PACKAGING - INNOVATIVE

The main problem with packaging disposal is complexity: There are too many different types of packaging and countless players on the market. The many packages that are produced are rarely reusable or, if reusable, do not achieve the economies of scale that would be necessary for resource-saving processes.

The problems of today's packaging system can only be addressed through complexity reduction.
At the Frankfurt Bridges, a sustainable packaging world is completely redefined, starting with the use of three basic materials for the production of packaging: lightweight glass that is not fragile, thin enameled stainless steel and polyethylene that can be burned to produce water and relatively pure, i.e. industrially reusable CO2.

In addition, all packaging materials are included which are 100% biodegradable and can be disposed of in a group with organic waste and without microplastic-emissions.

All the packaging materials chosen are low in CO_2-production over their lifetime, and they leave no microplastics behind when they are disposed of. In addition, they are planned to be pollutant-free in their production and disposal.

The surrounding area of the bridges can also be successively connected to the reusable system with glass and stainless steel packaging: The more the system is spread in the city, the greater the economies of scale - once started, the roll-out is always easier and faster.

AN END TO TAKE-AWAY IN PLASTIC

Reusable takeaway packaging needs to be available when you need it, and easy to get rid of once you're done.

SUPERMARKET AND DRUGSTORE

The packaging must be low in CO_2 in production and disposal, reusable or microplastic-free compostable.

PACKAGING - SUITABLE FOR THE PRODUCT

Packaging materials, closures and portion sizes were defined for the most important product groups sold in the shops of the Frankfurt Bridges.

VARIETY IS POSSIBLE

Despite the reduction in complexity of the material, packaging diversity for informational and marketing purposes is made possible.

SHOPPING IN THE FUTURE

Price and product information as well as payment by scan code - all with the intelligent shopping cart and delivery system.

CIRCULATION SYSTEM AND REFUND

Collection containers with reusable packaging autonomously exchange themselves regularly for empty counterparts and thus ensure deposit refund.

Take-away Packaging

On Frankfurt bridges, take-away packaging should be mainly glass or stainless steel

The take-away system of the Frankfurt Bridges makes the use of reusable food containers as easy and convenient as that of disposable containers. On the Frankfurt Bridges, for example, every gastronomy establishment is required to provide reusable take-away packaging made of sturdy lightweight glass or enameled thin stainless steel in return for a deposit. The emptied containers can be returned to one of the 300 collection roundels on the bridges. The deposit is immediately refunded, the containers industrially cleaned and delivered back to the catering industry.

Content: A sustainable reusable system for take-away containers on the Frankfurt Bridges is described

Instead of plastic, the extremely durable and thus very long reusable materials „sturdy special glass“ and stainless steel are proposed.

For both materials, the focus is on lightweight solutions, and in the case of glass, there is the added consideration that it must not break easily.

All restaurants on the bridges are required to sell their food and beverages in a wide but fixed range of container designs. Consumers can return these containers at any time to various locations on the bridges - from there they are collected, cleaned and made available to the restaurants again.

An end to disposable plastic packaging: on the bridges, there are only reusable systems for take-away gastronomy

Takeaway gastronomy is becoming increasingly important. The food is usually sold in disposable packaging. The result: a mountain of waste. The fact that everyone brings their own container is a positive approach, but it only works with precise advance planning or when containers are carried along prophylactical - accordingly, it is rarely practiced: Most of the time you grab a coffee at Starbucks spontaneously without having your own cup with you – and once you finished drinking it, you don‘t want to carry the dirty cup with you when you continue to move through the city.

A packaging system therefore must be uncomplicated and at the same time environmentally friendly and resource-saving. This means: (1) It must be possible to take the packaging with the food on site when buying it, and then get rid of it again without complications: Availability of packaging when buying the food must be as simple as disposing of packaging once you are finished, because only then will people accept it.
(2) The material of the packaging must be reusable. This can only work if the economies of scale in return/collection, cleaning and redistribution to the catering industry are realized through a limited number of packaging forms.

Only if the complexity of take-away packaging is reduced and all restaurants use the same range of containers can the necessary economies of scale be achieved

Similar to the way different beverages -from sparkling water to lemonade to spritzer- are being bottled by different suppliers successfully and efficiently using one and the same type „bead bottles“, a standardization of the container range can also serve to establish an environmentally friendly reusable system in the take-away sector: Consumers can get rid of take-away containers anywhere in the neighborhood at collection points; this way, the containers do not have to be returned to the exact vendor they came from, but can be collected in bundles for all restaurateurs in the neighborhood, cleaned, and redistributed according to the needs of the individual establishment. If each restaurant and café had its own specific bin designs, this would not be possible – at least not with the necessary economies of scale.




The Frankfurt Bridges takeaway system operates without plastic containers

There are already some reusable systems for the catering industry, but often the tableware here is still made of plastic.

And reusable plastic tableware has one major disadvantage: scratches and discoloration make it look unhygienic and unappetizing after a while, so it will have to be replaced at some point. Therefore, even plastic tableware that can be reused up to two or three hundred times eventually ends up in the trash and needs to be replaced.

Since reusable plastic that can be used as a container for hot or acidic food must have certain properties, it is currently not recyclable. In addition, people often intuitively or subjectively dislike consuming hot or acidic food and beverages from plastic containers.

The aim at the Frankfurt Bridges is therefore to use only packaging that (1) is produced with the lowest possible energy input, (2) can be reused as often as possible, and (3) is lightweight and unbreakable. In addition, there are two further essential aspects: (4) the containers must look appealing and (5) intuitively, hot and sour foods and beverages should also be gladly consumed from them.

A look into the past helps to find solutions.

The first reusable solution: enameled metal take-away containers

People have been transporting ready-made food for centuries, but only the past few decades have they been doing so in plastic. So what did they use before that? Among other things: containers made of metal, such as the „Henkelmann“. The metal containers are sturdy and durable and, because they are equipped with compartments, very practical.

If they do become unusable, the material can be recycled and used to make new containers.

However, metal has a disadvantage: eating from it with metal cutlery is unpleasant. That's why modern „Henkelmann“-containers should be enameled inside. Enamel is nothing more than a glass coating applied to the metal. And eating and drinking from enameled tableware feels very pleasant.

For short-term take-away use on the bridges, correspondingly wafer-thin metal containers with enamel coating on the inside are used.

The metal of choice for these containers is stainless steel

The most important criteria in selecting the metal were (1) it should be common, (2) it should be durable, (3) it should have high durability ("strong") while being comparatively light, and (4) it should be suitable for food contact. Three (enameled) metals have been considered accordingly: Stainless steel, titanium and aluminum.

Stainless steel was chosen because of its frequent occurrence, durability and recycling potential, as well as its excellent food compatibility. In addition, stainless steel has another advantage: The market for recycled steel is already very large -the ratio of crude steel production to steel scrap use worldwide was 2:1 in 2015. Even if every household in Germany permanently had a set of 10 steel containers with an average volume of 250ml in use, a quarter of the end-of-life vehicles scrapped each year in Germany would already suffice as recycling material for their one-time production. The ecological rucksack for titanium and aluminum, on the other hand, is significantly larger, both in extraction and in the recycling process.

A magnesium alloy would theoretically also have been a candidate. For this, however, the metal selection would have had to be extended to various alloys, which would have been beyond the scope of the feasibility study for the Frankfurt Bridges. The poor corrosion resistance and brittleness during processing make pure magnesium unsuitable as a pure material for dinnerware.

Metal Weight

An important selection criterion for packaging: weight

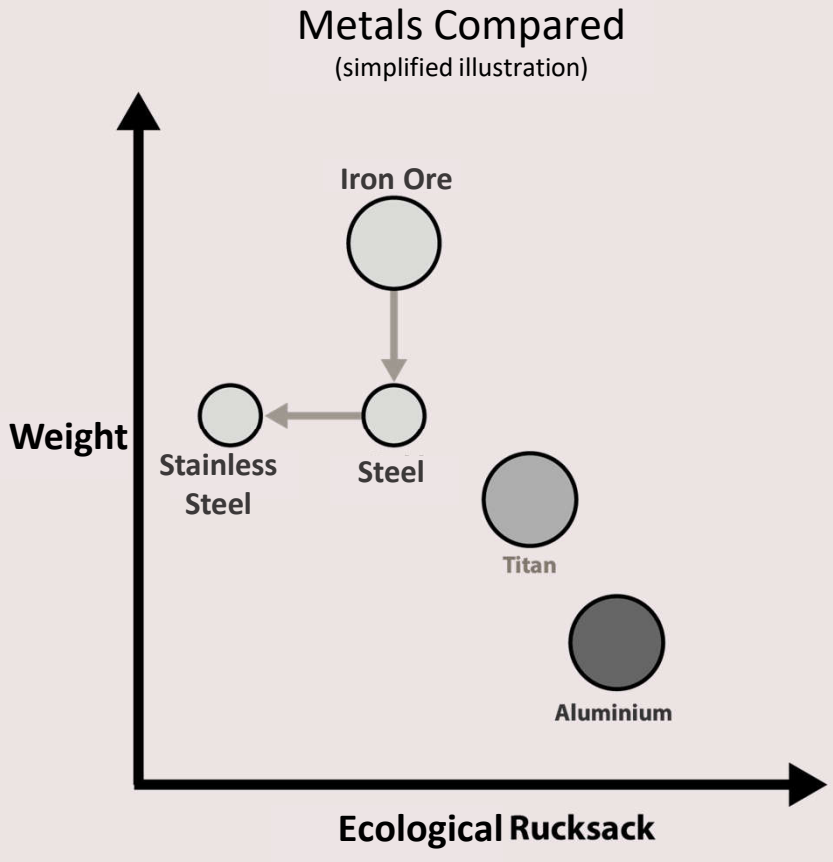
Specific weights in comparison:

- Steel 7.5 to 8.5 gr/cm³
- Titanium 4.5 to 4.8 gr/cm³
- Aluminum about 2.7 gr/cm³

Steel has an average density of 7.85 g/cm³ (=7850 kg/m³) and is thus significantly heavier than aluminum and titanium for the same volume. Its weight disadvantage compared with lighter metals is compensated for by the strength of stainless steel: Since it has a higher tensile strength than aluminum or titanium, it can be processed thinner. This means that less material is needed for a vessel with the same strength.

The properties of stainless steel packaging are further massively improved by an additional enamel coating. In particular, the increased impact resistance, as well as the improved resistance to acids and alkalis, ensures a significant extension of the service life of a packaging.

An enameled stainless steel container with a capacity of 250 ml and a wall thickness of 1.5 mm weighs approx. 36 g, plus lid. An aluminum container, which would have to be about twice as thick to make it similarly impact-resistant, would then no longer be a third as light in terms of weight, but only slightly lighter.



Selection criterion: Sustainability

Sustainability can be measured using the ecological rucksack: Here it is made up of energy consumption and pollutant emissions during production and disposal, as well as service life. Titanium and aluminum are lighter than stainless steel, but their ecological rucksack is larger.

Although titanium is one of the most abundant elements in the earth's crust, it is extremely expensive due to the manufacturing process. This requires high temperatures, resulting in increased CO_2 emissions. It also requires the use of chlorine, which is obtained in an energy-intensive process.

The Bayer process commonly used to extract aluminum from bauxite is also energy-intensive. It also produces a toxic residue known as red mud, which is difficult to dispose of.

Although the extraction of steel also requires a relatively large amount of energy, it can be recycled with less energy input than aluminum or titanium because it oxidizes less easily. If recycled steel is used, the ecological rucksack is improved. Added to this is the higher durability and thus service life.

The thermal conductivity of metal must be bypassed during take-away

To counter the thermal conductivity of metal, there are also special sheaths made of completely compostable biopolymer in which containers can be placed. The enamel coating on the inside of the stainless steel containers also slows down heat conduction.

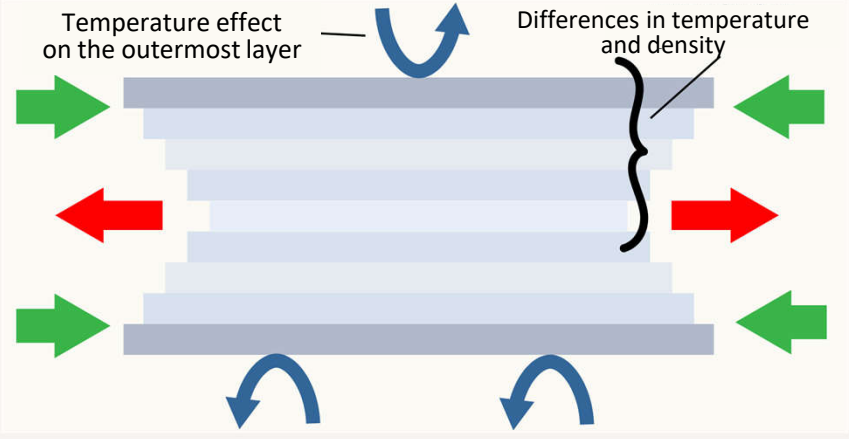
In addition to steel, another reusable material has been identified for the packaging on the bridges that weighs less than stainless steel: glass has an average density of 2.5 g/cm³, so it is even lighter than aluminum and joins our porcelain dining tradition.

