An Industry Initiative: Transparent CO_2 Calculation of thermal Packaging Solutions

Comparison of temperature-controlled reusable Air Freight Containers

A consistent Documentation Standard for increased Transparency

Due to an increased public awareness of climate change, the topic of CO_2 emissions has been gaining importance. The associated challenges also come into focus in the sector of temperature-controlled logistics for stakeholders such as pharmaceutical shippers, airlines and forwarders. When selecting suitable temperature-controlled packaging, **the quantity of CO_2 (carbon dioxide) emitted during use, production and disposal** will become a vital decision-making criterion in the future.

Within the industry, there are **no documentation standards to date which enable a true comparison** between the various types of temperature-controlled packaging.

In this document, an **industry standard will be established**, among other things, by giving answers to the following questions:

- According to which **criteria** can CO_2 emissions be calculated in order to allow comparison between different solutions?
- Which **documentation standards** are necessary to transparently show the quantity of CO_2 emitted?
- Which **influencing factors** affect the product's carbon footprint over its complete lifecycle?

The Basis for transparent Accounting of the Product Carbon Footprint: The Greenhouse Gas Protocol (GHG)

There are currently a multitude of different instruments for "carbon accounting" which do actually not allow for comparison among one another as well as no or very few legal guidelines. An internationally established standard is the **Greenhouse Gas Protocol (GHG)**. Here, the emissions are classified into various scopes.

- **Scope 1** includes all direct emissions, i.e. those originating in emissions in the company's own systems, e.g. from the company's vehicle fleet or power plant.
- **Scope 2** describes all emissions connected to purchased energy, such as electricity and district heating.
- **Scope 3** covers indirect greenhouse gas emissions, which arise for example by business trips or by purchased goods and services.

This establishes a **holistic approach** which takes the different types of CO_2 emissions into account and includes them in the calculations. Due to the holistic nature of this approach, many globally operating companies in the logistics sector, such as DHL or Kuehne+Nagel, already use the accounting approach of the GHG Protocol.

Greenhouse Gas Protocol (GHG)
Basis for the documentation of CO_2 emissions according to published standards for the quantification and management of greenhouse gas emissions coordinated by the World Resources Institute and World Business Council for Sustainable Development

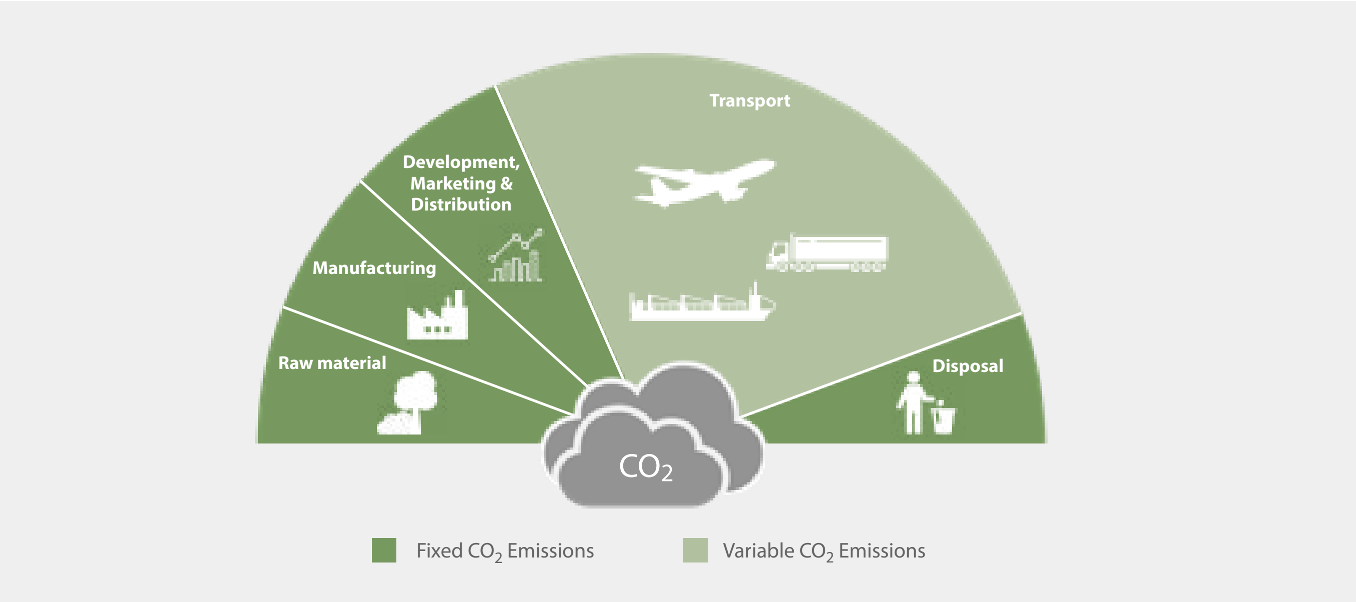
Active Technology
A cooling unit and a heater or fan in combination with dry ice allow the internal temperature to be set

