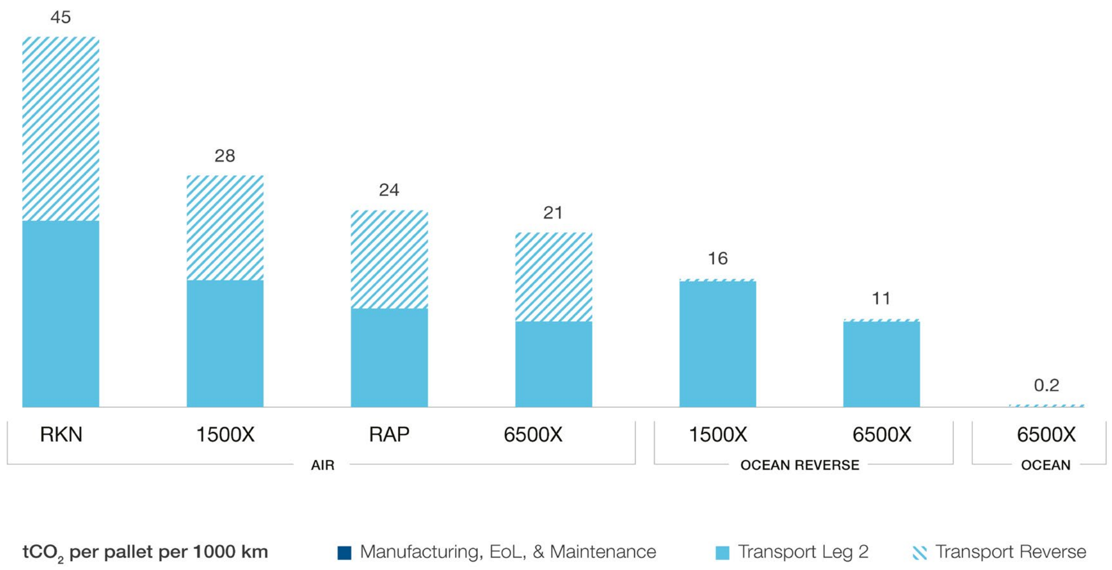



The 6500X container represents a significant step forward in reducing emissions for larger shipments. When considering an airfreight only scenario as presented in the graph, the container achieves a potential emissions reduction of **24%** per pallet per 1,000 km compared with the 1500X, and **13%** compared with the RAP.
In a full ocean freight scenario, emissions can be reduced by up to **93%** compared with a RAP shipment with air-based reverse logistics when using the 6500X.

Switching reverse logistics from air to ocean freight cuts transport emissions substantially. Compared with active solutions that return by air, the 1500X emits up to 64% less than the RKN, and the 6500X around **53%** less than the RAP. Even comparing a hybrid container with itself, simply changing the return leg from air to ocean lowers overall emissions by **41%** for the 1500X and **46%** for the 6500X. In short, replacing airfreight returns with ocean transport delivers major emissions savings.

## Application to Other Transport Lanes

Considering the results presented in the graph above, the potential emissions for specific lanes can be analyzed, by adjusting the variable emissions by the transport distance and by adding the fixed emissions (manufacturing, preconditioning, and EoL). For example, for the Amsterdam – Sydney (AMS–SYD) route with an estimated distance of 16,900 km, the following results can be identified to compare container types.



## Key Takeaways

1. The methodology used and the assumptions made, especially on the specific pharma weight and volume capacity of the containers has a significant influence on the shipment emissions.

2. Ocean freight represents an alternative to air freight transport that helps avoid carbon emissions.

3. Reverse transports can have a great impact on overall emissions and therefore should be contemplated whenever possible.

4. Emissions can be substantially reduced when container solutions enable higher payload efficiency, reuse over multiple shipment cycles, and a shift from air to ocean transport where operationally feasible.

5. Most industry-agnostic methodologies result in comparable transport emissions reporting; however, there is still a need for clearer guidance on accounting for reusable tertiary packaging and rented temperature-controlled containers, as this specific transport group is not yet explicitly addressed in existing standards.

6. Volumetric weight can significantly influence emissions on shipments, particularly in air freight.

Additional lane-specific analyses can further refine the outcomes and support more tailored, customer-specific decision-making. Upon request, the underlying methodologies, assumptions, and scenarios can be reviewed in detail with the sustainability team or adjusted based on specific shipment data to generate more accurate emission estimates.

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# Protection Beyond Limits.

→ Contact the sustainability team **here** for more information and support.