The second solution are hardened glass containers

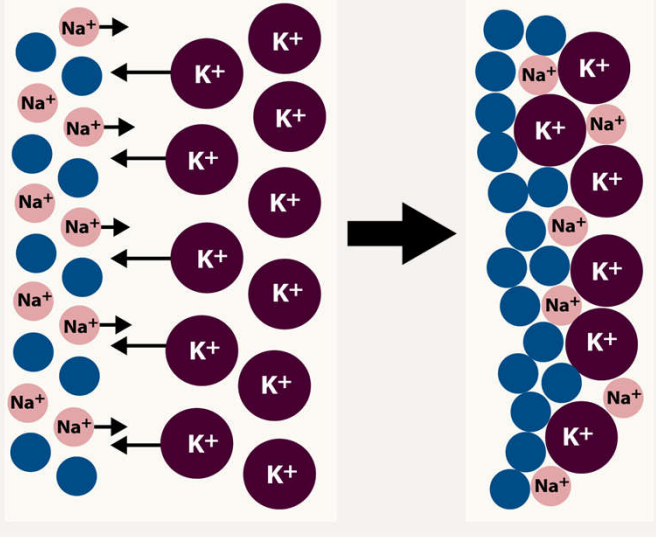
Many people eat mostly from ceramic. However, this is heavy and therefore not suitable as a material for take-away containers. For eating similarly pleasant is glassware. Like stainless steel, it has many advantages: It is food safe, tasteless, can be cleaned hygienically and can be recycled. However, glass has one disadvantage: it breaks relatively easily. If you make the glass thicker, it becomes more break-resistant, but also heavier - and therefore more laborious and expensive to transport.

But there is a solution for this: tempered glass.

Thermal hardening
Stress differences in the glass cross section



Chemical hardening
Stress differences of the top glass layer



Glass can be hardened in two ways: thermally or chemically

With thermally tempered glass, the tension between the outer layer and the glass core is changed by heating the glass a second time. This makes it up to 15 percent more break-resistant. However, thermally tempered glass needs a certain thickness to maintain the temperature difference between the glass core and the outer layer. It cannot therefore be processed as thin as desired.

The situation is different with chemically tempered glass: Here, sodium ions are interspersed with larger potassium ions on the glass surface: this densifies the glass surface. This multiplies the so-called flexural strength of the glass - colloquially: its hardness. Since no temperature difference between inner and outer layers is necessary, chemically tempered glass can be processed relatively thinly.

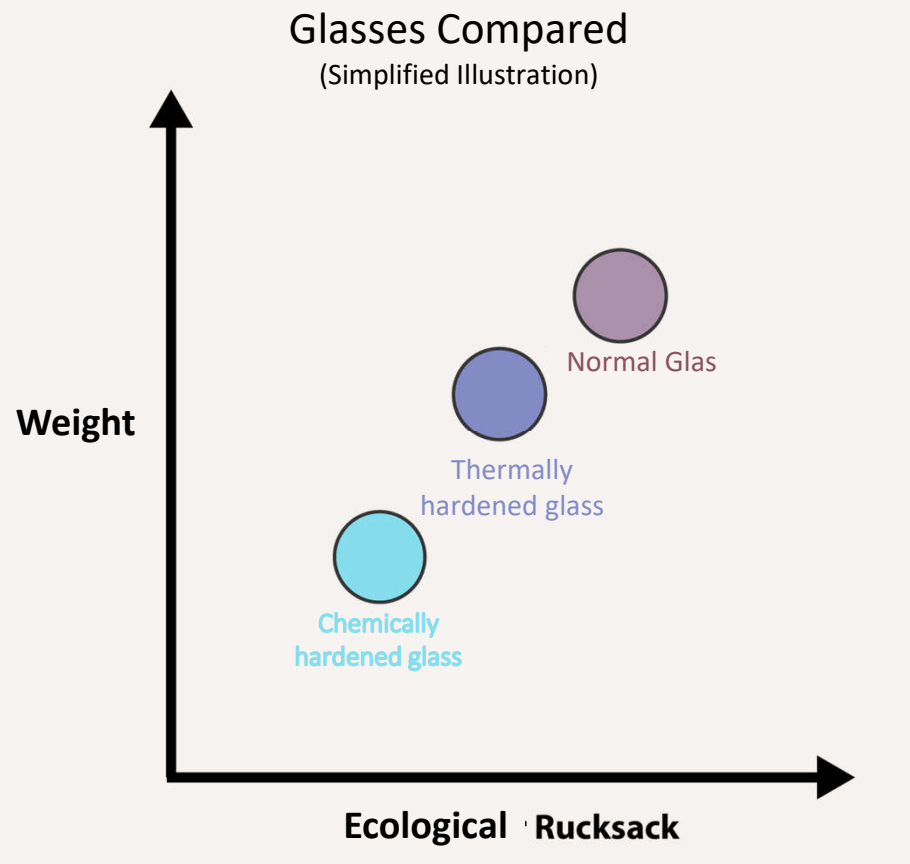
For the hardening of smartphone-glass, a similar process is used.

Particularly stable glass was available in the GDR with „superstrong" glasses

The chemically hardened "Superfest" glasses were available in every pub and household in the GDR. The manufacturing process was developed in the GDR at the end of the 1970s. At that time, they were looking for ways to make production more economical. The result was "Superfest" glasses, which were five times as hard as normal glasses and even survived falls from a height of 50 centimeters. Many of these glasses are still in use today. But like many things that drastically increase the service life of products - and would thus eventually lead to a saturated market - the process was not pursued further after the fall of the Berlin Wall, and all the machines were scrapped.

Interview with Dr. Dieter Patzig, chemist and inventor of Superfest glass

As noted by Dr. Patzig, the task in the GDR was similar to today's due to climate change: "(...) to produce raw material-saving, long-lasting glasses". The newly developed process consisted of spraying the drinking glasses formed by rotary blow molding at 430°C with potassium salt (degradable in Germany) instead of drawing them through a solution. In GDR times, 40,000 glasses per day were produced, which lasted up to 5 times as long as conventional pressed glasses. After 8 years of production until the end of the 80s, this meant that the market in the GDR was saturated. So then there was the idea to offer also chemically hardened packaging glasses, but this was never realized due to the reunification. Theoretically, anyone could revive this process, because the production is no secret: all patents are freely available online.



Energy-intensive glass production is worthwhile - but only in a reusable system

Like steel, glass is comparatively energy-intensive to manufacture: melting the input materials requires temperatures of over 1,000 °C.

As with stainless steel, however, the life cycle assessment of glass improves significantly if it is used long and frequently enough:

Chemically tempered glass therefore saves both material and energy:

(1) Hardening significantly extends the service life of the containers. They need to be produced again less frequently, which saves material and energy.

(2) As the glasses are more break-resistant, they can be manufactured thinner with the same strength. This also reduces the energy required for transport between the cleaning station, the catering trade and the consumer.

If, in addition, waste glass is used for production, the energy requirement is reduced a further time.

Break-resistant, relatively thin glass is a sustainable alternative to plastic take-away packaging and tableware

Research into glass technology for smartphones has led to rapid improvements in break resistance of glass over the last two decades: A wide variety of tempering processes and laminated glass materials have been developed.

The experience gained from these research fields should be used for the further development of take-away tableware made of break-resistant glass.

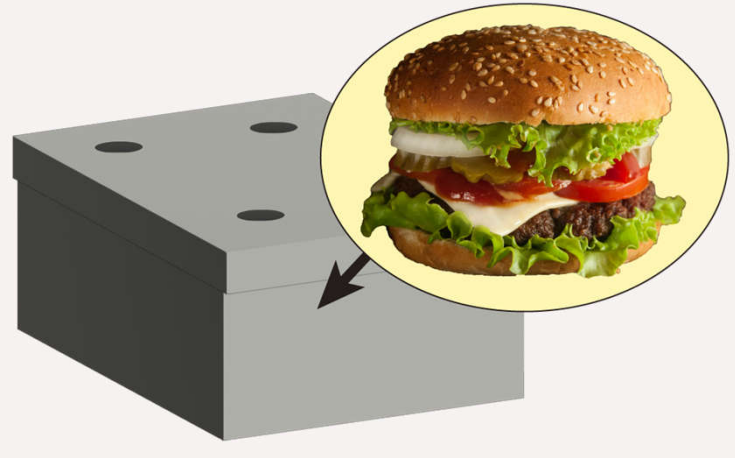
Transport, cleaning and other process energy can always be expended during the day when photovoltaically generated electricity is abundant. They are cleaned with the help of steam and UV radiation, i.e. with comparatively little water or detergent.

In addition, packaging made of lightweight, break-resistant glass or thin enamelled stainless steel fulfils another important criterion: Even if they end up somewhere in the environment, break or are disposed of incorrectly - they leave no microplastics behind.

The range of containers is so wide that there is a suitable one for every dish

For some dishes, you need containers with several compartments, for example, for Asian dishes, where the main course and rice should be kept separate. For noodle dishes, soups and the like, on the other hand, no subdivision is necessary. Containers with two or more compartments are made of metal because it is easier to shape than glass. Containers without divisions are made of glass.

For fried foods and for foods with special shapes, such as burgers, there will be cans made of metal that are modeled after the previous cardboard boxes in terms of shape. Holes in the metal allow heat and steam to escape. This keeps the food fresh.



And there are also special take-away packagings for special cases

What about pizza and Doner kebab? Pizzas will continue to be delivered in folding boxes. In the medium term, the aim here is to switch to materials with a better eco-balance than paper. For example, leftover cocoa shells could be used for the packaging. There is also a wide range of containers made from plant waste already on the market. These are food-grade and degrade completely.

Doner kebabs can still be packaged in aluminum foil, as the disposal concept of the Frankfurt Bridges also provides for metal separation. The aluminum is thus recycled.

Another important sustainability lever for take-away containers: Adapted portion sizes eliminate the need to throw away food and save resources

Another form of resource waste is leftovers that are thrown away because standard portions are too large for many people. Therefore, another requirement for restaurants on bridges is to offer small, medium and large portions at proportional prices. Without proportional pricing, it's easy to tend to buy too much because, after all, it only costs a little more. But carelessness results in waste: not only of food, but also of the energy used to produce and transport it.

Moreover, Take-away containers can be used in a variety of ways: unpackaged stores, for example, can also keep the containers on hand for their customers

Theoretically, the jars would also be ideal for home-cooked lunches on the go.

Efficiently designed reusable systems are the most sustainable solution – and convenient and fast return options are important aspects of consumer acceptance

Every catering business that offers food for direct consumption on the Frankfurt Bridges undertakes to participate in the bridge reusable system. According to the German government's amendment to the Packaging Act, vendors are to offer a "recyclable alternative" to all take-away packaging from 2023, anyway.

But many different solutions do not make the world any simpler. A uniform bridge-wide system therefore offers caterers and customers an environmentally friendly and resource-saving reusable system that is as simple as a single-use system.

Depending on the food and portion size, there are different reusable containers for the take-away area. Like any reusable system, the system on the bridges also works with a deposit.

But who wants to carry the coffee mug or dinner set back to where it was bought? Most of the time you would stroll on, look for a bench in a park or walk home with it.

Take-away packaging can be returned to 300 collection machines on the bridges

On the bridges, there are round collection machines about every 500 meters (in more densely built-up sections, every 50 to 100 meters). Beautifully designed on the outside (whether ultra-modern, baroque or fancy - in any case artistic), inside they all consist of "mini dishwashers" mounted in a rondel around the central axis of the cylindrical vending machine. Each vending machine has three such rondels inside, one above the other.

Correspondingly, each vending machine also has sliding windows on three levels, which open when the bridge card is scanned. Through the open sliding window, you can put the dirty reusable tableware into the "mini dishwasher". When the window closes, the filled "mini dishwasher" moves on, and the next (still empty "mini dishwasher" on the traffic circle) moves up. The deposit paid for the catering containers is credited back to the card. Everything can be viewed in an app.

Color-matched photovoltaic modules with battery island solutions are attached to the top of the vending machine so that the energy for operation can be partly drawn from it.

The collection machines are not installed, i.e. they are not connected to the bridge wastewater network, but only to the bridge power network. They are de facto dishwashers in the outdoor area, but they do not perform a complete cleaning, only a pre-cleaning.

Next to the collection machines are separate trash cans for leftover food, any bags that may be produced, etc. These trash cans are connected to the waste disposal pipes of the Frankfurt Bridges.

Rondell cleaning

The cleaning process begins on site in the collection machine

It will be possible to put the used take-away containers and tableware into small, separate mini dishwashers, which are self-contained units, because when the sliding window is opened, no other dishes with food remains must be seen or smelled.