Passive Technology
Passive systems do not have active components such as electrical batteries, electronics, fans or electrically powered heating or cooling systems

In the case of emission calculations for temperature-controlled air freight containers, the distinction between the various scopes also demonstrates various advantages. Depending on the approach taken, the **carbon dioxide emissions during the production and disposal phases are fixed**, while they are extremely **variable in the use phase** due to the large number of influencing factors.

Considering the carbon footprint of the various container technologies (active vs. passive) alone, it becomes clear that a **consistent, comprehensive documentation standard is indispensable**. Numerous factors of all kinds affect carbon dioxide emissions. Batteries, for example, are only used in **active solutions**. For this reason, they exhibit a completely different footprint to **passive solutions**, which do not require an external supply of energy during transport.

Greenhouse Gas Protocol (GHG):
The basis for transparent accounting of a product's carbon footprint



Factors influencing the Carbon Footprint of temperature-controlled Air Freight Containers

When holistically accounting for CO_2 emissions according to the GHG Protocol, it becomes clear that for temperature-controlled air freight containers, the largest proportion is emitted during the use phase. However, there are several variables during the manufacturing and disposal phases which must be considered in order to compile a full account.

Manufacturing and Disposal Phases

The first and last phases of the product lifecycle, in particular, offer a range of opportunities to save CO_2:

- **Centralized production of all key components**: Long transport routes can be avoided by the manufacturing of air freight containers at one production location. A regional supplier structure additionally supports this potential to save CO_2.
- **ISO-certified processes**: In order to guarantee high quality of both products and production processes and to subject them to a continuous improvement process, ISO audits on energy and environmental management can be used as a support.
- **Energy production in the company**: The new and further developments of existing possibilities for in-house generation of energy lead to efficient options, which save increasing amounts of CO_2. Combined heat and power plants, solar or wind power systems produce energy where it is required.
- **Underlying technology of the air freight container**: In some cases, high emissions are already caused during manufacturing and disposal, such as by the batteries of active solutions.

Use Phase

The amount of carbon dioxide emitted during the use phase of an air freight container is primarily dependent on whether **active or passive solutions** are used. They not only differ with regards to weight and the resources used to create a certain temperature, but also in the processes which must be carried out prior to transport.

Air freight containers with active technology are, for the most part, heavier, while containers with passive technology are usually lighter. Batteries and cooling units also increase the weight. A **higher weight means more CO_2 emissions** due to the increased use of fuel during transport.

