Tank Containers:
A Sustainable Solution for Bulk Liquid Transport

Prepared by Atlantic Consulting for the International Tank Container Organisation

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1 Foreword from ITCO

Over the last 30 years there has been a continuing trend to transport an increasingly wide range of cargoes in intermodal ISO shipping containers. Tank containers have been part of this shift – they have provided safe, reliable and cost-effective transport for liquids, powders and gases, both hazardous and non hazardous, foods and chemicals. Although the shift to containers was aimed primarily at improving efficiency and cutting costs, containerisation has also helped to protect the environment by lowering the carbon footprint and reducing waste.

The International Tank Container Organisation (ITCO), formed in 1998, is a voluntary, non-profit trade association that represents the industry and advances its interests. ITCO's main function is to be a platform on which the industry coordinates its efforts in quality, safety and environmental protection. Members represent much of the global tank container industry, including companies that manufacture tank containers, operators, lessors, and service providers such as depots and inspectors.

ITCO General Secretary Patrick Hicks, President Willy Van Loon and Vice-President Heike Clausen (left to right)

Sustainability is a key issue for ITCO and it supports chemical industry initiatives such as Responsible Care, developed by the European Chemical Industry Council (CEFIC). Responsible Care Members work to:

- Improve continuously environmental, health, safety and security knowledge and performance so as to avoid harm to people and the environment.
- Use resources efficiently and minimise waste.
- Report openly on performance, achievements and shortcomings.
- Listen, engage and work with the public to understand and address their concerns and expectations.
- Cooperate with governments, international institutions and organisations in the development and implementation of effective regulations and standards. Provide help and advice to foster the responsible management of chemicals by all those who manage and use them along the product chain.
- Appoint a Responsible Care Coordinator and develop an annual Responsible Care plan.

Moreover, tank containers provide sustainable transport. Tank containers are re-usable. They reduce the handling of cargo in transit by use of a multi-modal international standard ISO transport module. Highly sophisticated logistics techniques are used to transport the tank container from points of loading to discharge. At the end of life, a tank's materials are readily recycled.

This report documents the sustainability status of Tank containers, and it identifies areas where further progress might be made. We welcome your comments and feedback.

Patrick Hicks, ITCO General Secretary

2 Summary: Tank containers provide a sustainable solution for bulk liquid transport.

As a freight transport option, how sustainable are tank containers?

Some of this report's answers should not surprise. Tank containers offer obvious sustainability benefits: they are reusable, recyclable and resistant to product wastage. Safety, quality and efficiency are watchwords throughout the industry.

And then there are less-obvious findings. Nearly all of an ISO tank's environmental impact happens not during its manufacture, cleaning or disposal, but during its actual usage; i.e. it is not just economically efficient, but environmentally efficient as well. This efficiency – which reduces deadhead journeys and maximises use of water and rail connections – pays its benefits in the form of a lower carbon footprint.

Nonetheless, the ongoing struggle against global warming means that Tank containers will, like other industries, need to find ways to de-carbonise even further. These might include ITCO-led initiatives to work with Statutory Authorities to enable efficient regulatory controls, cut tare weight, boost capacity and perhaps to improve aerodynamics. ITCO members also might lead the way in establishing performance benchmarks by improving the quality and quantity of emission factors. In addition, members will want to keep abreast of de-carbonisation moves across the freight-transport sector. One might be a reduction in marine travel velocity – a 'speed limit of the sea'.

The body of this report is aimed at readers with working, but non-expert, knowledge of sustainability issues. It is divided into three general parts.

First, Chapters 3 and 4 give an overview of how tank containers are inherently sustainable and how sustainability is practised by their manufacturers, operators and service providers.

Second, Chapters 5 and 6 discuss the environmental impact of tank containers: where does their carbon footprint happen, and how this is lower than some alternative transport methods?

Finally, Chapter 7 points out some ways in which tank containers might become even more sustainable.

3 Tank containers: reusable, recyclable, re-manufacturable

Containers are a prime choice of shippers, moving more than 90% of non-bulk cargo. Since their introduction in the 1950s and 1960s, the world fleet of all container types has grown to some 25 million units. Tank containers belong to this fleet: an estimated 290,000 of them are in operation, and more than 10,000 new tank containers are manufactured each year.

What are tank containers? They consist of a pressure vessel (the tank) supported and protected within an ISO frame (Figure 1). The International Standards Organisation (ISO) frame is identical in dimension to an ISO dry freight container, and it uses the same type of corner castings to enable lifting and stacking. The tank design is governed by international regulations ensuring the safe transport of a wide range of bulk liquids and powders. Tank containers are also commonly referred to as “portable tanks” or “ISO tanks”.

Tank containers are manufactured in a range of capacities, with various configurations of valves and fittings. Typically, a standard tank carries 25,000 litres and has a maximum gross weight of 36 metric tonnes. A discharge valve is mounted at the rear end; access for loading, cleaning and maintenance is at the top. Accessories can include steam heating, ladders and walkway access to the top.

Figure 1: Workhorse of the transport sector – a typical Tank container

Tank containers are reusable, recyclable and can be re-manufactured.

3.1 Reusable

Tank containers are designed for an economic life of typically 20 years. During this life the tank is used over and over again. After discharge of cargo the tank is cleaned, inspected and prepared for the next cargo load.

A tank container engaged on long-haul trades, for instance China to Europe, where the door-to-door voyage lasts about 6-7 weeks, might ship up to eight loads annually. Over 20 years, that amounts to 160 loads or 4,000 metric tonnes of cargo. Short-haul trades will result in considerably more loads.

The tank operates door-to-door. It is loaded with cargo in plant A and transported by truck, rail and ship to the destination plant B where the tank is unloaded and the cargo directed into the production process.