Once a mini dishwasher has been filled with its containers, cutlery, glasses etc. through the window, the window closes, the mini dishwasher is moved one place further from the roundel (so that the next, still empty mini dishwasher comes to stand behind the sliding window) and then all take-away containers etc. in the mini dishwasher are briefly filled with hot steam and then irradiated with UV light to kill germs. The mini dishwasher carries the water for the steam with it and receives the electricity via contact surfaces with the electronics in the Rondell core.

This is not yet the actual cleaning, but merely serves to ensure that when the containers are collected and taken to central cleaning sites, they do not arrive there germ-ridden and fungus-ridden.

As soon as all the mini dishwashers have been filled in all three rondels of the machine, the collection machine sends a signal to a vehicle that -driving autonomously- comes and collects the three inner rondels: The easiest way to do this is to have half of the vending machine housing consist of doors that open, the rondel core together with the three rondels and their mini dishwashers is lifted by rotating trolleys and transported into the car, from which a new empty rondel unit comes and takes the place of the old one in the collecting vending machine.

The vehicle brings the rondel units to the railing of the FES, and after the containers have been centrally cleaned in accordance with regulations in a facility specially built there, they are returned to the catering trade on the bridges according to the quantities ordered.

The prerequisite: The consumer plays along and fills the mini dishwashers just like his own at home: without food leftovers or foreign objects - which the collection machine, however, also registers with sensors and can assign to the respective bridge card of the user - and, if necessary, books a fine via deposit deduction.

Food leftovers can be disposed of next to the roundels in bio-waste garbage cans connected to the pneumatic disposal tubes of the Frankfurt Bridges

There are cleaners on the bridges during the day - but bridge dwellers and residents, the expected large number of tourists and Park&Ride users from the Frankfurt area are likely to ensure an extraordinarily high volume of waste on the bridges that goes beyond take-away leftovers. It therefore makes sense to provide the bridges with a separation waste garbage can system connected to pneumatic tubes (located in or under the body of the bridges), as has already been implemented in Songdo/Korea and has also been designed for New York's Highline: There, a study commissioned by the NY Department for Transportation even considers connecting neighboring buildings to the "pneumatic waste disposal system".

Conclusion: A sustainable reusable system without plastic is created for takeaways on the bridges

Enameled thin stainless steel and more break-resistant, relatively thin - and thus also somewhat lighter - glass meet the criteria of the packaging regulations: properly treated and with the appropriate disposal process, they are definitely reusable. Stainless steel can be expected to last for several decades, while sturdy glass can be expected to last for years. At the end of their use cycle, both materials are easily recyclable.

Even though both materials are relatively energy-intensive to produce, the long service life means that the energy expenditure is recouped relatively quickly. If the containers are recycled, the energy balance is even better.

They also meet another important criterion: even if they end up somewhere in the environment, break or are disposed of incorrectly - they leave no microplastics behind.

Old New Territory
Frankfurt

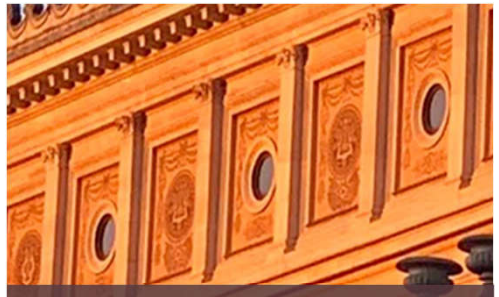

Supermarket and drugstore


Packaging - suitable for the product

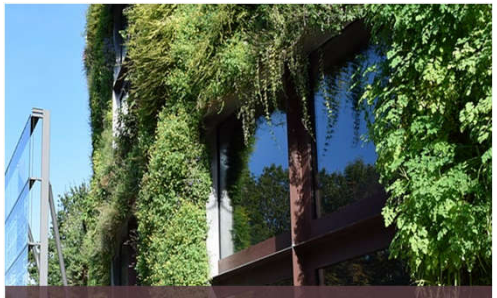

Packaging variety desired


Shopping in the future


Circulation system & refund


The Master Academy

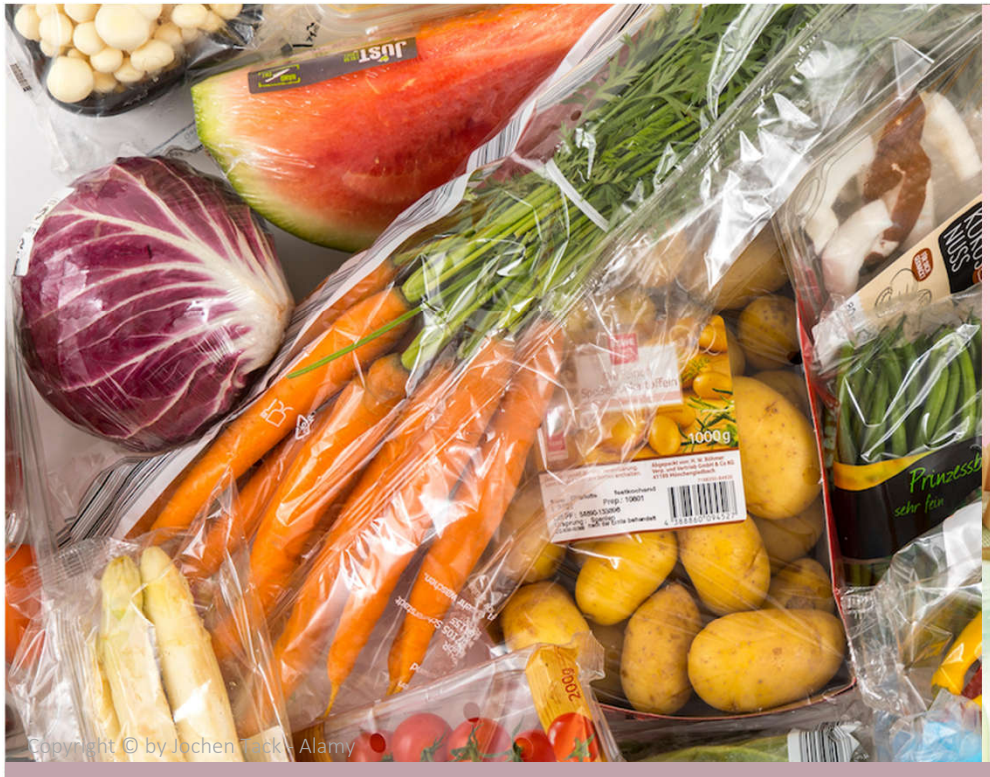

Special quarters


The green metropolis of the future

TEAM MEMBERS

Architecture	Geoinformation	Urban climate - world climate	Water	Law	**Critical sparring partners:**
Image & photo	Green & Nature	Statics	Packing	Finance	Professors
Bridges	Communication	Transportation	Webpage & Design	Implementation	Inspirers & Supporters
Energy	Art & Culture	Technology & IT			

Supermarket and Drugstore



The biggest challenge with many packages: Weight, hygiene and durability requirements - solvable by reducing the multitude to one plastic.e biggest challenge with reusable packaging: Weight, hygiene and shelf life requirements

For many food and drugstore products, reusable packaging made of break-resistant glass or stainless steel is also available on the Frankfurt Bridges. For particularly lightweight products or those for which glass or stainless steel packaging is unsuitable, the plastic alternative bio-based polyethylene is provided: Here, the large number of plastics used is reduced to one, the combustion of which produces only water and CO2, the latter in such a pure form that it can be reused industrially – since a mixture of plastics once incinerated, produces too many combustion products, thus making the clear separation and reuse of CO2 impossible. And polyethylene fits all: It can be used to produce all forms of packaging, from films to hard shells, and it can also be made from renewable raw materials.

Content: The solution to the packaging problem must combine different approaches - unpackaged, reusable and (ecologically immaculate) disposal

1. Products that do not necessarily require end-user packaging are left unpackaged.
2. Reusable glass and wafer-thin stainless steel packaging is used for all food and drugstore products for which it is suitable.
3. Residual materials from the processing of agricultural products are used for sustainable packaging - so that no new cultivation areas have to be created, but instead existing CO_2 -binding plant residues are put to good use.
4. For many products, however, plastic packaging is necessary for reasons of hygiene and durability. On the Frankfurt Bridges, therefore, there is also plastic packaging, but its variety is reduced to input materials so that even in the event of disposal by incineration, the CO_2 is released in the process in such a pure form that it can be collected with a standard filter and used as a manufacturing agent for further production processes.

Only when the variety of packaging materials is limited to a few materials can each remaining packaging-form reach a scale that enables economies of scale and thus sustainability

The world of packaging is almost impossible to grasp: It is extremely diverse and confusing. So far, the easiest option has therefore been to incinerate the majority of packaging: Because re-use, recycling and disposal processes for so many different materials have a correspondingly low throughput, so that the economies of scale that would be necessary to save resources and energy cannot be achieved. The answer to the problem: The complexity of the materials must be reduced - then the individual processes, whether re-use, recycling or disposal, will result in a significantly higher throughput per process, making the system more sustainable.

However, the reduction must be differentiated and take into account that different product groups have different packaging requirements. Unfortunately, there is no single "super material" that can replace all current packaging materials in one fell swoop.

Previous approaches to solving packaging problems in supermarkets and drugstores are unsatisfactory

Most of our food and drugstore products are packaged in single-use plastic. Once used up, the plastic packaging is found in the waste garbage can.

Just under 19 million tons of packaging waste was generated in Germany in 2018 - in the year 2009 it was still 15 million tons, according to statistics from the German Federal Environment Agency. Most of the household waste is incinerated. Only 16% of it was recycled, according to a 2017 study by market research institute Conversio.

According to a 2020 statement by NABU (the German Nature and Biodiversity Conservation Union), thermal waste treatment plants in Germany emit more than nine million metric tons of CO_2 equivalents.

There are good approaches, but they all have certain disadvantages:
(1) Recyclable plastics do not completely solve the problem of energy and resource consumption, because mostly true recycling is only possible in parts - the largest part is lost to downcycling.
(2) Bioplastics: Most are not biodegradable with reasonable effort or if biodegraded they shed microplastics.

One valid approach to solving this problem, which is also being promoted on the bridges, is unpackaged stores: however, their concept is not suitable for all products in terms of hygiene and shelf life.

A sustainable reusable and disposal system will therefore be created on the Frankfurt Bridges, using robust glass, enameled stainless steel, plastics that can be incinerated without leaving residues, and packaging materials that are completely biodegradable with low energy consumption. This system can be successively transferred first to the area surrounding the Frankfurt Bridges, then to all of Frankfurt, and then to other cities.

Today, resources and energy spent on disposable packaging literally end up in the garbage can - full recycling is rarely possible

Even if part of the valuable material plastic is recycled: Most plastic packaging is so heterogeneous and multi-layered that a recycling process with separation into recyclable components is far too costly or simply impossible.

Even the reusable plastics usually undergo downcycling rather than recycling because they are no longer suitable for food contact. This means that no new food packaging can be made from them, but rather more undemanding products such as doormats and flower pots.

The positive core idea of recyclable packaging is therefore retained on the Frankfurt Bridges in a more sustainable way: Glass is 40% recyclable, stainless steel even completely.

Bioplastics are often deceptive, as many of them can also release microplastics

Even packaging certified as compostable is not straightforward. The label "compostable" is often misunderstood, as these products do not decompose in home garden compost, but only in industrial plants under certain circumstances.

In addition, polymers classified as compostable only have to decompose to 90% into parts smaller than 2mm (see EN 13432). So there are always small particles left over.

This 3-month process also devours energy, since the mass to be composted must be moved and certain temperatures must be maintained, which places a massive burden on the ecological rucksack.

If such "compostable" packaging ends up in nature, in landfills or in bodies of water, they decompose, if at all, releasing microplastics.

There is often a call for a return to earlier shopping processes - but the demands in supermarkets and drugstores are higher than they used to be in corner stores or markets

While take-away packaging has a life-cycle-time of a few hours, supermarket packaging in particular needs to protect food throughout the supply chain and eliminate any deterioration.

It is therefore difficult to shop as we used to in the corner store: a large part of our food still has to endure too long transport routes and is not regional.

Shopping habits and demands on food are also constantly changing: While visits to restaurants used to be the exception, today we cook much less ourselves.

Moreover, in the past, vegetables were bought and eaten when they were already a little limp or wilted, but today we want everything spotless and crisp and fresh.