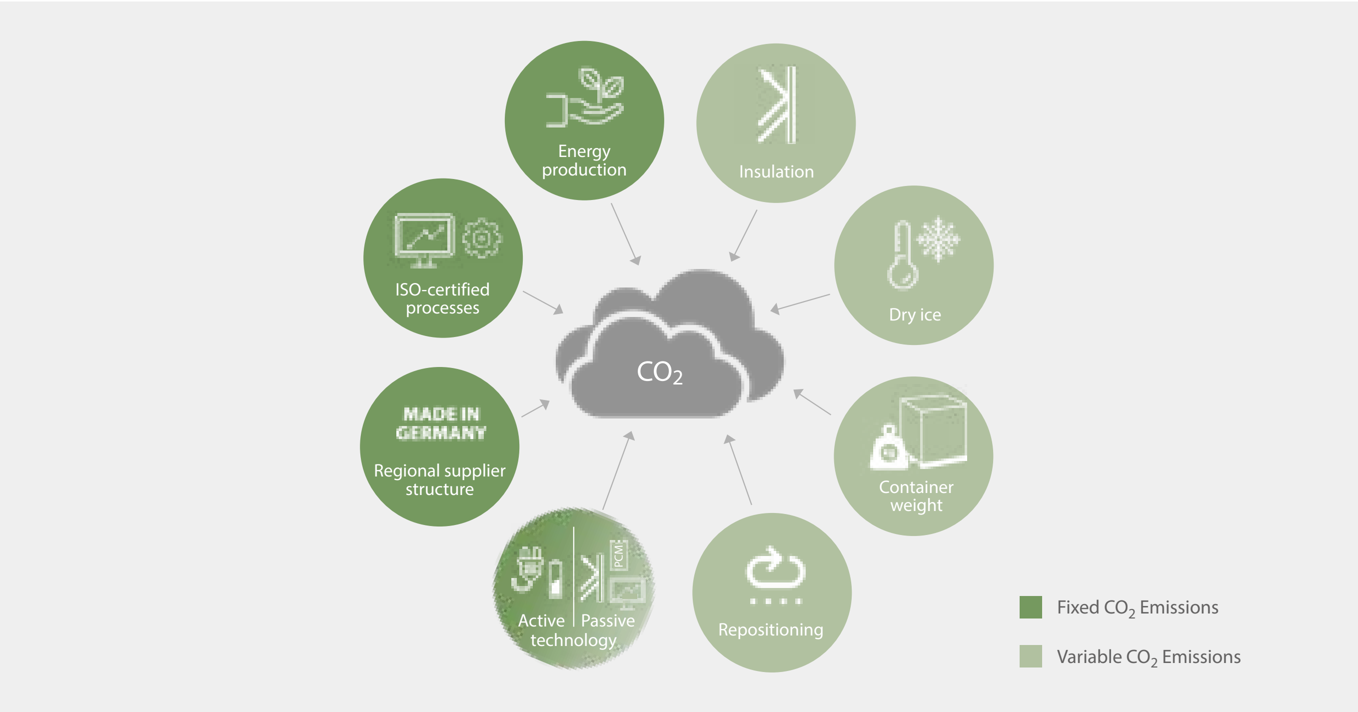
In active containers, the internal temperature is partially generated using **dry ice** (solid carbon dioxide). It is used both to temper the air freight container before transport and to maintain the required internal temperature through regular re-icing. During use, the cooling agent turns directly into gaseous CO_2, making this impact on the calculation of emissions quite clear: 1kg of dry ice yields 1kg of CO_2 in the calculations. Additionally, the energy usage must also be added to the calculation such as the aggregates responsible for temperature changes inside the container. **Batteries**, therefore, affect the CO_2 emissions not only in the manufacturing and disposal phases but also in the use phase. Due to **aging processes**, batteries must be charged often and over the lifespan of the battery the charging time required increases. Longer or more frequent charging causes increased CO_2 emissions.

The **energy efficiency**, and therefore the emissions of a passive temperature-controlled air freight container are closely linked to its thermal insulation and the associated **pre-conditioning** process. Pre-Conditioning of non-modular passive systems is significantly more time-intensive, and therefore more energy intensive, than that of modular passive systems. In modular systems, the temperature storage elements used can be removed from the container and separately pre-conditioned to the temperature required, before being placed into the container correctly tempered. The sum of the carbon dioxide emitted for the thermal energy produced is ultimately significantly lower.

Pre-Conditioning
Temperature storage elements are pre-conditioned in precise temperature-controlled cooling chambers

Repositioning of the container is another determining factor for emissions in the use phase. With a close-knit global network as well as strategic partnerships, extensive repositioning and empty movements can be avoided, as can the associated CO_2 emissions.

Factors influencing the Carbon Footprint



The Reasonableness of various Comparisons

As part of its sustainability strategy in 2021, the German company, va-Q-tec, has become the first manufacturer of passive modular containers to draw up a detailed carbon footprint for its temperature-controlled containers according to the **GHG Protocol**. The standards set in this accounting process for the **transparent calculation of carbon dioxide emissions** within the sectors lead to the question of comparability with other packaging solutions. In order to create a valid overview of these emissions, both a **standardised calculation** and the **reference value** on which this comparison can or should be based **must be defined**.

va-Q-tec developed these definitions jointly with independent experts. This provides stakeholders in the industry with the opportunity to carry out **realistic, well-founded comparisons**. This is the only way for decision makers in the industry to evaluate all the solutions available, reduce their emissions and thereby contribute to climate protection.