3.2 Recyclable

Tank containers are manufactured of materials that are very suitable for re-cycling. The total weight is typically 3,700 kg, of which the majority is metal, namely the stainless steel tank and the carbon steel frame. These are easily cut into manageable dimensions that can be melted and made into new materials.

3.3 Re-manufacture

To extend the life beyond 20 years, tank containers often undergo re-manufacture. This starts with the removal of the entire tank frame and insulation, retaining only the stainless steel tank vessel, valves and fittings. Stainless steel is a long lasting metal; it is highly suitable for re-use.

The re-manufacture process re-cycles the retained tank into a new frame. The tank is re-insulated and tested and continues its service life as new. It is expected that this process will extend the life of the tank a further fifteen years.

4 Sustainability in practice: the case of Tank containers

Sustainability is part of an ISO tank's entire life cycle, from manufacturing to operation. And it includes not just manufacturers and operators, but also players such as lessors, service providers and inspectors.

4.1 Manufacture

Tank containers are manufactured in specialist plants located within regions where there is a demand for at least the initial bulk liquid cargo transport to economically position the container to the buyers place of need. The majority of standard fleet tank manufacture is concentrated in China and South Africa ensuring manufacturing economy of scale and access to export cargo. In addition, regional plants exist world-wide, primarily for the manufacture of specialist tanks to meet local requirements.

Manufacturing plants are concentrated to take advantage of locally based construction materials (e.g. stainless steel suppliers), thus reducing the effects of transportation.

Designs of tank container are primarily required to ensure the maximum safety. The tank shell is manufactured of ductile stainless steel and encased in a high tensile carbon steel frame.

The vessel is designed to ASME pressure vessel code, manufactured to the highest standards and able to withstand test pressures of 6 bar or more. The ISO modular frame enables the tank container to be safely lifted, stacked and transported on standard intermodal transport systems and utilising standard and existing infrastructure.

Tank containers are insulated both to maintain cargo temperatures and as an added safety feature. Insulation improves efficiency by maintaining cargo temperature. By developing improved insulation materials and systems the cargo is better protected against temperature rise that might in turn increase pressure. Temperature fall might also affect the cargo. By maintaining temperature throughout the voyage, energy costs to re-heat the cargo at destination are eliminated. Insulation and its outer protective cladding further provide a sandwich construction around the tank, which creates a shield against accidental impact.

Tank containers are manufactured of sustainable materials. Typically weighing 3700kg, the tank consists of a stainless steel tank barrel within a protective carbon steel modular frame, materials that may be recycled at the end of life. Protective paint to the frame is applied in vapour filtering paint booths. Insulation materials are less sustainable but research continues to develop improved products.

Tank containers are manufactured on production lines designed to reduce workload, energy and emissions. Components and sub-assemblies are made ready "just in time" and materials are increasingly sourced locally. Material off-cuts from the manufacture process are re-cycled.

Tank container designs continually improve to make the optimum use of modern locally available materials. Designs have developed to ensure efficient low energy production utilising the latest technology e.g. pressed vessel ends, auto-welder machines, rotating jigs, and recycled surface cleaning passivation process. Increased plate dimensions reduce the number of plates and therefore welded joints and electronically controlled material thickness control the material used to a fine tolerance. Computer controlled plasma profile cutters ensure the maximum components from each steel plate. Waste material is collected and recycled.

The tank tare weight has been reduced by use of computer aided designs, enabling a higher strength but lighter structure that maximises cargo payload. Finite element analysis software programmes determine the optimum material requirements and ensure safety of design by simulating the potential stresses sustained during tank working life. The design is further proven by mechanical prototype tests undertaken in accordance with the regulations and witnessed by the Competent Authority.

Component parts such as valves and fittings, sourced locally from specialist manufacturers, are largely universal. This facilitates efficient production and ensures interchange and in due course efficient spare parts for repairs and maintenance.

The latest designs and material have enabled the tank tare weight to be reduced by some 10%, resulting in lower transport weight or more cargo for each tank. Designs have also enabled increased tank capacity within the same ISO frame, the standard 25,000 litre tank being 20% greater cargo capacity than tanks commonly manufactured in the 1970s.

4.2 Operations

Operators are specialist third party logistics suppliers providing bulk liquid transportation services to shippers. ITCO member operators account for a total fleet of more than 200,000 tanks.

Shippers load their cargo into an operator's tank container. Operators undertake the entire logistic move, transporting the cargo door-to-door. At the required destination, the cargo is discharged and the tank re-used on another trade. By re-using the packaging (the tank container) for a return cargo and ensuring the benefits of multi-modal logistics, the operation is highly efficient. To achieve efficiency the operator's business requires:

- Expert management and computer management systems
- Client base with balanced trade lanes
- Network of locally based contracted third party transport modes and depots

Operators frequently achieve fleet utilisation greater than 80%, downtime largely consisting of the time needed to undertake safety maintenance and cleaning between loads. Cargo is delivered to meet just-in-time requirements thus minimising shippers' stock inventories. However, operators also supply tank containers for the strategic stock of cargo. This enables shippers and receivers to obtain temporary storage space and meet the requirements of peak demand.

Multi-modal transport permits the ISO module tank container to be transported by road, rail and sea, eliminating the need for wasteful and potentially hazardous transhipment of cargo from one tank to another e.g. from ships tank to rail tank to tank truck or the need for handling and disposal of steel drums (125 200 litre steel drums required for the equivalent ISO Tank load).