Uncontrolled omission of packaging would lead to wastage of food and thus of raw materials and energy

By keeping food fresh and preventing it from spoiling, packaging plays a key role in reducing CO_2 emissions:

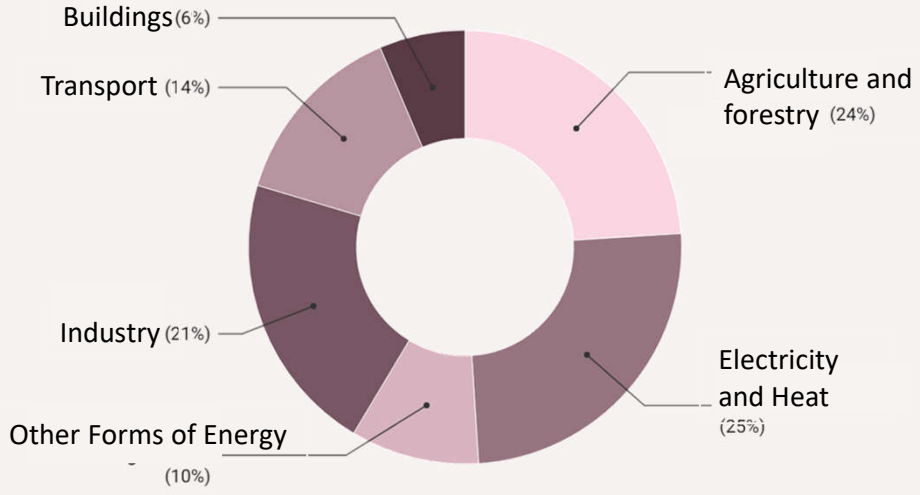
Agriculture accounts for almost 20% of global CO_2 emissions. This does not include the energy used to transport the food, which also has an impact.

All food that is thrown away because it no longer meets our requirements has been produced for nothing and has polluted the environment with $CO_2$for nothing.

Therefore, packagings are not per se a wasteful component of our modern life – in fact, adequate packaging of food can save large amounts of agricultural land, fertilizer as well as methane and CO_2 emissions.

CO2 emissions from agriculture

Share of global annual C02 emissions per industry



Erstellt mit Datawrapper

Climate Gas Emissions

The agricultural sector is one of the most important sources of anthropogenic greenhouse gas emissions today.

It is estimated that around one third of global greenhouse gas emissions are due to food production (IPCC 2021, Nature Food 2021). They result from land-use change through the conversion of forests to cropland and pasture, as well as from the draining of peatlands and the burning of biomass. Transportation, waste management and industrial processes also contribute.

The unpackaged stores therefore have a selected range of products that tolerate sales processes without packaging

Unpackaged stores are proliferating, expressing society's willingness to change profound patterns of convenience. But to do so, customers must be willing to bring their own containers to the store for certain products. This works for the portion of people who consciously store at unpackaged stores. But the question is: Does it also work on a large scale? If you want to switch to the system of today's unpackaged stores, you first have to plan exactly in advance, and second, you still have to go to the supermarket for all refrigerated or canned products. So you have to be willing to invest some time and say goodbye to spontaneity for a bit.

Offerings without packaging have nowadays been discovered by life style providers

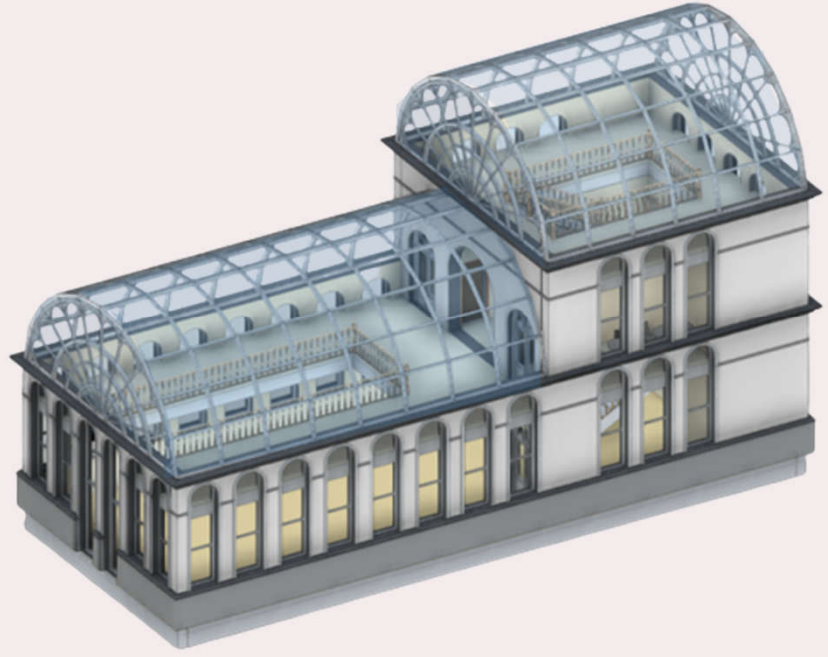
In the area of drugstore products, too, there are more and more offers without packaging.

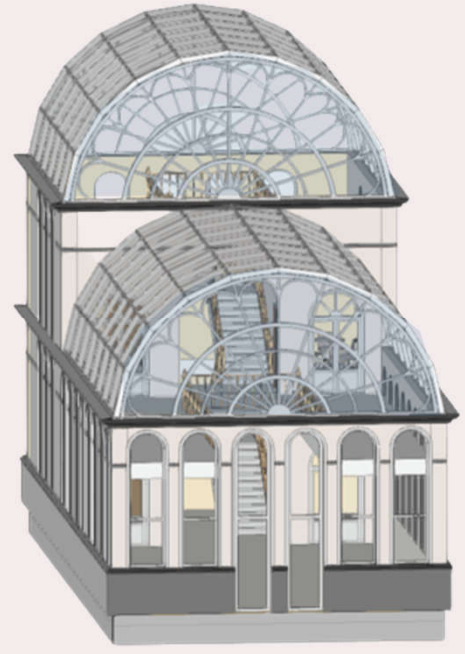
This clearly shows the interest in society and the willingness to buy unpackaged products.

To promote unpackaged products, there are market halls on the Frankfurt Bridges with stands for sellers from the region

The shorter the delivery routes, the less packaging is needed. For this reason, special market halls on the Frankfurt Bridges are reserved for products from the region or production communities from the surrounding area.

Market hall on the bridges for products from the region, urban gardening, or even allotment harvests





The next best packaging option: a reusable system in standard containers

Organic supermarkets in particular are moving towards offering environmentally friendly reusable glass packaging for typical unpackaged products - because self-filling is time-consuming for many customers or is perceived as unhygienic.

However, if the products are "packaged," you can take them right off the shelf, you don't have to fill and weigh them, and you can be sure that they have not been contaminated before reaching the shelf.

From the consumer's point of view, however, the usually heavier reusable packaging primarily has the weight disadvantage. The need to transport them back also affects the purchasing process.

Reusable tempered glass and enameled stainless steel packaging works for many supermarket products

Supermarkets already have glass and metal packaging - but most of them are not reusable: Weight and return costs often make buyers shy away, while transport and cleaning costs also make it a costly solution for food manufacturers.

Special glass packaging is therefore used on the bridges: Chemically hardened, shatterproof glass allows glass containers to be made much thinner while retaining the same strength. This makes the jars lighter. The thinner glass also saves energy during transport, as with the take-away lightweight glass containers, and significantly reduces the weight in the shopping basket.

Metal containers are also potentially reusable. In contrast to today's classic metal cans, the Frankfurt Bridges packaging system uses standard containers made of enameled stainless steel for supermarket products, which are fitted with a screw cap. This means that the can does not have to be destroyed in order to be opened - as is the case with today's cans - but is reintroduced into the cycle. Only when it is no longer fit for use is it recycled.

If enough suppliers use the same standard containers, the transport costs for the return transport of used packaging will decrease significantly due to the possible logistics optimization.

As with all reusable concepts, a deposit system ensures that the containers are returned. Either via a Renomat garbage can, which is located like the yellow garbage can at the bridge houses, or directly at the supermarket.

The efficient reusable system on the bridges: reduction of complexity with a large selection of container sizes and shapes at the same time

Different products from different manufacturers can be filled into the same standard containers. These are available in different size gradations, so that suitable sizes are always included for the most diverse products - for example, only very small containers are suitable for ginger shots, while fruit juices are usually requested in containers of over 100ml.

This means that empty packaging can be returned flexibly and interchangeably to all manufacturers connected to this system. This enables significant logistics optimization for the return transport routes of the reusable packaging. In addition, trucks from manufacturers delivering goods can always return with empty, pre-cleaned returnable packaging.

When it comes to packaging selection for drugstore products, ensuring hygiene and light weight is the biggest challenge

Similar to food in the supermarket, there are items in the drugstore that could do without packaging, such as brushes, hand mirrors or even bars of soap.

However, cosmetic as well as medical products require packaging, as certain hygiene standards must be met. The same applies to hygiene products such as tampons or pads.

While the more break-resistant glass packaging described in the chapter "Take-away packaging" could be provided for creams, this material would be too heavy in relation to the product weight for many other items (kitchen rolls, etc.).

Flat tinplate jars can be used for many cosmetic products such as mascara or lip gloss.

For food packaging, shelf life is the biggest challenge

In the supermarket, most food groups require packaging to maximize shelf life: Packaging protects them from germs on the one hand, and from being damaged on the other. This is important, for example, for sensitive foods such as sausage or raspberries.

But packaging also prevents foods such as lettuce, broccoli and other vegetables from drying out and wilting, or conversely, "sweating," as with mushrooms.

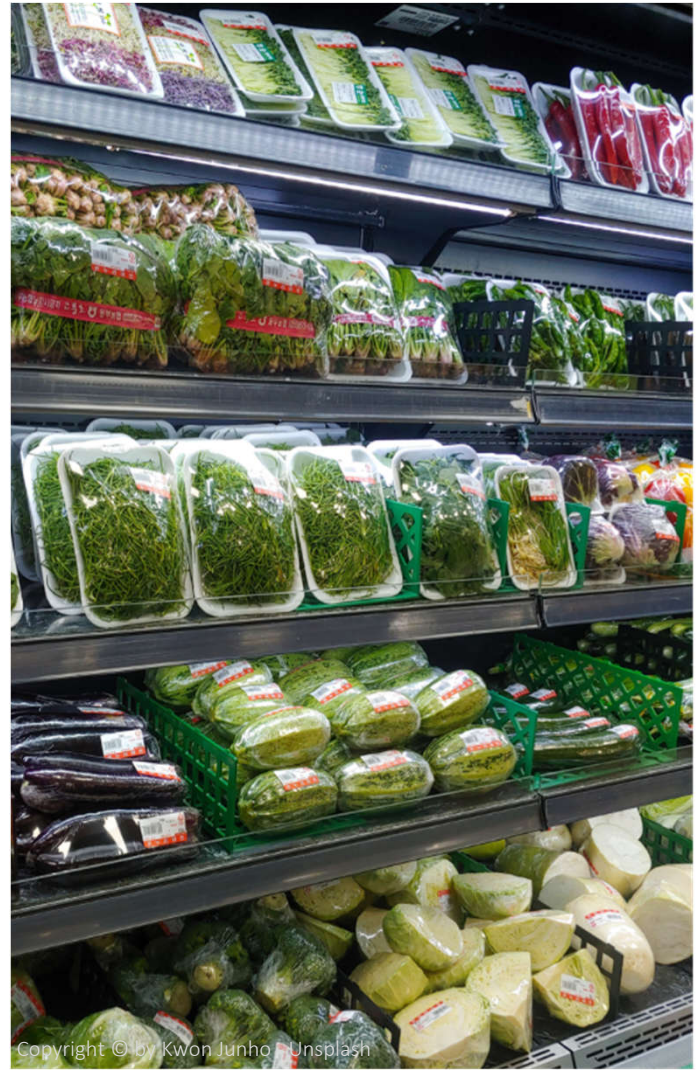
Sometimes packaging is also necessary to prevent the food from oxidizing. For example, meat and fish are therefore often vacuum packed or packaged in a modified atmosphere. Crispy products such as chips must also be packaged in an inert gas atmosphere. This prevents these foods from drawing water and thus losing "crispness" or flavor.

Packaging is therefore not bad per se - on the contrary: by preserving shelf life and hygiene standards, it indirectly contributes to making consumption more sustainable overall.

Especially in the case of food, many products have very specific requirements for their packaging

1. Protection against mechanical injuries (pressure marks, bruises): especially with sensitive fruits and vegetables, pressure marks result in reduced shelf life.

2. Protection from chemical processes and metabolic processes in plants:
   I. Transpiration: In leafy plants, such as lettuces, water evaporation occurs as a result of natural processes in the plant. This occurs via specially adjustable openings on the underside of the leaves. The process is influenced by temperature as well as humidity. To prevent dehydration and thus reduce food waste, packaging is necessary that keeps the humidity around the product relatively constant and thus reduces transpiration.
   II. Respiration and metabolic production: fruits whose skin (their natural protection) has been damaged start fermenting. In the case of mushrooms, anaerobic respiration occurs without packaging, which leads to changes in taste and odor and faster spoilage. More precisely, sugar, that oxidized to CO_2, consumes oxygen in the process and water is released at the same time.



3. shelf life through vacuuming

Removing air not only reduces reactive gases on the food, but also preserves nutrients. Fresh meat, for example, is increasingly being vacuumed. It contains the purple pigment myoglobin. This would oxidize to oxymyoglobin (bright red dye) by an increased concentration of atmospheric oxygen.
By oxidizing the iron II ion to the iron III ion, metmyoglobin is formed. As a result, the meat then exhibits a gray-brown color. (DLG.org) This process can be prevented by vacuuming or a protective atmosphere.