If the existing reference values are considered, it becomes clear why this type of **comparability was not previously possible**:

- **Internal volume**: This is only a useful reference value when it refers to similar transport solutions. However, when calculating carbon footprints, an efficient relationship between external and internal volume is important, in order to fill the available freight space with as much freight as possible. Variable emissions of concrete transport lanes, however, cannot be compared using this parameter.
- **Volumetric weight**: This is a fictional measuring unit based on external dimensions. CO_2 emissions, however, are based on real parameters, such as the weight of the container. In addition, there are differing definitions used by airlines and forwarders.
- **Hypothetical considerations**: In some instances, the emissions caused by individual packaging solutions are calculated using purely hypothetical assumptions which do not relate to practice. For example, the freight room is often assumed in calculations to be filled with just one type of temperature-controlled container. In reality, however, packages often consist of various types. The pharmaceutical shipper or freight forwarder only have limited influence on this.

Volumetric Weight
The volumetric or dimensional weight is calculated by multiplying the external dimensions of a container and is used to calculate the air freight rate

With these aspects in mind, va-Q-tec therefore sees **two components** as necessary for a reasonable comparison of temperature-controlled packaging solutions. This firstly includes the **CO_2 product carbon footprint** of the packaging solution (fixed emissions) and secondly the **emissions expected due to the transport** of a temperature sensitive product (variable emissions).

The CO_2 Footprint of a specific Solution

If the CO_2 impact of a specific temperature-controlled air freight container is calculated based on the data of the GHG Protocol, all the scopes are incorporated proportionally. This accounts for all fixed emissions in the manufacturing and disposal phases, as well as the variable emissions over the complete product lifecycle in the use phase. The latter includes not only transport but also pre-conditioning and repositioning of the transport packaging.

The following overview shows which data of the GHG Protocol va-Q-tec assigns proportionally to the CO_2 product carbon footprint of the air freight container and which are ascribed to fixed or variable emissions. Additionally, the concrete parameters are detailed.

Fixed emissions (material, production, disposal) Proportional quantity of GHG-Protocol emission results for:	**Relevance for products** Emissions occuring for:	**Scope**
Stationary combustion	Heat production	1
Mobile combustion	Vehicle fleet	1
Fugitive gases	Dry ice	1
The generation of the electrical energy used	Electrical energy generation	2
Product material	All materials used for production of the product	3
Purchased goods and services	Operating expenses for all kinds of purchased goods and services	3
Upstream heat	The upstream production of fuels and energy purchased and not included in Scope 1 and 2	3
Upstream electricity	The upstream production of fuels and energy purchased and not included in Scope 1 and 2	3
Upstream vehicle fleet	The upstream production of fuels and energy purchased and not included in Scope 1 and 2	3
Waste generation	Disposal and treatment of waste by third parties	3
Business travel	Employees while traveling for business activities	3
Employee mobility	Employees while commuting to and from work	3
Disposal of products	The disposal of products and packaging	3

Variable emissions (use-phase) footprint based on:	**Relevance for products** Emissions occuring for:	**Scope**
Proportional emissions of fleet shipment (considering different container weights)	Pre-Conditioning and transportation of the product	3
Proportional emissions of fleet repositioning (considering different container weights)	Repositioning of the product incl. cleaning, sterilization & maintenance	3

Emissions for a specific Lane

In order to calculate emissions for a specific transport route, the variable part of the CO_2 emissions must be considered above all.

The following formula is used for the calculation:

CO_2 emissions (per lane) = Distance (in km) * CO_2 emissions (per km)

The emission factor per km is determined individually by independent partners for each container type, taking the different temperature ranges into account, as the **tare weight** can vary significantly according to the container technology and construction used. It takes verified average values into account, which are measured by specialized agencies based on audited calculation bases from international databanks and are regularly updated.

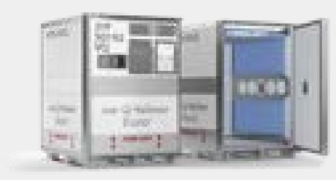
Tare Weight
The actual weight of a container without product load

The **weight of the goods** to be transported is not included in the comparison, as this is **an identical constant** when calculating the various logistics solutions.