Investment in sophisticated computer systems provides for optimum performance. A myriad of data is processed to ensure the most suitable tank is available and in safe condition for the next load. Safety and quality are critical to operating tank containers, and management systems are designed to meet the requirements of quality and safety systems such as ISO 9001, SQAS (Safety and Quality Assessment System) and Responsible Care (International Council Chemical Industries)

4.3 Leasing

The tank container industry is supported by a number of established leasing companies ("lessors") - companies that own stocks of strategically positioned tanks and lease (rent) to users for short or long term durations.

Leasing companies contribute to the sustainability of the tank container industry by balancing peaks and troughs of operators' and shippers' business cycles. This means customers are not required to hold idle inventories of tanks for potential strategic needs.

In addition to the required fleet of standard tank types that an operator or shipper might manage, there is often a requirement for a specialist tank to be procured at short notice. Lessors are able to fulfil this need by leasing the optimum and most efficient tank for the scheduled business.

Lessors additionally enable operators to grow their business without expending capital, enabling the operator to invest in efficient management systems and remain competitive with other less environmentally efficient forms of transportation. The bulk procurement of tank containers by lessors enables manufacturers to gear their production to maximum efficiency, reducing boom and bust cycles.

Like operators, lessors manage their tank inventories by investing in expert management and computer systems and engaging tank service providers in the region of need.

4.4 Tank Service Providers

Tank service providers (TSPs) provide the facilities and expertise to store and maintain tanks in safe working condition. A worldwide network of depots ensures that a facility is available within the region of demand.

TSPs have invested heavily in new technology to clean tanks with high pressure automated jets that conserve water. Effluents are managed in automated treatment plants using biodegradable flocculants to accelerate the separation of suspended solids, enabling waste water to be recycled with only the minimal loss. With remaining treated waste at a minimum, it is being disposed through highly regulated facilities.

An inventory of replacement parts are held on site to ensure the minimum downtime. Tank containers are increasingly designed to standardize parts required. Replacement seals and gaskets are almost all standard dimensions.

Tanks, being a modular dimension, are stored in depots in stacks up to seven high. This considerably reduces the area required for storage. At times of high activity, e.g. when a ship has berthed, depots manage incoming and outgoing traffic to reduce truck waiting times and thereby reduce fuel use.

Health and safety are paramount. TSPs invest in training of their personnel and ensure work is undertaken in accordance with the regulations. A skilled workforce is continuously developed to maintain the necessary high standards. Many depots are have been accredited to ISO 9001 quality systems.

4.5 Inspection

Safety is paramount and the tank container is highly regulated with exacting international and regional regulatory standards including UN, IMDG, ADR, RID, CFR49.

Compliance entails independent assessment from design approval and prototype testing, inspection and testing at manufacture and retesting at 30 month periods throughout the tanks working life. Furthermore, operators, manufacturers, lessors and TSPs are required to meet international standards such as SQAS, Responsible Care and ISO 9001 and inspection companies are engaged to undertake independent audits.

The regulations ensure that tank containers are operated to the highest standards of safety protecting personnel and the public. Safe operation is the most efficient operation. The highly regulated industry requires that Inspection Companies locate their personnel in strategic locations. This ensures minimal travel costs and reduces the environmental effect of travel. Local inspectors can promptly respond to the tank operators significantly reducing tank container downtime.

5 Eco-impact of tank containers

Where and how do Tank containers affect the environment? This chapter explores answers to that question, looking at carbon footprints and all environmental impacts of a shipment from China to Europe. Then it considers general variations in transport footprints. The next chapter explores how tank containers help minimise this environmental impact.

5.1 Carbon footprint: tank container shipment from China to Europe

Carbon footprints are surely the best-known measure of environmental impact. A carbon footprint represents the sum of all 'carbon' – short for greenhouse gases, the primary one being carbon dioxide – emitted over the lifetime of a product. Lifetime includes extraction of raw materials, manufacturing, distribution, use and disposal, often expressed as 'cradle-to-grave' coverage. The common unit of a footprint is CO_2e, meaning carbon-dioxide-equivalents, usually expressed in g, kg or tonnes. Footprints have been estimated for many products and services, from average European passenger-car transport (current footprint around 180 g CO_2e/km) to production of potato crisps (around 75g CO_2e for a 33.5g packet of potato crisps, including the packaging).

What is a tank container's footprint? For a typical 24-tonne shipment, originating in China and terminating in Western Europe, the carbon footprint is 422 g CO_2e per kg of product shipped (or about 19.5 g CO_2e per tonne-kilometre). This is smaller than the footprint of manufacturing, say, a chemical – where production footprints generally fall in the range of 1-4 kg CO_2e per kg of product. This footprint can be disaggregated in three ways: by function, by life-cycle phase and by greenhouse-gas.

5.1.1 By function

The disaggregated carbon-footprint of the China-Europe shipment by function can be expressed in absolute (Figure 2) or percentage (Figure 3) terms.

Figure 2: Absolute carbon footprint by function, ISO tank container shipment from China to Europe