4. simply keeping contaminants out of the environment

There are many influences in the environment that cause food to spoil more quickly, for example germs that cause a cold cut to spoil. Tight packing or vacuuming can provide a remedy.

5. shelf life through protective gas atmospheres

Here, the gas inside the food packaging consists of various gas components such as carbon dioxide, nitrogen and oxygen. These have various functions such as inhibiting oxidation processes and the growth of aerobic bacteria (CO_2 and N_2) and inhibiting growth for anaerobic microorganisms (O_2). A distinction is made here between different compositions.

I. **Controlled Atmosphere:** Enrichment with nitrogen and displacement of oxygen. Not used in sales, but mainly for long storage of fruit or vegetables.
II. **Modified Atmosphere:** Different gas mixtures depending on the product. For example, to keep baked-on rolls as long as possible and prevent mold, an inert gas atmosphere is introduced into the packaging. Nuts, on the other hand, require an inert gas atmosphere of nitrogen, otherwise they quickly go rancid due to their high fat content. In the case of dairy products such as cheese or yogurt, nitrogen or carbon dioxide is also added to the product as an atmosphere.
III. **Equilibrium Modified Atmosphere (EMA):** Atmosphere in which gas exchange is possible. This is mainly used for fruit and vegetables, as the product's own respiration must be taken into account. Therefore, the packaging film is micro-perforated, which allows gas exchange between CO_2 and O_2 and thus better shelf life and longer freshness. Strawberries or mushrooms are an example of this.

Plastic is required for the packaging of some products due to shelf life requirements, weight reasons or due to the product shape

Reusable jars and cans are suitable for all foods that adapt their shape, such as jam or yogurt, rice, beans or even butter. However, glass jars and metal cans are not ideal for everything: Cold cuts or cheese as well as fruits and vegetables cannot be packed in them.

They are also not suitable for frozen products, nor for finished products prepared in their packaging (e.g. in oven or microwaves), as extreme temperatures can have a negative effect on the extremely thin glass or metal.

Other products, on the other hand, require plastic to be vacuumed or to ensure gas exchange through special microperforations.

For bulky drugstore products such as toilet paper, correspondingly large packaging made of glass or metal would be too heavy in proportion: for some such products, uncoated, and thus easily recyclable, paper packaging is the solution, but for all moisture-containing products in the drugstore, this option is also eliminated.

Conclusion: To meet all the requirements of a modern food and drugstore market, there is indeed still a need for a packaging material other than metal or glas – a material with the properties of plastic.

The plastic of choice: bio-based polyethylene (PE)

To minimize the damage potential of plastics, they should:

1. not be produced from scarce or regionally limited resources (i.e. not from petroleum, for example), but should preferably be able to be produced from renewable raw materials.
2. be recyclable or at least suitable for downcycling.
3. emit neither microplastics nor pollutants nor unfilterable (i.e. contaminated with residues) CO_2 during disposal.

In addition

1. combustion does not produce any substance that cannot be easily filtered out.
2. the plastic must be suitable for food, ideally also for acidic products.
3. the plastic must be approved for food contact under German food law.

Polyethylene (PE) is one such plastic. It is already used as a packaging material in the food industry for both robust hard plastic packaging and film packaging.

Polyethylene can be made from renewable raw materials such as sugar, starch or cellulose, or even from waste products such as food scraps or peels. If it is burned in a single-variety process, only CO_2 and water are produced. The CO_2 can be captured and taken out of the cycle or even used for other chemical manufacturing processes.

Polyethylene made from renewable raw materials is therefore primarily used for films and plastic packaging on the Frankfurt Bridges. By limiting the packaging of all items requiring plastic in the bridge stores primarily to the one plastic PE, it is possible to incinerate it by type - unlike the large number of plastics that end up in the yellow garbage can today.

PE can be produced from renewable raw materials

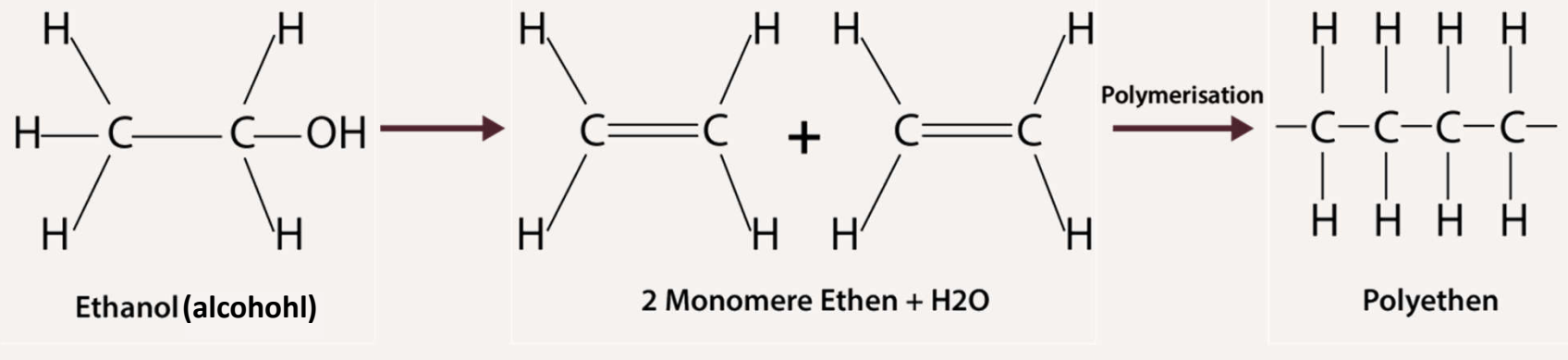
Polyethylene can be produced from renewable raw materials such as sugar, starch and cellulose, or from waste products, such as peels, which are produced during the production of food.

However, this also applies to polypropylene, the second widely used plastic for food packaging, although it has other disadvantages (see below).

Made from Cane Sugar: $C_{12}H_{22}O_{11}$

or from Ethanol : C_2H_5OH

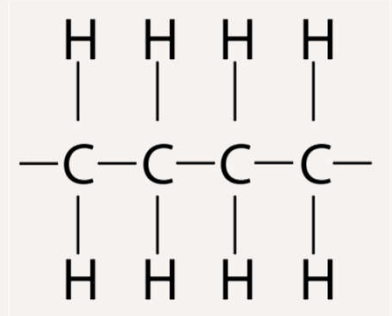
Ethanol can be produced by yeasts, fungi and many other processes, e.g. in nature by fermentation of ripe fruit.



The combustion of pure PE produces only water (H2O) and carbon dioxide (CO2)

The emphasis is on "pure", because polyethylene is not the same as polyethylene: Rather, the same PE must always be taken so that CO_2 and pollutants (mostly due to additives) can be tapped schematically and thus without gaps during managed combustion. Only then will only CO_2 and H_2 O be produced. In very small quantities, the combustion products of additives are also released, which must be added to all plastic packaging. But here, too, the number can be significantly reduced through standardization.

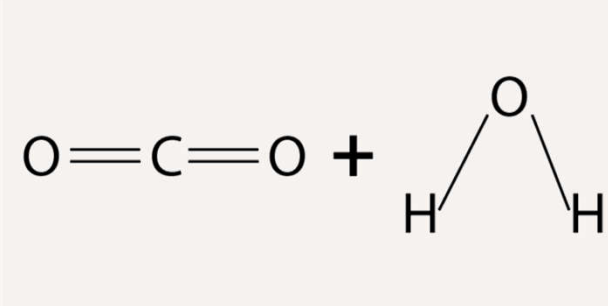
If CO_2 is filtered out in (almost) pure form using standardized processes, it can be used for other biological-chemical processes, for example algae farming (but requires large "lakes") or for the production of other plastics such as polyhydroxybutyric acid (PHB) or artificial photosynthesis.



Polyethylen

Heat O_2 (oxygen)

$n*(CH_2) + 3n*O \rightarrow n*CO_2 + H_2O$

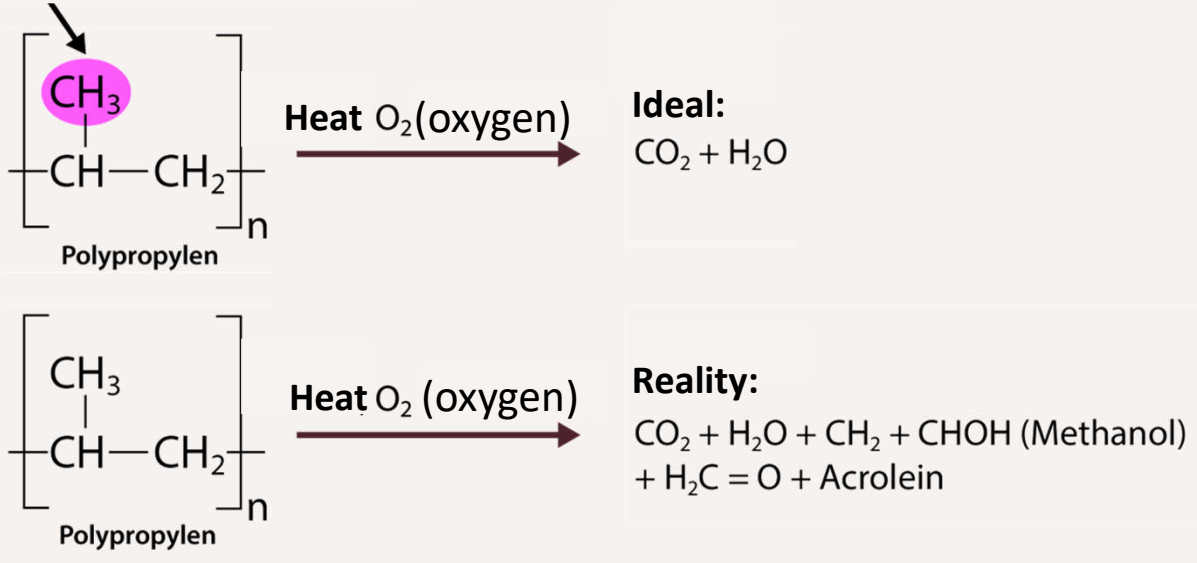


Carbon Dioxide + Water

The incineration of polypropylene (PP), on the other hand, gives rise to numerous by-products

Polypropylene (PP) is used in many take-aways and canteens because it is robust and food safe. PP has comparable properties to polyethylene (PE), but there are disadvantages when it comes to thermal recycling due to by-products: Combustion gases produced during incineration contain mainly carbon monoxide and dioxide, also in small proportions and, depending on the fire conditions, lower hydrocarbons, alcohols, formic acid, acetic acid, formaldehyde and acrolein, benzene and others.

Problems with the incineration of PP arise from the side chains, as the incineration does not always function cleanly.



In addition to PE, only those plastics are included in the bridges' packaging range that can also be produced from renewable raw materials, can be incinerated with low CO2 emissions or for which a miroplastic-free disposal can be guaranteed

The range of plastic packaging must be reduced to those plastics that can be incinerated without releasing CO2 emissions: However, this is only possible if pure CO2 is produced during incineration, because only this can subsequently be used in other chemical processes or bound in a standardized manner.

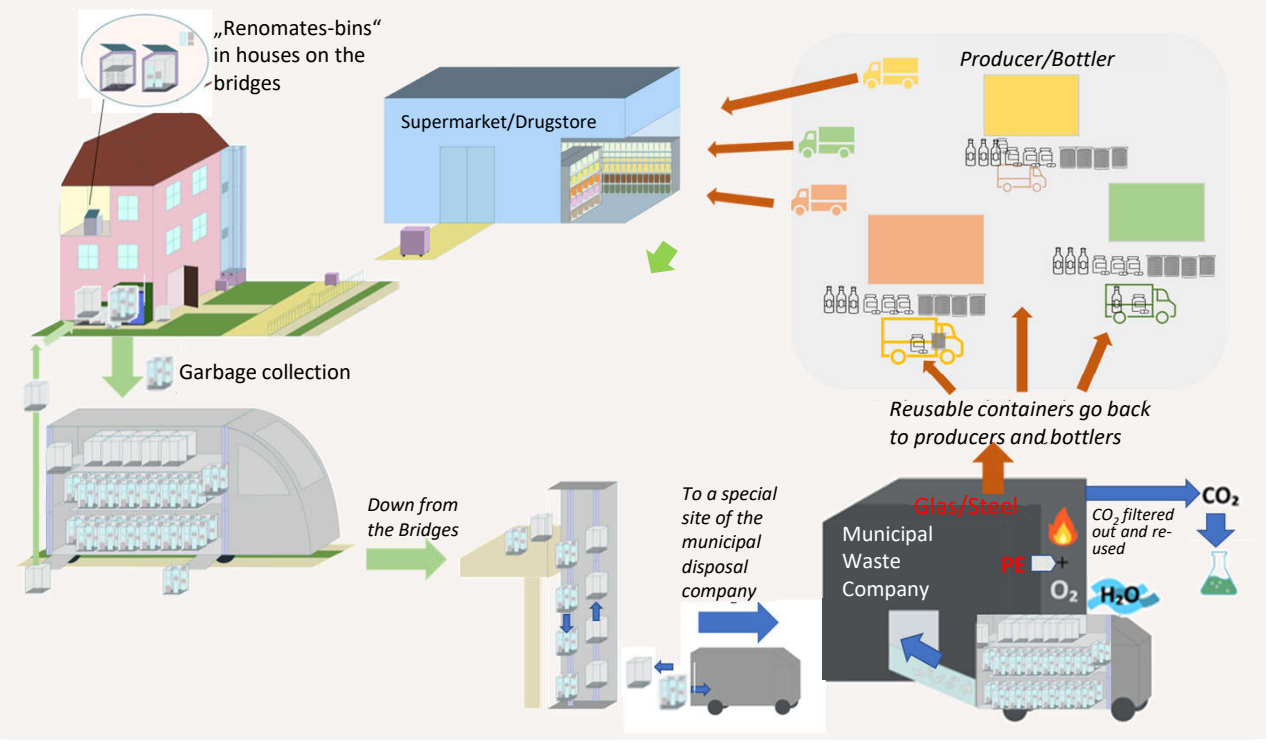
In addition, there are plastics that can be degraded without leaving residues, i.e. can be disposed of in the organic waste garbage can. It is important here (1) that they are really degradable without leaving residues and not only under laboratory conditions, i.e. they decompose completely without leaving microplastic residues. Furthermore, it must be ensured (2) that their biodegradation process is not energy-intensive or that they decompose in a composting plant within a reasonable period of time without the need for costly microcultures to be grown, tempered and continuously renewed etc.