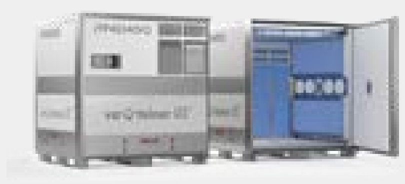
Using the formula, the **variable carbon dioxide emissions for each transport lane** can be individually calculated, taking the **method of transport used into account**. The transparent comparison of temperature-controlled transport solutions can therefore be individually used **for each specific customer requirement** with regards to the specific temperature range, the planned transport lane and the specific product load. The result thereby excludes the use of single-use or reusable products, the technology (active or passive), or the type of transport solution (parcel or pallet solution). The load capacity is also not considered in this type of calculation, nor is the utilization or load of the freight space.

Practical Examples of the individual Calculation of the CO_2 Footprint of a Shipment

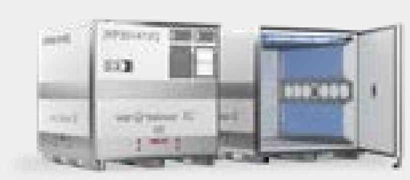
Comprehensive Container Portfolio



va-Q-tainer EUROx for 1 Euro Pallet



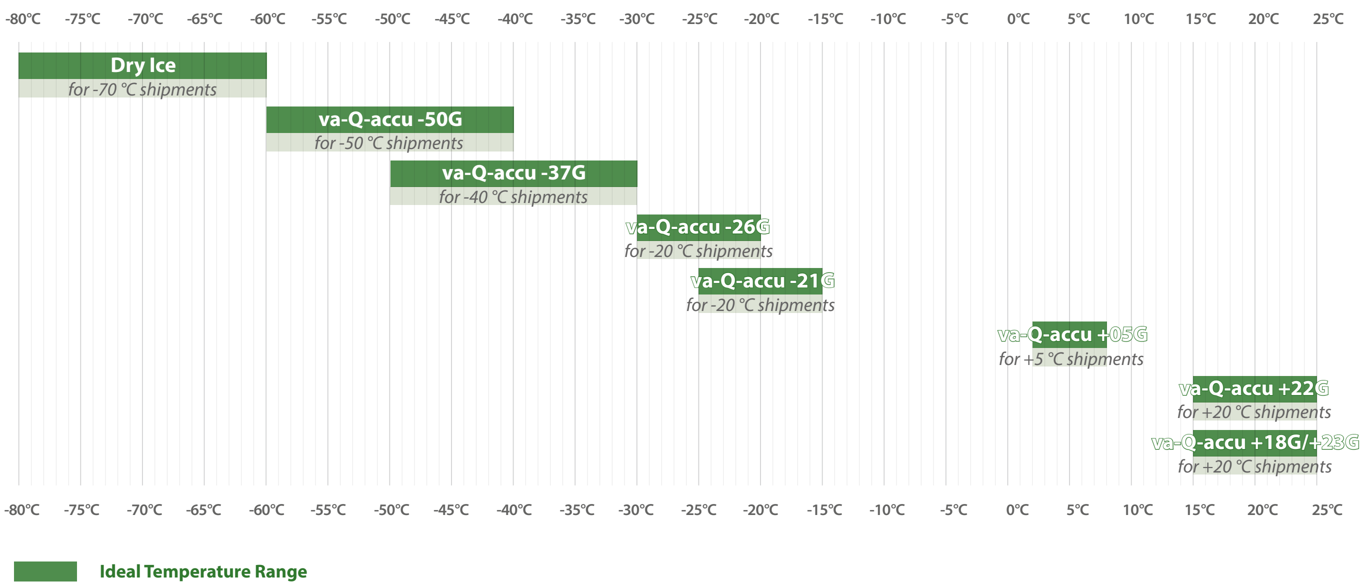
va-Q-tainer USx for 1 US Pallet



va-Q-tainer XLx for 2 Euro Pallets

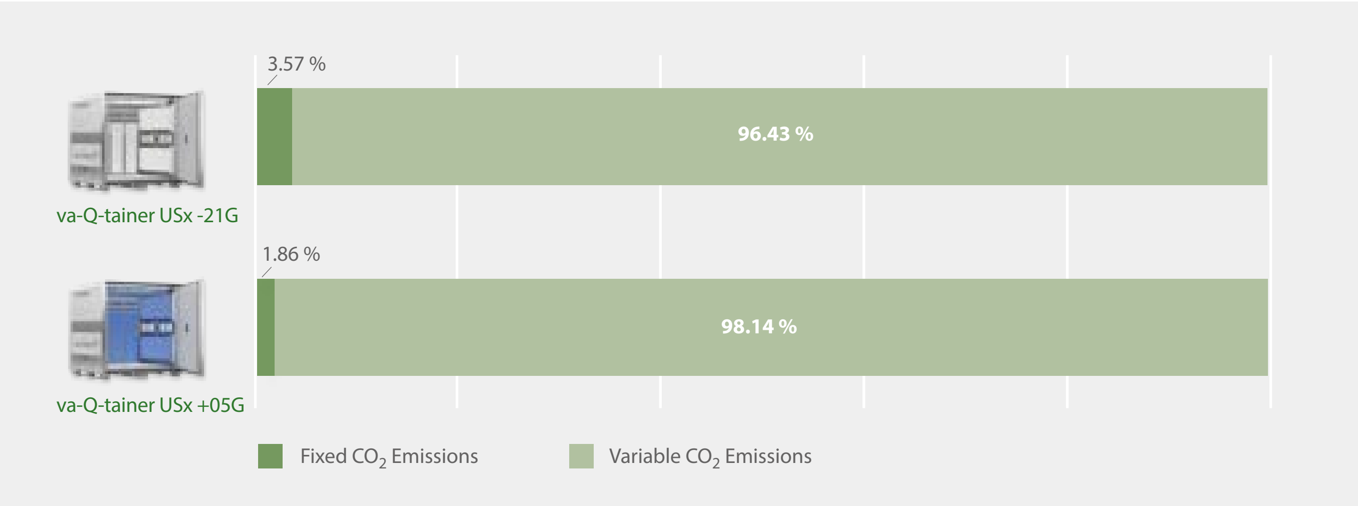