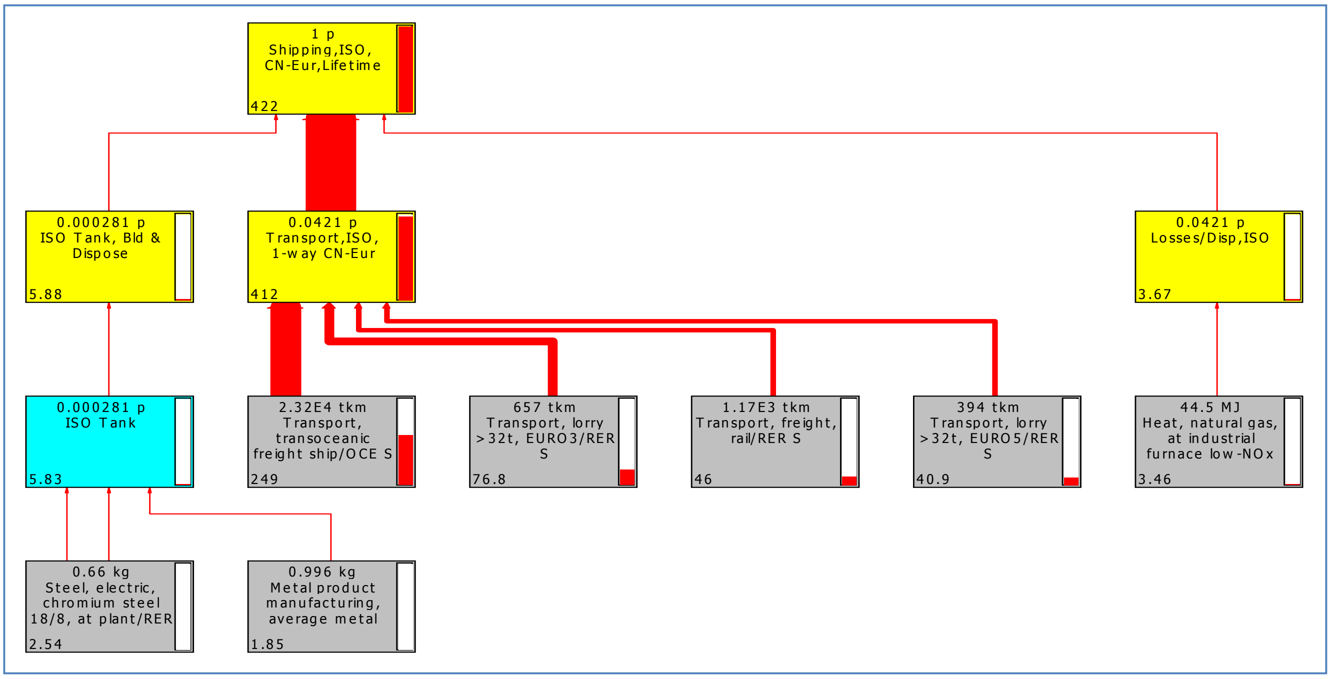
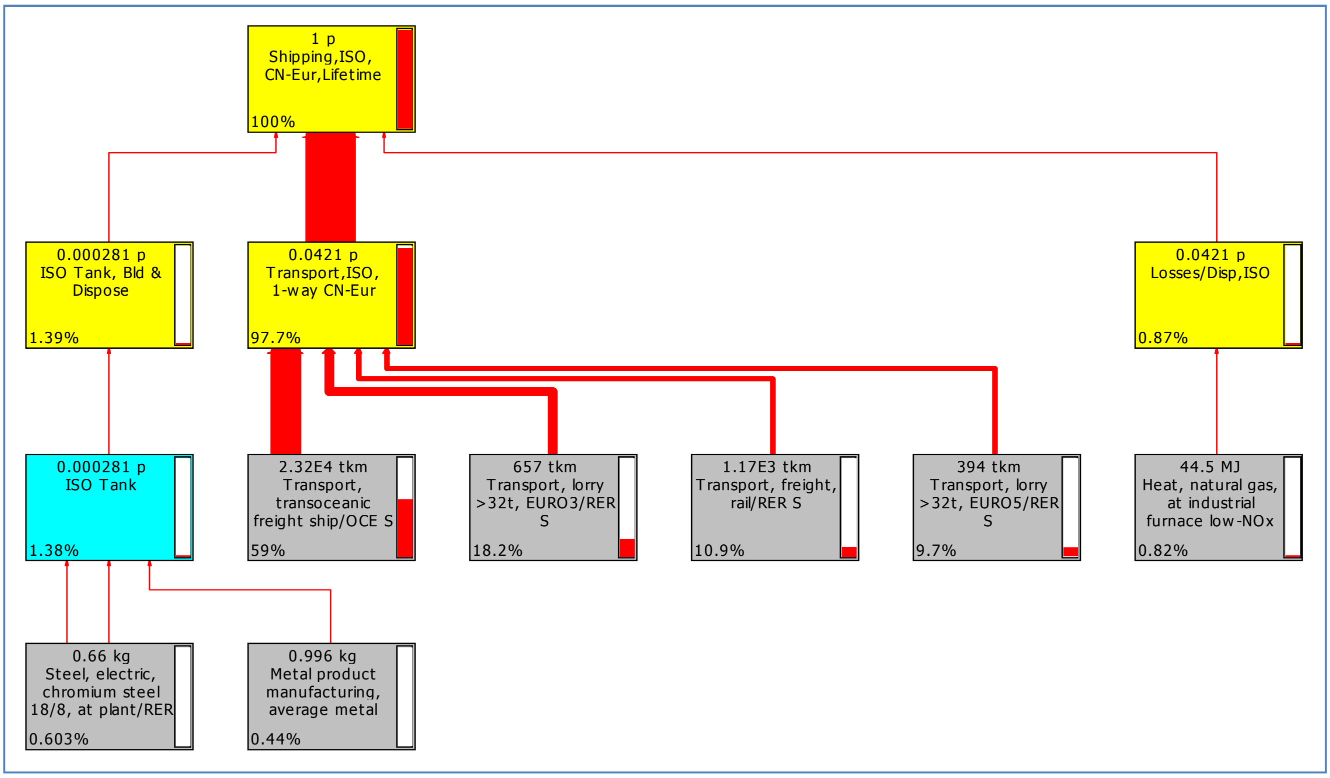


Figure 3: Percentage carbon footprint by function, ISO tank container shipment from China to Europe