Plastic	PE	Polyvinyl alcohol (PVA)	Biobased polymer
Manufacturing material	Residues of renewable raw materials	Fossil-based raw materials	Residues of renewable raw materials
Disposal by incineration with CO_{2}- filter	Burns without residue to water and CO2	Burns without residue to water and CO2	Burns like plants
Disposal in the organic waste garbage can		**Only in aqueous environment** Microplastic-free biological degradable	Microplastic free organic degradable

The recycling of PE can be seamlessly integrated into the circulation system on the bridges

After the PE packaging is separated from other packaging materials, it is incinerated. As long as the PE was produced cleanly, only CO_2 and H_2O (water) are produced during this process. The energy produced during the incineration process can be further utilized. The CO2 is captured with special filters so that it does not enter the atmosphere. It can be recycled in various ways, e.g. in the protective atmosphere of certain products, but also in the chemical industry.

The process has to follow stirct rules: Because if the PE were to be stored in open landfills - as many plastics are today - the gas methane would be produced, which stores 25 times more heat in the atmosphere than CO_2 .



Schematic illustration of packaging disposal or recycling

The three types of packaging (made of glass, metal or PE) are collected from the houses on the bridges, transported to the municipal waste disposal company, where they are either incinerated in a managed manner (PE) or cleaned and returned to the producer to be refilled and returned to the supermarket (Glas & Steel).

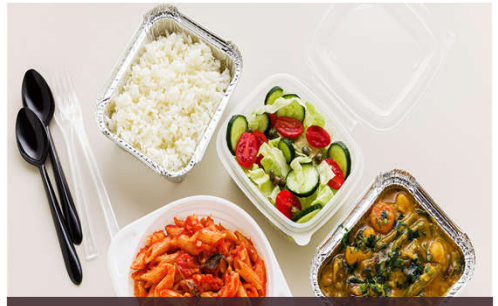
Conclusion: Reducing complexity is the goal of packaging material selection with regard to the disposal process

We have to find the right shape for all products: Unpackaged wherever possible, and standard glass and standard metal containers as a reusable solution when it suits the product.

All products that do not fall under this , but are made significantly more durable with plastic packaging, should actually be packaged with plastic for sustainability reasons to avoid throwing away food.

The single-use disposal of plastic is less problematic if it has been produced from renewable raw materials (i.e. CO2-neutral) and can either be disposed of in the organic waste garbage can without the risk of microplastics or, like bio-based PE, produces such pure CO2 when incinerated that it can be used in downstream processes to manufacture other products and is not emitted into the air.

Old New Territory
Frankfurt



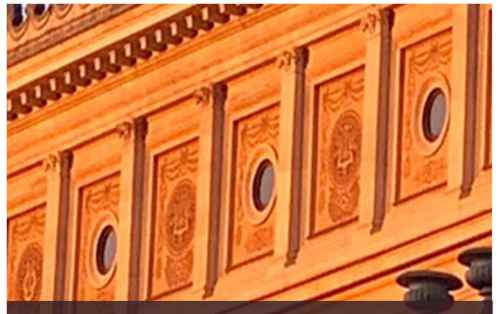
Putting an end to plastic takeaways

Packaging - suitable for the product

Packaging varitey desired

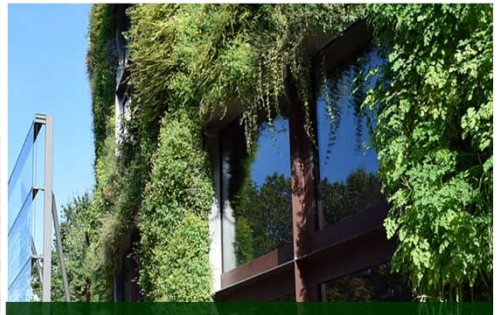
Shopping in the future

Circulation system & refund



The Master Academy

Special quarters



The green metropolis of the future

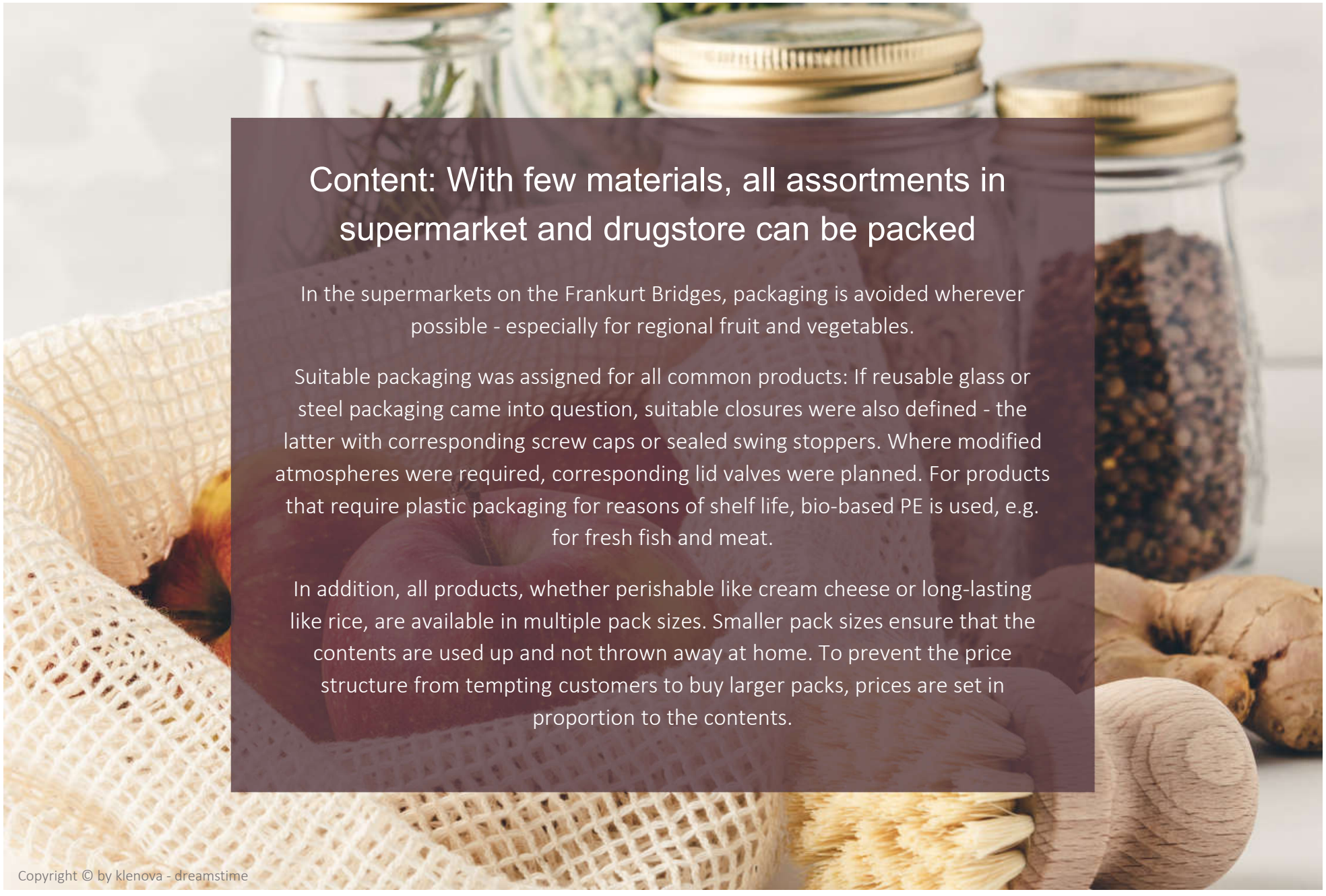
TEAM MEMBERS

Architecture	Geoinformation	Urban climate - world climate	Water	Law	**Critical sparring partners:**
Image & photo	Green & Nature	Statics	Packing	Finance	Professors
Bridges	Communication	Transportation	Webpage & Design	Implementation	Professionals
Energy	Art & Culture	Technology & IT			Inspirers & Supporters

Packaging - Suitable for the Product

Packaging and closures have been defined for the most important product groups in drugstores and supermarkets on the Frankfurt Bridges

Exemplarily, it has been defined for the most important drugstore products and foodstuffs in the supermarket which packaging is best suited with which closure. In addition, there will be significantly more packaging sizes on the Frankfurt Bridges: This is because food is often thrown away primarily because packaging is too large and contents are not used up before the expiration date. This represents a major environmental burden.



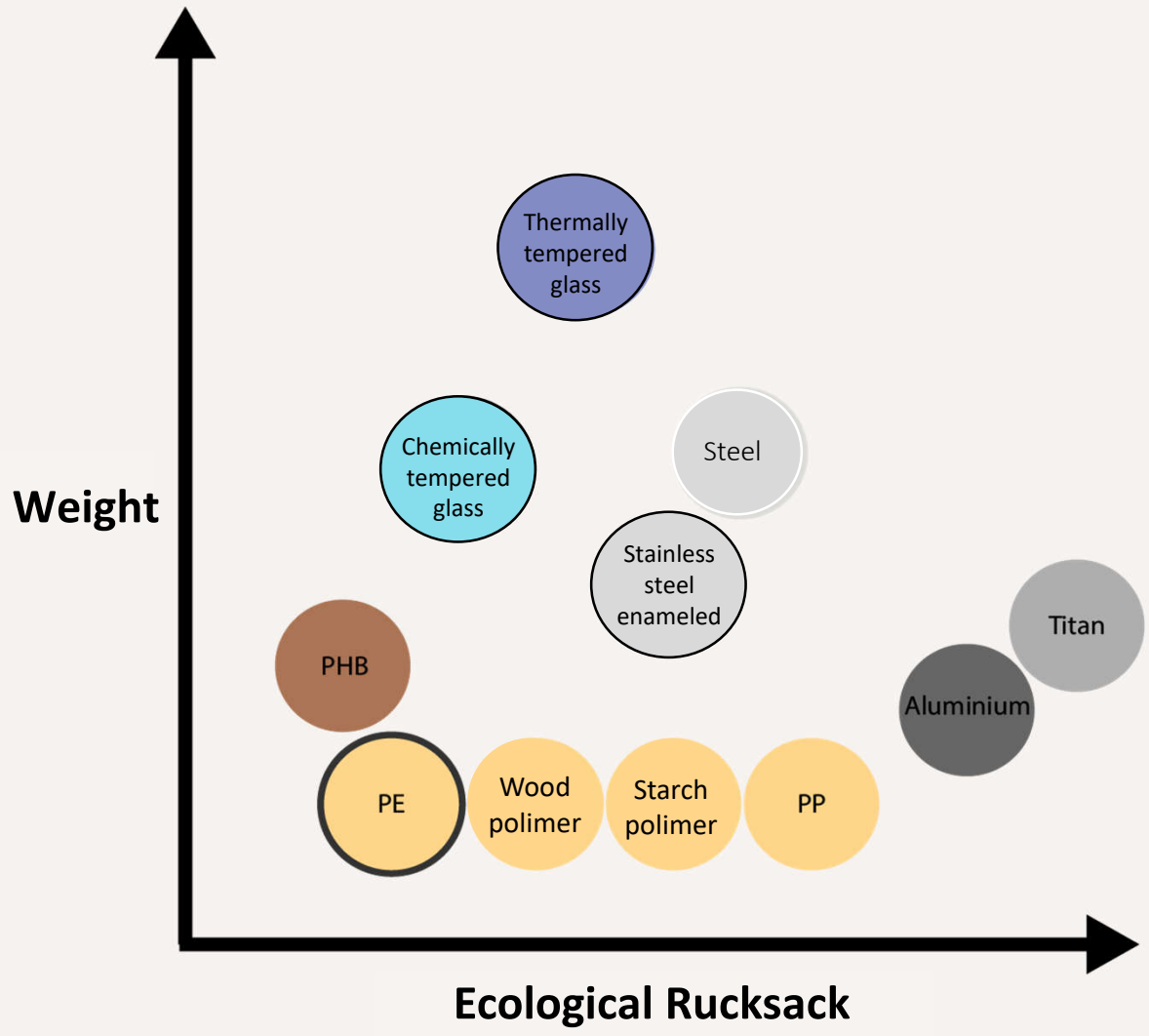
Content: With few materials, all assortments in supermarket and drugstore can be packed

In the supermarkets on the Frankurt Bridges, packaging is avoided wherever possible - especially for regional fruit and vegetables.