va-Q-tainer TWINx for 2 US Pallets

Comprehensive Temperature Range



The following shows an example of a calculation of the va-Q-tainer USx CO_2 footprint for +5 °C and -20 °C shipments.
This type of temperature-controlled container is an advanced passive multi-use single-pallet solution. For +5 °C transport, the temperature storage elements **va-Q-accu** +05G are required, while -20 °C transport can be implemented with va-Q-accu -21G.

va-Q-accu
A temperature storage element filled with Phase Change Material (PCM) which maintains the required temperature range



Considering the carbon dioxide emissions from manufacturing until disposal over the lifecycle of a **va-Q-tainer USx +05G** with a total operating lifetime of 10 years, it can be seen that **98.14 %** of the emissions occur during the **use phase**. In the case of the va-Q-tainer USx -21G, this figure is **96.43 %**.

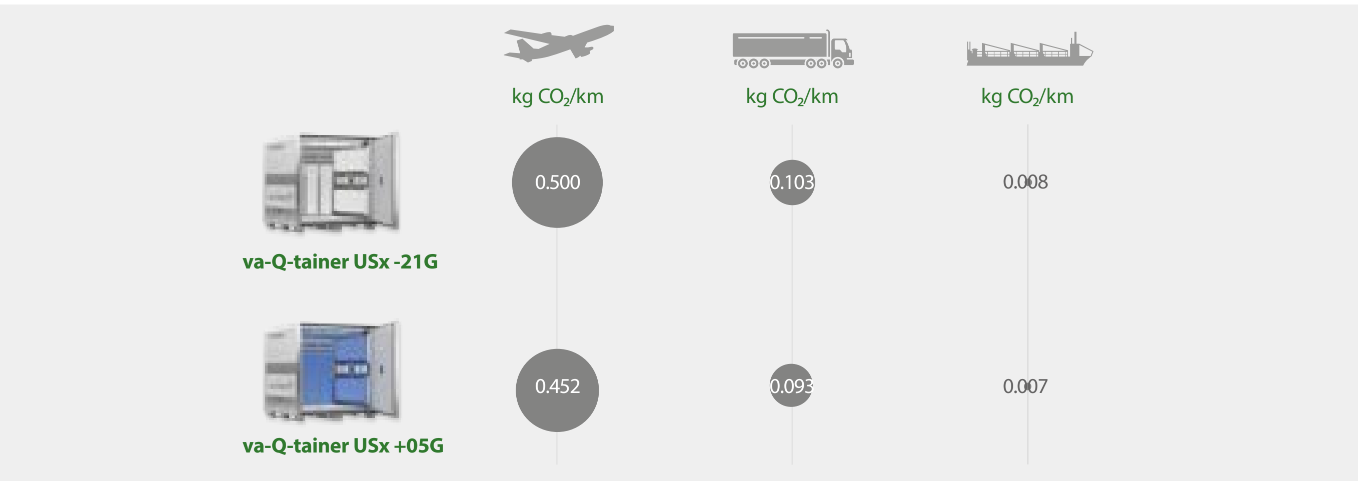
With all the values documented according to GHG Protocol, the **fixed CO_2 product footprint** for the va-Q-tainer USx +05G is **4.03 t CO_2e** and **3.65 t CO_2e** for the va-Q-tainer USx -21G.