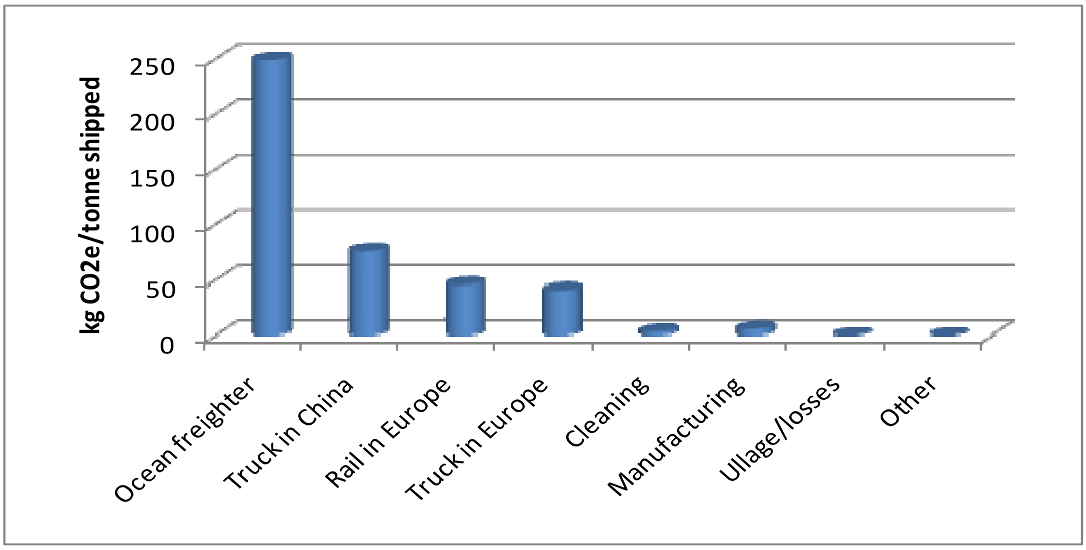


Either way, there are three primary functions in the footprint: construction and disposal of the tank container; transport operations, by ship, rail and road; plus losses and disposal. Clearly, the main contributor to the footprint is transport operations. It accounts for 98% of the total footprint, construction and disposal for just over 1%, with the slightly less than 1% remaining to losses and disposal (most of which is generated by tank cleaning).

5.1.2 By life-cycle phase

Transport's dominance of the footprint is again obvious, when the result is presented by life-cycle phase (Figure 4).

Figure 4: Carbon footprint by life-cycle phase, ISO tank container shipment from China to Europe



Although the ‘ocean freight’ portion of the journey accounts for the largest single part of the footprint, nearly 60% of the total, it is for a much larger distance, some 20,000 km from Shanghai to Rotterdam. Truck transport is only for 1,600 km, and rail for 1,700 km.

5.1.3 By greenhouse gas (GHG)

Of the three main greenhouse gases, carbon dioxide dominates the ISO tank footprint (Table 1). This is not surprising, given that the transport is dominant, and carbon dioxide is dominant in transport.

Table 1: Carbon footprint by life-cycle phase, ISO tank shipment from China-Europe

Greenhouse gas	Footprint *kg CO_2e/journey*	Proportion of total
Carbon dioxide	406.6	96%
Methane	3.3	1%
Dinitrogen monoxide (N_2O)	10.8	3%
Remaining airborne emission	1.2	<1%
Total	421.9	100%

In other industrial sectors – most notably agriculture – carbon dioxide can be far less dominant. From all sources, carbon dioxide accounts for about 80% of worldwide greenhouse-gas emissions.

5.2 All environmental impacts: tank container shipment from China to Europe

Global warming is not the only environmental impact. Others include ozone depletion (creation of the ozone hole), photochemical oxidation (smog), eutrophication (excess nutrients to lakes and rivers) and eco-toxicity (poisoning of nature’s plants and animals).

An overall assessment of eco-impacts can be conducted – a so-called life cycle assessment (LCA). It is similar to a carbon footprint, in that it represents the sum of all environmental impacts (including global warming) incurred over the lifetime of a product. Again, lifetime includes extraction of raw materials, manufacturing, distribution, use and disposal, often expressed as ‘cradle-to-grave’ coverage.

Various units are used in LCA. One fairly common measure is the use of ‘eco-points’. Put simply: products or processes that create more environmental impact receive more eco-points in an LCA. Because eco-points are dimensionless, they are meaningful only in comparison. For instance, driving an average European passenger-car for one kilometre generates 0.0219 eco-points[1] - this becomes meaningful only by comparison with, say, one kilometre of hi-speed railroad transport, which generates 0.00625 eco-points.