Suitable packaging was assigned for all common products: If reusable glass or steel packaging came into question, suitable closures were also defined - the latter with corresponding screw caps or sealed swing stoppers. Where modified atmospheres were required, corresponding lid valves were planned. For products that require plastic packaging for reasons of shelf life, bio-based PE is used, e.g. for fresh fish and meat.

In addition, all products, whether perishable like cream cheese or long-lasting like rice, are available in multiple pack sizes. Smaller pack sizes ensure that the contents are used up and not thrown away at home. To prevent the price structure from tempting customers to buy larger packs, prices are set in proportion to the contents.

The most important supermarket and drugstore products have been assigned packaging together with closures



Different materials were studied and ranked in terms of weight as well as ecological backpack in order to make the most sustainable and convenient choice for the consumer.

The reduced range of materials for the packaging containers on the bridges includes chemically tempered glass and thin stainless steel, as well as polyethylene (PE) for those products for whose protection or shelf life a plastic is absolutely necessary.

Appropriate packaging material options and closure types have been defined for common drugstore items

Product	Main packing	Closure	Form	Special valve	Comment
Disinfectant	Glass	Tinplate	Small bottle	Lid closes completely	Contains ethanol, may evaporate if incorrectly packaged
Hair oil	Glass	Tinplate	Small bottle		
Baby oil	Glass	Tinplate	Small bottle		
Liquid conditioner / shampoo	Glass	Tinplate	Crucible		
Toothpaste tablets	Glass	Tinplate	Crucible		
Foundation	Glass	Tinplate	Crucible		
Dishwasher tabs	Glass	Tinplate			
Various cleaning sprays	Glass	PE attachment			
Plaster	Glass	Tinplate			Medical device
Hairspray	Tinplate	PE attachment	Spray can		Gas atmosphere under pressure
Hair mask	Tinplate	Tinplate	Crucible		
Body lotion	Tinplate	Tinplate	Crucible		
Shaver	Tinplate	Tinplate	Can for storage		
Sunscreen	Tinplate	Tinplate			
Face cream	Tinplate/ Glass	Tinplate	Crucible, flat		
Hand cream	Tinplate	Tinplate	Crucible		
Deodorant container	Tinplate	Tinplate	Oval cylinder		Deodorant container for refilling
Mascara solid	Tinplate	Tinplate	Crucible, flat		
Lip gloss	Tinplate	Tinplate	Crucible, flat		
Deodorant piece	Wood polymer		Oval cylinder for insertion		Refill for deodorant container
Solid bar of soap shaving foam	Wood polymer				
Solid bar of soap hand dishwashing liquid	Wood polymer				
Solid soap bar hand soap	Wood polymer				
Solid bar of soap shampoo	Wood polymer				
Solid soap bar rinse	Wood polymer				
Washing machine powder	Cardboard box				
Dishwasher salt	Cardboard box				
Dishwasher powder	Cardboard box				

All food products have also been assigned suitable packaging: made of robust, lightweight glass, enameled stainless steel or bio-based PE

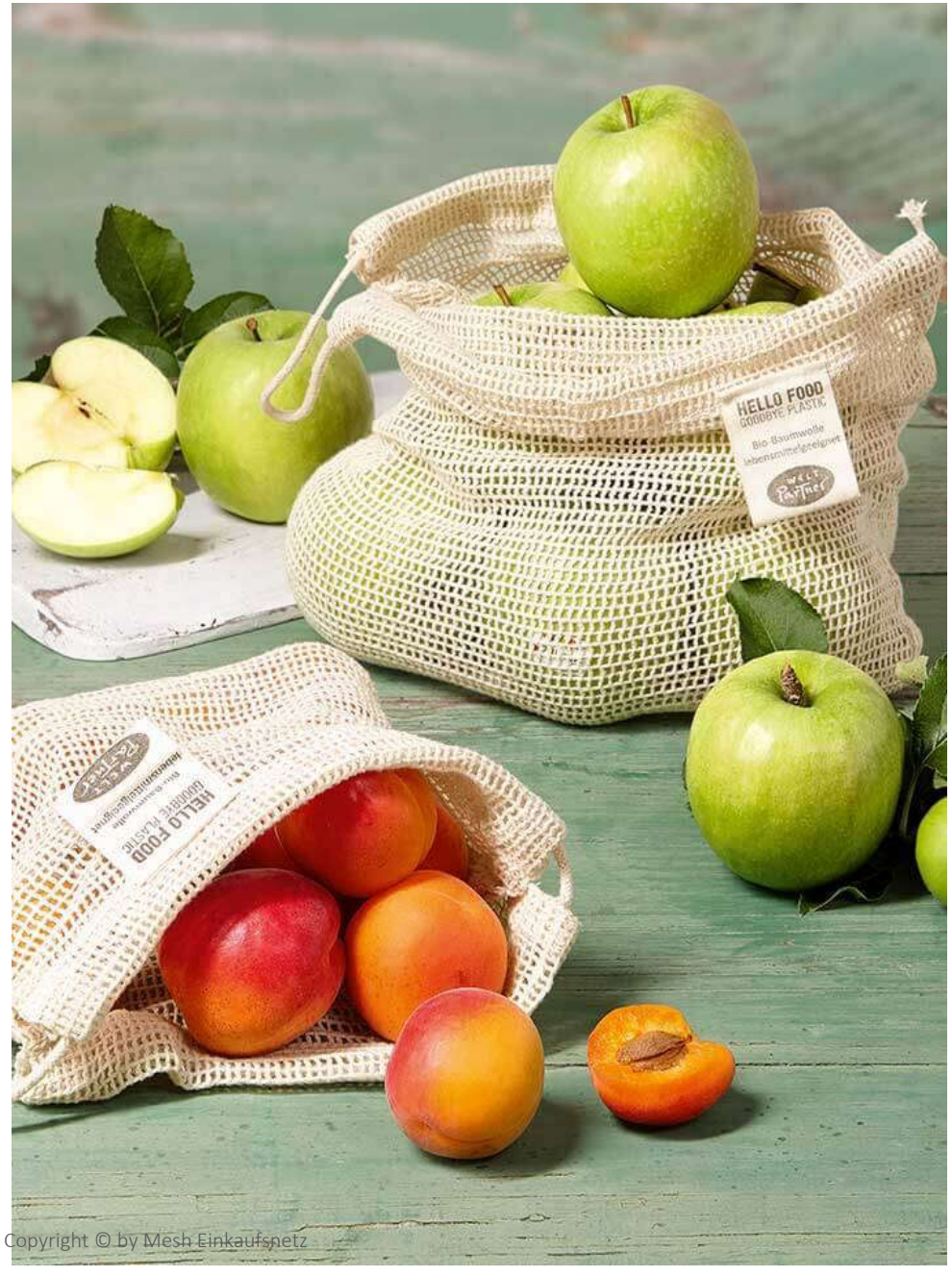
Product	Main packing	Closure	Special valve	Protective atmosphere	Note	Alternative packing
Pasta	Glass	Tinplate	Double twist lock with pouring aid			PE at 11
Rice	Glass	Tinplate	Double twist lock with pouring aid			PE at 11
Buckwheat	Glass	Tinplate	Double twist lock with pouring aid			PE at 11
Bulgur	Glass	Tinplate	Double twist lock with pouring aid			PE at 11
Quinoa	Glass	Tinplate	Double twist lock with pouring aid			PE at 11
Couscous	Glass	Tinplate	Double twist lock with pouring aid			
Polenta	Glass	Tinplate	Double twist lock with pouring aid			
Spices in powder form	Glass	Tinplate				
Spices whole	Glass	Tinplate				
Mozarella	Glass	PE film		yes		Wood Polymer at 7
Feta	Glass	PE film			in brine	
Tofu	Glass	PE film			in liquid	
Other in (salt)lake	Glass	PE film			in liquid	
Mackerel (whole)	Tinplate	PE film		yes		Wood polymer
Salmon fillet	Tinplate			yes		Wood polymer
Trout	Tinplate	PE film		yes		Wood polymer
Sliced salmon	Tinplate	PE film		yes		Wood polymer
Sardines	Tinplate	PE film		yes		
Tea	Tinplate	Tinplate	Aroma protection valve			
Coffee / espresso ground	Tinplate	Tinplate	Aroma protection valve			
Coffee / espresso beans	Tinplate	Tinplate	Aroma protection valve			
Instant coffee	Tinplate	Tinplate	Aroma protection valve			
Cocoa	Tinplate	Tinplate	Aroma protection valve			
Dried fruit	Tinplate	Tinplate	Double twist lock with pouring aid			PE at 7
Nuts	Tinplate	Tinplate	Double twist lock with pouring aid	yes		PE at 7

For fruits and vegetables, the best solution remains: avoid packaging

Even insensitive fruits and vegetables are often packaged in plastic to facilitate the checkout process by portioning them or to get rid of less attractive fruits or vegetables by packing them together with better specimens.

Therefore, in the case of insensitive products (e.g. tubers, apples etc.), the shops on the Frankfurt Bridges do not have the small-part consumer packaging; only the wholesale packaging for transport from the point of harvest to the point of sale remains.

The delicate varieties of fruits and vegetables are sold in sturdy trays of different sizes (similar to the cardboard trays commonly used today) pressed from leftover renewable raw materials (e.g. orange residues, cacao bean husk etc.)



Another option for fruit and vegetables: collecting individual pieces in reusable nets

Whether made of hemp and organic cotton, nets are a good solution if consumers are willing to bring them with them when they shop and wash them at home at appropriate intervals.

They are less suitable as reusable nets, since a washing cycle after each use would be more energy-intensive than the provision of thin PE bags, which are produced from vegetable waste and can be used in a thermally climate-neutral manner under CO_2 filtering. In the case of textiles, unlike glass or stainless steel, sterility cannot be achieved by brief high-heating or UV irradiation, but only by a comprehensive washing process - with negative consequences for the service life and the ecological footprint.

In addition, especially some vegetables can be transported more protected with a film-like protection and keep longer at home, which reduces the rate of throwing them away.

On the Frankfurt Bridges there is an option for delicate vegetables and fruits to be packed in thin PE bags

Thin bags are often not necessary in the supermarket. But there are also cases where a large number of individual parts would otherwise roll around in the shopping cart, for example mirabelles or Brussels sprouts. Still others vegetables have tender leaves that could be crushed in the shopping cart, such as chard or pak choi.

For these fruits and vegetables packaging bag dispensers with PE bags of different sizes are also available in supermarkets on the bridges.

A variety of products - everything from rice to pickles - can be packed in standard containers: This does affeect the diversity and breadth of the assortment

To avoid waste due to suboptimal packaging, not only packaging materials but also package sizes are adjusted product by product

Grocery stores on the Frankfurt Bridges also have products that require refrigeration such as cold cuts, minced meat or fish fillets.

They are packaged in bio-based polyethylene, which is included in the sustainable disposal process.

Different packaging sizes are planned for all products:

After all, spontaneity is a big factor in shopping - and food that ends up being thrown away because you initially buy a package of it that is actually too big, but soon don't feel like it anymore, means a waste of raw materials and energy.