CO_2e
CO_2 equivalent (CO_2e) is a measuring unit for the standardisation of the climate impact of various greenhouse gases

Variable Emissions: CO_2 Emissions during Transport

For the calculation of the variable CO_2 emissions during the use phase of a temperature-controlled container, the measuring unit **Emissions per km** must be used.
The graphic below shows an example of the emission values audited by an agency, split by temperature range and transport mode.

Average CO_2 Values by Temperature Range and Transport Mode



With this information, it is now possible to calculate **the variable carbon dioxide emissions of a transatlantic shipment** from Frankfurt to Los Angeles, as seen below.

The CO_2 emissions from the transport of a product are thereby displayed from the shipping origin in Germany to the final destination in California, and two different methods of transport are compared.

1. Full Service Monthly Rental

Full Service Monthly Rental
With this rental type, the va-Q-tainers are returned to the TempChain Service Center (TSC) of origin by the client

Scenario 1: Würzburg (FRA) - Los Angeles (LAX) - Würzburg (FRA)

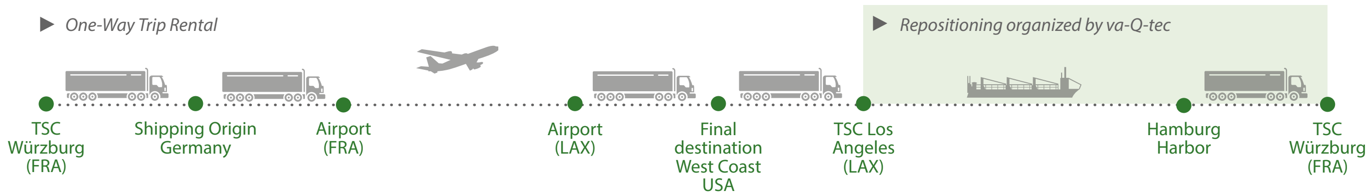
Transport Leg	Method of Transport	Distance in km	Emissions	
			-20 °C Shipment	+5 °C Shipment
TSC Würzburg (FRA) – Shipping Origin Germany		251	26	23
Shipping Origin Germany – Airport (FRA)		324	33	30
Airport (FRA) – Airport (LAX)		9,326	4,663	4,215
Airport (LAX) – Final Destination West Coast USA		583	60	54
Final Destination West Coast USA – Airport (LAX)		583	60	54
Airport (LAX) – Airport (FRA)		9,326	4,663	4,215
Airport (FRA) – TSC Würzburg (FRA)		118	12	11
		Total	**9,517 kg CO_2**	**8,604 kg CO_2**

The containers originate from Würzburg and are transported to the German shipping origin from where they are shipped to Frankfurt Airport and onwards to Los Angeles by air. The goods are then transported across the West Coast of the USA by truck and later the empty container is directly returned to Würzburg (plane/truck).