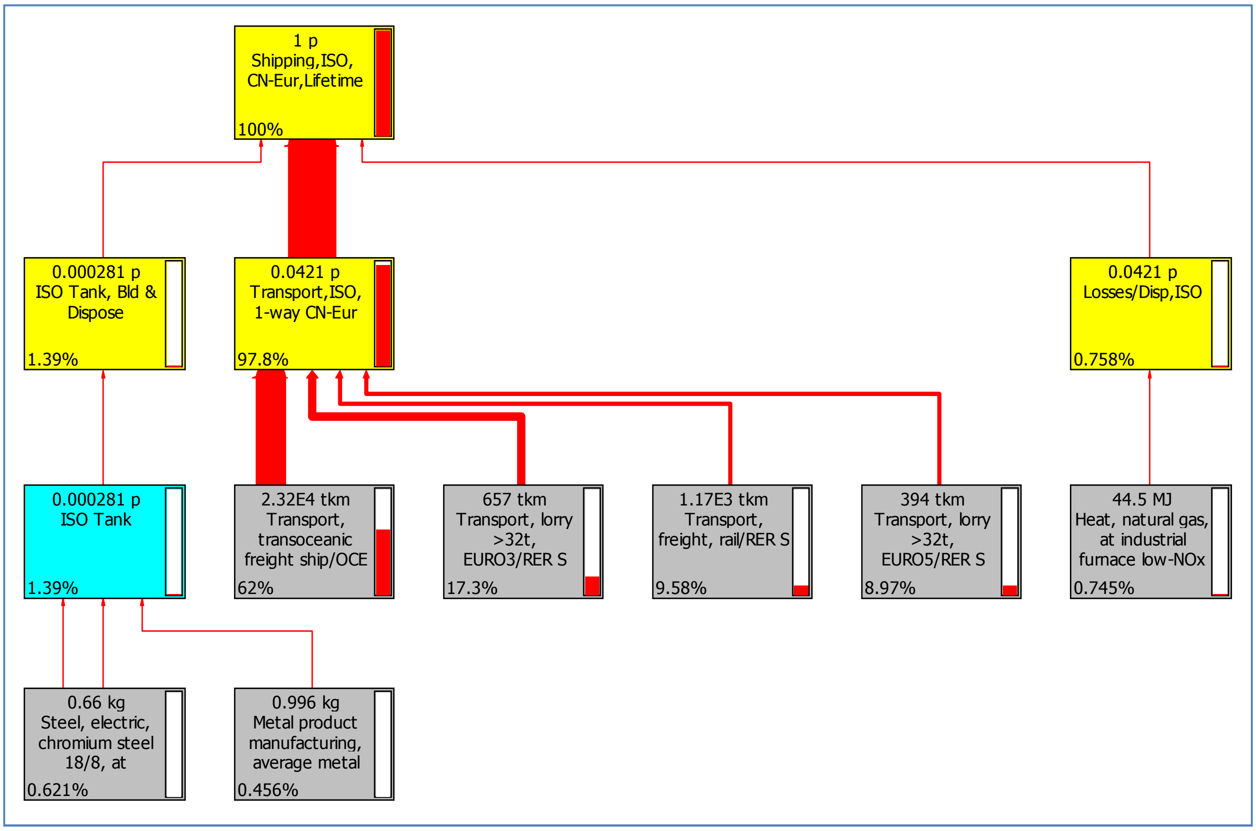
What are the eco-points for tank containers? For the same China-to-Europe shipment from discussed above, the one that creates a carbon footprint of 422 g CO_2e per kg, its score is 59.2 eco-points per tonne of product shipped. Taken by itself, this figure is rather meaningless. By comparing it with passenger-car transport, it suggests that tank containers

[1] Eco-points used here are defined by the so-called ReCiPe model (Version 1.04, World model, Endpoint, H/H normalisation and weighting). ReCiPe, first published in 2008 by an expert group led by academics and regulators in The Netherlands, is currently the most-widely accepted method for calculating eco-points. Details at www.lcia-recipe.net

create an order-of-magnitude less environmental impact[2]. Still, this comparison is of limited value, because tank containers and passenger cars are not competing modes of transport.

A more useful application of eco-points, in this instance, is to measure them by percentage throughout the ISO tank lifetime (Figure 5). This shows that the distribution of overall eco-impacts is almost identical to that of the carbon footprint (Figure 3).

Figure 5: Percentage total eco-impact by function, ISO Tank shipment from China to Europe



What this means is that, for an ISO tank, a carbon footprint is an excellent proxy for overall eco-impact. So, rather than using eco-points to discuss an ISO tank's environmental impact, carbon footprints will do the job just as well – and they are more understandable to non-specialist audiences.

5.3 Variations in transport footprints

For the China-to-Europe journey described above, the carbon footprint has been compiled from the ecoinvent database (ecoinvent 2010), with particular reliance on its transport modules (ecoinvent 2007). Why ecoinvent? Of the available databases for carbon footprints and life-cycles assessments, ecoinvent is clearly the most authoritative and comprehensive, and it is probably the most-used by environmental analysts.

Although ecoinvent is most authoritative, its assignation of precise figures – for instance in Table 1 and throughout the above text – belie the inherent variation of carbon footprint data. Clearly, there is a broad spread among reported figures (Table 2).

[2] A typical passenger car weighs about one tonne. So comparing the eco-points per tonne-kilometre, the ISO Tank's impact is about one-tenth that of the passenger car.

Table 2: Emission factors for freight transport (g CO_2e/tkm)

Source	Comment	Mode						Reference
		Road		***Rail***		***Marine***		
		Type	*Factor*	*Type*	*Factor*	*Type*	*Factor*	
ecoinvent	Used in this report	Truck >32 t, China Truck >32 t, Europe	117 104	European average	39.4	Transoceanic freight ship	10.7	(ecoinvent 2010)
CEFIC[3]	Recommended average factors	Truck	62	Rail, unspecified	22	Deep-sea container Deep-sea tanker Barge	8 5 31	(McKinnon and Piecyk 2010)
IMO						Products tanker Container General cargo	5.7-45 12.5-36.3 11.9-19.8	(International Maritime Organization 2009)
DEFRA				All rail freight	21	Small container Larger container	13.5 11.5	(CEFIC and ECTA 2011)
BSR Clean Cargo						Avg deep-sea container	8.4	(CEFIC and ECTA 2011)
McKinnon, based on Coyle	Size and load variations	10 t, 50% load 29 t, 100% load	151.1 39.7					(CEFIC and ECTA 2011)
INFRAS				All rail Diesel Electric	22.7 38 19			(CEFIC and ECTA 2011)

In transport, this variability of emission factors is a function of four influences:

- *Mode* – In almost all cases, carbon intensity descends in the order of truck>rail>marine transport.