2. One-Way Trip Rental

One-Way Trip Rental
With this rental type, the shipment ends at the TempChain Service Center (TSC) and the va-Q-tainers are repositioned by va-Q-tec

Scenario 2: Würzburg (FRA) - Los Angeles (LAX)



Transport Leg	Method of Transport	Distance in km	Emissions	
			-20 °C Shipment	+5 °C Shipment
TSC Würzburg (FRA) – Shipping Origin Germany		251	26	23
Shipping Origin Germany – Airport (FRA)		324	33	30
Airport (FRA) – Airport (LAX)		9,326	4,663	4,215
Airport (LAX) – Final Destination West Coast USA		583	60	54
Final Destination West Coast USA – TSC Los Angeles (LAX)		612	63	57
TSC Los Angeles (LAX) – Hamburg Harbor		19,469	156	136
Hamburg Harbor – TSC Würzburg (FRA)		514	53	48
		Total	**5,001 kg CO_2**	**4,516 kg CO_2**

Until the shipment reaches the final destination on the West Coast, the process, and therefore the emissions, are identical to those of the Full Service Monthly Rental (see above). However, the empty container is then transported to va-Q-tec's nearest TempChain Service Center in Los Angeles and the official shipment ends here.

However, in order to operate as transparently as possible, the subsequent steps are also shown: the container is transported from the USA back to Germany (Hamburg) by sea freight, from where it is finally transported back to Würzburg by truck.

Conclusion:
For a full, **transparent comparison** of the CO_2 emissions, both the **fixed CO_2 emissions and the variable CO_2 emissions** must be considered.

Authentic Sustainability Approach at va-Q-tec

As shown, transparent, comparable processing of the presented data is essential for climate protection and the associated necessary reduction in CO_2 emissions. Companies like va-Q-tec are aware of this vital necessity. In order to create the basis for a true comparison, the company developed this useful comparison approach on the basis of the two central reference values: **fixed CO_2 footprint and variable emissions**. In order to set a good example, va-Q-tec has been documenting all emissions since 2020 according to the GHG Protocol, making its accounting transparent.

This pioneering role of the German company is emphasized by numerous measures to reduce CO_2 emissions: Since the 1st January 2020, va-Q-tec has been **climate-neutral** at its German locations. In order to achieve this goal, all processes and structures are continously being optimized. **Key components of its temperature-controlled containers are produced at the company's own factories** at two locations in Germany. This keeps transport routes short and environmentally friendly. The products themselves are designed from the basic idea upwards to be lower in emissions during pre-conditioning and transport than comparable products from the competion. For example, va-Q-tec offers the possibility of using **various phase change materials (PCMs) to maintain temperatures down to -60°C without the use of dry ice**. Due to the advances in passive technology, **no batteries or electrically powered cooling units** are required during transport.

To produce sustainable energy used in production, va-Q-tec has installed a **photovoltaic system** and a **combined heat and power plant**. Additionally, va-Q-tec undergoes **regular ISO, environmental and energy audits by neutral external institutions**. This underlines the company's high standards in the field of climate neutrality and the associated requirement for transparency.

Conclusion: Transparent CO_2 Accounting through comparable Reference Values

va-Q-tec transparently accounts its CO_2 emissions **according to the internationally recognized standard of the GHG Protocol.** The reason for this is that it is the only neutral approach which provides the necessary opportunity for generalizable transparency. **Accounting and monitoring by an external partner** play an important role in the establishment of credibility. The focus of va-Q-tec's efforts was on the **development of useful reference values**, such as a comparable carbon footprint which provides clarity in the calculation of variable emissions of a concrete shipment. These reference values allow for **transparent comparison**, taking into account all important factors such as manufacturing and disposal, temperature ranges, weight of container, kilometers transported and mode of transport.

The company calls on all its friendly competitors to use this internationally recognized standard for the documentation of data. **All reference values should also be presented openly and as transparently as possible**. Only that way can CO_2 emissions of the individual temperature-controlled transport solutions be reasonably compared with each other, independent of both technology and manufacturer. Clients are thus put in the position of being able to select their transport solution according to these CO_2 calculations and can then actively contribute to climate protection.

About va-Q-tec

va-Q-tec is a pioneer of highly efficient products and solutions in the field of thermal insulation and TempChain logistics. The company develops, produces and sells highly efficient and thin vacuum insulation panels (VIPs) for various insulation applications, as well as thermal energy storage components (Phase Change Materials – PCMs) for reliable, energy efficient temperature control. With this key thermal technology, va-Q-tec manufactures advanced passive thermal packaging systems (containers and boxes), which can maintain a constant temperature for up to 200 hours, depending on type, without an external supply of energy. For the provision of temperature-sensitive logistics chains, va-Q-tec maintains a fleet of rental containers and boxes within a global network of partners, which can fulfill demanding thermal protection standards. This strongly growing company, founded in 2001, is based in Würzburg, Germany.

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