[3] European Chemical Industry Council

- *Definition of the transport* – is it an average or a more-specific measure, is it global or regional, is it an average of several types (say, all ocean-going ships)? What load-factors and repositioning movements are assumed?
- *Performance* – fuel efficiency, hence emissions intensity, can vary significantly by vehicle type and technology. Operating conditions and maintenance regimes often influence performance as well.
- *Measurement* – actual versus imputed values can differ. These differences, however, are usually smaller than those caused by definitions and performance.

6 How ISO tank containers make transport more sustainable

Two aspects of tank containers make them most sustainable than some competing transport options. One, using an ISO tank operator rather than dedicated transport can reduce deadhead journeys significantly. Two, tank containers are inherently multi-modal, which can be far-less carbon intensive than mono-modal trucking, steel drums and even rail transport. These aspects, and their benefits, are detailed in the following subsections.

6.1 Reduction of deadhead trips

Tank operators (see section 4.1) typically manage a fleet of containers that serve a variety of customers. Because the containers are readily cleaned and are uniform, it is easy for them to go from one cargo to another completely-different one. This flexibility is critical to operators, who want to minimise empty journeys out of their own and their customers' economic interest. Avoiding deadheads is also in everyone's environmental interest.

For marine tankers shipping liquid cargoes, deadheading or partial-load journeys are common. According to (International Maritime Organization 2009, Table 9.1, page 131), load factors[4] for tankers are around 50%, while those for tank operators are 85% (Table 3).

Table 3: Load factors for cargo shipping, by type

Type of shipping	Average load factor
Crude oil tanker	48%
Products tanker	45-55%
Chemical tanker	64%
LPG tanker	48%
LNG tanker	48%
Container	70%
ISO tank operators	85%

How does this work in practice? Take, for example, a Glasgow-Melbourne route travelled by a Scottish exporter of whisky to Australia. If whisky is shipped one-way and the tank container is returned empty to Scotland, the resulting footprint is 318 kg CO_2e per tonne of whisky. If, instead of returning empty, a cargo of wine is picked up in Australia and returned to the UK, the resulting footprint per tonne of whisky/wine shipped is about 15% lower.

6.2 Ease of multi-modal transport

Tank containers are inherently multi-modal, transferring easily and quickly from ships to barges to rail to road. Being able to travel on the water can significantly reduce a journey's footprint. For example, the footprint of a cargo shipped by sea from Le Havre (France) to St Petersburg (Russia) is nine times lower than by road. If it goes by rail, the footprint is about five times lower than by road. This order-of-magnitude difference applies to most any journey where either water, rail or road transport are viable options.

Multi-modal transport's advantage is its flexibility. For instance, tank containers recently have been shipped from Antwerp to central Asia by rail, rather than by ship and truck. It is possible that this first option generates a lower footprint, and in any case, these sorts of multi-modal shipments are less accessible when shipping in bulk.

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[4] IMO calls them capacity utilization

7 Areas for possible improvement

As the world's population and temperature continue to rise, so too will popular pressure for more sustainability. While details of "what-should-be-done" and "how-to-do-it" are still very debatable, one trend is fairly clear: de-carbonisation. Industries, institutions and individuals will be expected to cut their carbon footprints. Freight transport generates some 10% of all greenhouse-gas emissions, so along with other sectors, it will be pushed – formally and informally – to decarbonise. One researcher (Lindstad, Asbjornslett et al. 2011, p 3456) estimates that carbon emissions (per ton-kilometre) for sea transport will need to fall by 2050 to 20% of their current level.

Tank containers are already part of this trend. Owners and operators are steadily working to improve economic efficiency, which as a side effect also lowers carbon emissions.

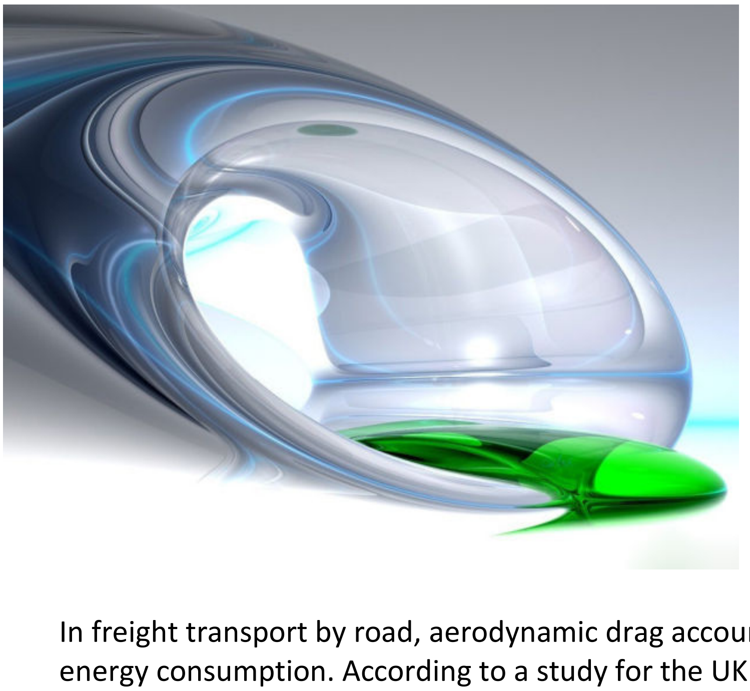
So, what can the tank container industry do above what it is doing already? There is no 'single solution', no secret formula that will deliver major reductions. However, there are several actions that might be explored, three of them internal to ITCO members and two of them affecting the freight industry as a whole.

7.1 ITCO-internal actions

There are three areas that might be explored. One of these relates to tank container design, one to modal optimisation and one to emissions measurement.

7.1.1 Reduction in tare weight, increase in capacity

In any transport mode, more weight equals more carbon. For example in road transport, weight reduction has been a leading factor in carbon-efficiency improvements of the past several decades. As noted earlier (see section 4.1), tank container tare weight has been reduced commonly by 10%, and capacities have increased within the same ISO frame. The standard 25,000 litre capacity is 20% larger and built to a higher standard of safety than those common in the 1970s.



It would be useful for ITCO to: quantify the tare weight and capacity trends in tank containers; and explore the potential for future reductions.

7.1.2 Improved aerodynamics

In freight transport by road, aerodynamic drag accounts for about one-third of a vehicle's energy consumption. According to a study for the UK Department for Transport (Baker, Cornwell et al. 2010), a 'typical' aerodynamic improvement package costing some $5,000 per new trailer could cut carbon emissions by about 10%. For existing cabs and trailers, aftermarket packages costing $500-2500 can cut carbon by 0.1-6.5%.

It would be useful for ITCO to investigate the technical feasibility, economics and carbon benefits of improving tank container aerodynamics.

7.1.3 Modal optimisation

As noted previously, carbon intensity of transport generally descends in the order of truck>rail>marine modes. In other words, the carbon footprint of shipping X tonne-kilometres by sea will be less than by rail, and both will be less than by road.

Where this gets tricky is in (potentially) multi-modal transport. For instance, should a shipment from Western Europe to central Asia go via rail or via a combination of sea and road?

The economics of such movements are regularly analysed by tank container operators, with an eye to optimising the costs and benefits. It would be useful for ITCO to investigate the feasibility of including 'carbon optimisation' in such analyses.

7.1.4 Improved emission-factor datasets

Carbon footprints are estimated via input-output models (see Section 5.1) that rely heavily on emission factors for various processes. A carbon emission factor is typically expressed as X units of CO_2e (carbon dioxide equivalent) per unit of function. For instance, the emission factor of a new European automobile's is around 150 g CO_2e per kilometre driven.

Emission factors for various processes are published by researchers and government agencies, and they are compiled in databases such as ecoinvent. Although in many cases the available emission factors are sufficient to drive decisions, researchers readily admit that they could and should be improved (see Section 5). Three main deficiencies are evident:

- *Data-gaps* – emission factors for many processes are unavailable. Carbon footprinting is a relatively new discipline, dating back probably about 20 years. For many processes – say, transport via tank container – no standard factors are available. For others, published factors sometimes are out-of-date.
- *Inappropriate scope* – published factors sometimes are over-aggregated or under-aggregated for particular analyses. For instance, general 'road freight' factors of 127-156 g CO_2e/tonne-kilometre are cited by (International Maritime Organization 2009, Table 9.2), while work commissioned by CEFIC (McKinnon and Piecyk 2010, Table 8) recommends an average factor of 62 g CO_2e/tonne-kilometre. Reasons for the difference are not entirely clear, but probably due to relative over-aggregation by IMO and under-aggregation by CEFIC. An example of under-aggregation is in power-

generation emission factors. Factors of g CO_2e per kWh vary dramatically by country and by fuel type, yet finding a European average for them can be challenging.

- *Lack of transparency* – many, if not most, published factors are unclear about vehicle type, fuel type and load factors (both percentage loads and repositioning distances).

To address these deficiencies, ITCO or its members might consider publishing its own factors for transport via tank containers. This would not contribute directly to de-carbonisation, but it would help actual de-carbonisation to be measured properly and not be confused with mis-measurement.

7.2 ITCO-external actions

There are two areas that might be explored. One is a general 'watching brief' on industry trends; the other relates specifically to operations.

7.2.1 Watching brief: efforts to measure and reduce shipping emissions

To be competitive, transport operators and vehicle suppliers are naturally inclined to de-carbonise, mainly by improving efficiency. ITCO members already do this (see above), through research and development sponsored individually, through governments and trade associations. It might make sense to formalise ITCO's role in this by assigning to a specific person or group a watching brief: a periodic survey of trends and policies in this area. This probably would entail a periodic review of reports from governments and trade associations.

7.2.2 Reductions in marine travel speed

One option for cutting marine-shipping carbon emissions not mentioned by the IMO (International Maritime Organization 2009) is that of reducing average speeds. A recent study by the Norwegian Institute of Marine Technology (Lindstad, Asbjornslett et al. 2011) estimates that cost-neutral speed reductions[5] would reduce marine carbon emissions by 28%. At the same time, to maintain capacity, this reduction would require a 19% increase in the shipping fleet.

Clearly, this sort of step change would require far more support than that of ITCO. Nonetheless, its promise of de-carbonisation coupled with industry growth is surely worth further investigation.

[5] Cost-neutral meaning that shipping times would be increased only as much as could be saved by increases in fuel economy.

8 References

Baker, H., R. Cornwell, et al. (2010). Review of low carbon technologies for heavy goods vehicles, Sponsored by UK Dept Transport.

CEFIC and ECTA (2011). Guidelines for Measuring and Managing CO2 Emission from Freight Transport Operations Sponsored by CEFIC, ECTA.

ecoinvent (2007). Transport services.

ecoinvent (2010). LCI Database. St Gallen, Switzerland. **Current database is V 2.2**.

International Maritime Organization (2009). Second IMO GHG Study 2009. London, International Maritime Organization.

Lindstad, H., B. E. Asbjornslett, et al. (2011). "Reductions in greenhouse gas emissions and cost by shipping at lower speeds." Energy Policy **39**: 3456-3464.

McKinnon, A. and M. Piecyk (2010). Measuring and managing CO2 emissions of european chemical transport, Sponsored by CEFIC.