Especially with perishable foods, smaller portion sizes can help save energy and CO2

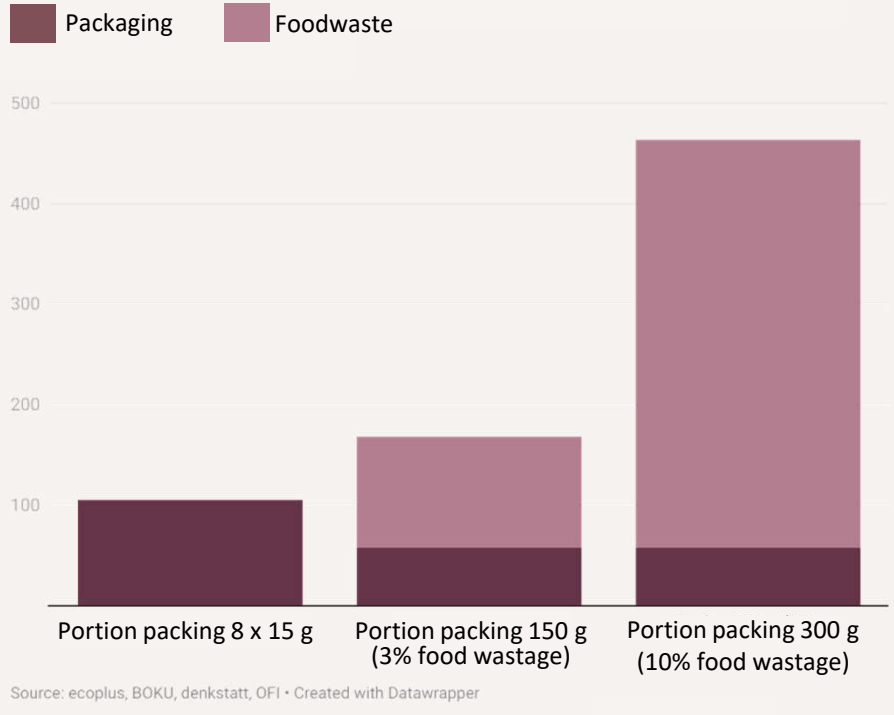
More packaging can keep goods fresh much longer and thus prevent spoilage.

For example, fresh cheese is more likely to be eaten whole if it is packaged in smaller portions.

While this requires more packaging material, less food is wasted. In fact, the CO2 savings of the avoided food waste is greater than the CO2 expense of the additional packaging.

However, small portion sizes make sense primarily for perishable products such as cream cheese, and not for honey, which keeps for many months.

Energy consumption in grams of CO2 equivalent per 150g of fresh cheese consumed



Supermarkets must permanently dispose of expired food - however, more than half of the waste occurs in private households

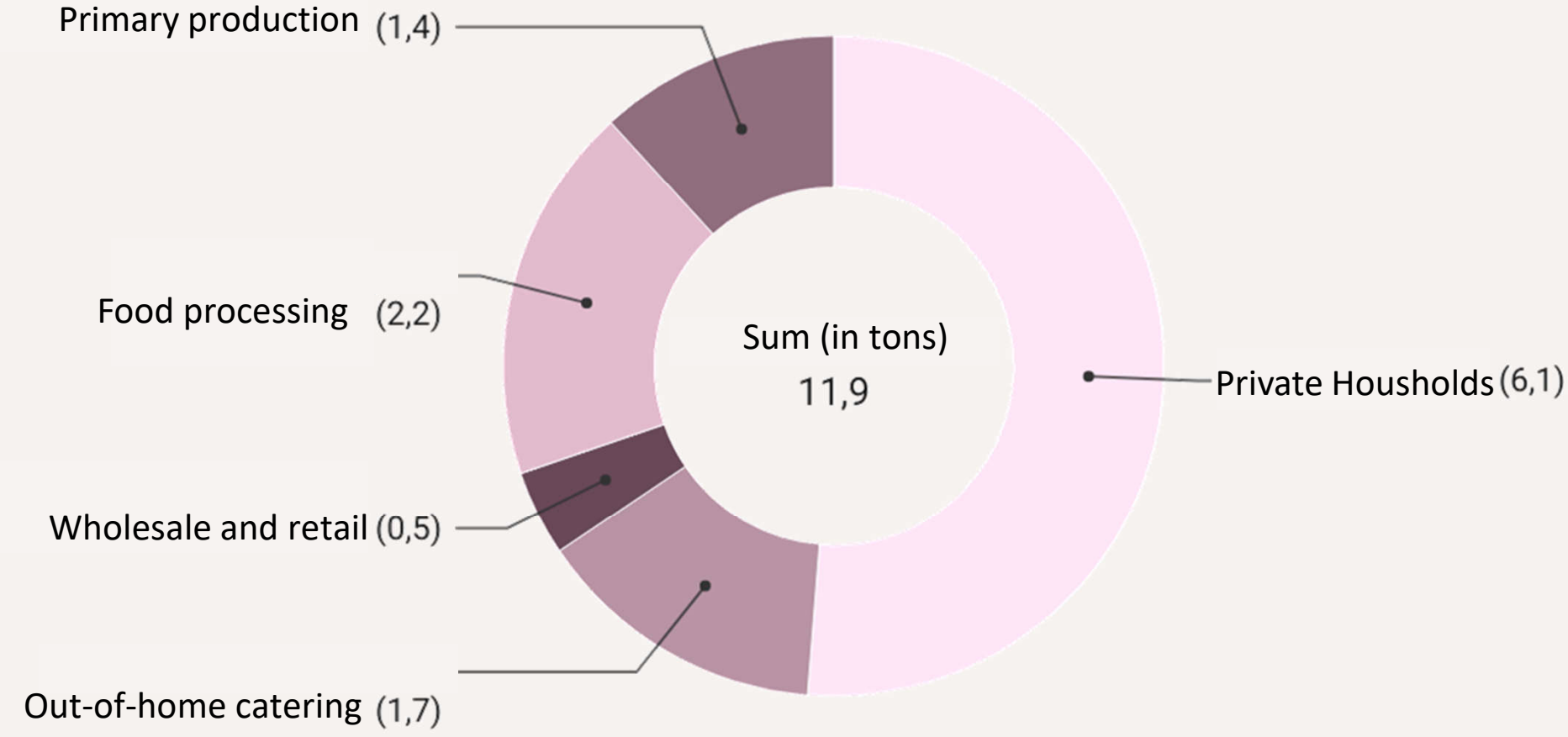
Why can't supermarkets simply distribute products that are expired but still digestible, but must dispose of them? The problem is that stores are responsible for food they put into circulation. They can be held liable if someone gets sick after eating an expired food that has been put into circulation.

In France, things have been different since 2015: there, supermarkets with an area of more than 400 square meters not only have to enter into cooperation agreements with non-profit organizations, they are also prohibited from throwing away expired food or rendering it inedible.

However, supermarkets, restaurants and even industry are not the biggest wasters: private household consumers are responsible for over 50%. Germans throw away just under 80 kilograms of food per capita every year: that corresponds to 220 grams per day.

Extent of food waste

Food waste in Germany per year in tons



Erstellt mit Datawrapper

Likewise, variety and spontaneity can only be served with smaller packaging sizes

The trend towards smaller or single households means that a lot of food cannot be used up because it is no longer possible to prepare food for several people.

Added to this is the demand for a varied and spontaneous menus.

Both factors contribute to the fact that food is often left lying around until it spoils.

Food in large packages is more likely to be thrown away because it is not used before the expiration date. It also happens that the rest in the package, although still durable, has become unsightly because the package was open too long.

The expansion of smaller package sizes on the Frankfurt Bridges will counteract food waste for these reasons.

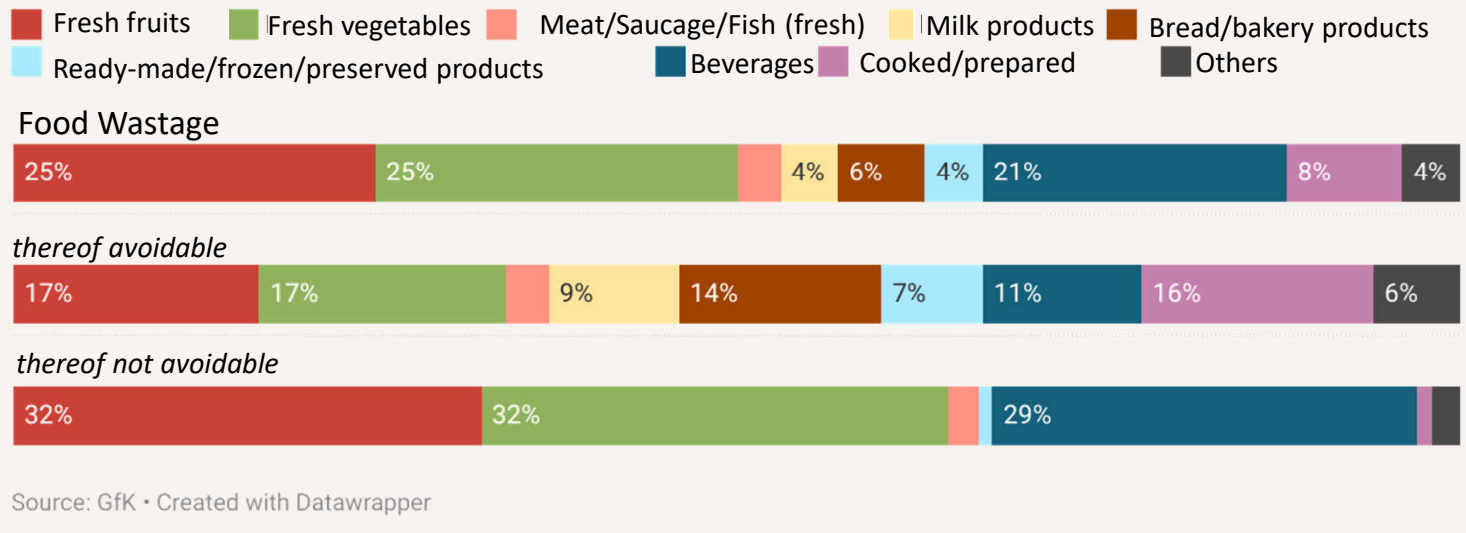
For products that only taste really good when fresh, small package sizes are extremely important to avoid throwing away leftovers

Bread, as we all know, tastes best when bought fresh, and fruit that is ripe and sweet when purchased is also best consumed within a few days. Simply buying smaller quantities (preferably without traditional packaging) is the most important lever for avoiding food waste with such products. Correct storage also contributes to longer life and therefore edibility for many products.

With meat and dairy products, on the other hand, smaller packaging in particular helps to avoid food waste and thus contributes most to sustainability.

What type of food is thrown away the most?

Unavoidable food waste refers to food that is normally discarded during preparation, such as peels



Source: GfK • Created with Datawrapper

Products	Packaging Sizes
Pasta	7, 9, 11
Rice	7, 9, 11
Buckwheat	7, 9, 11
Bulgur	7, 9, 11
Quinoa	7, 9, 11
Couscous	7, 9, 11
Polenta	7, 9, 11
Spices in powder form	1
Spices whole	1
Mozarella	2, 4, 7
Feta	2, 4, 7
Tofu	2, 4, 7
Other in (salt) lake	2, 4, 7
Mackerel (whole)	3, 9
Salmon fillet	3, 9
Trout	1, 3, 5
Sliced salmon	1, 3, 5
Sardines	1, 2, 3
Tea	1, 3, 5
Coffee / Espresso ground	3, 8, 10
Coffee / Espresso beans	3, 8, 10
Instant coffee	3, 6
Cocoa	1, 3, 5
Trockenfrüchte	2, 4, 7
Nüsse	2, 4, 7

Size	Quantity in g
1	50
2	80
3	100
4	120
5	150
6	180
7	200
8	250
9	300
10	400
11	500
12	1000

Therefore, all supermarkets on the Frankfurt Bridges always offer small package sizes, as well

For each product, it is necessary to differentiate exactly which packaging sizes would make sense. Shelf life and quantity consumed per use are particularly important here.

Also, pricing must be proportional to package size; this avoids paying less for the same product in larger packages than in smaller packages, unlike the current practice.

Smaller portion sizes do carry a larger share of packaging and logistics costs in relative terms; but cross-subsidization in assortments is a common practice in the retail business - most frequently under the aspect that producers want to be "full-range suppliers", i.e. leave less profitable products in their sales range in order not to show any gaps to retailers.

Accordingly, it is also possible to carry out such cross-subsidies with regard to less profitable packaging sizes within an article group.

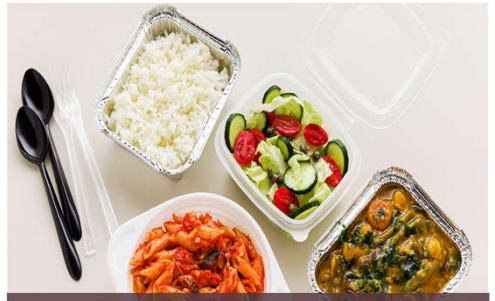
The bridge supermarket: unpackaged fruit and vegetables, standardized reusable containers made of glass and stainless steel, and bio-based PE packaging - all this in combination with different package sizes is the most sustainable system solution

Conclusion: Packaging materials and closure variants of the bridge packaging system can sustainably cover almost the entire range of supermarket and drugstore products

The Frankfurt Bridges are a neighbourhood on a second level in the City, on which a new packaging system can be created that, despite reducing complexity, can cover ALL packaging requirements for supermarket and drugstore products in a sustainable and CO_2 -neutral manner.

The system on the Frankfurt Bridges is designed in such a way that gradually stores in the vicinity of the bridges and the adjacent neighborhoods can join them - and eventually expand to the whole city and other towns, resulting in economies of scale for the packaging concept that can also make it very profitable in the long run.

Old New Territory
Frankfurt



Putting an End to Plastic Takeaways

Supermarket and Drugstore

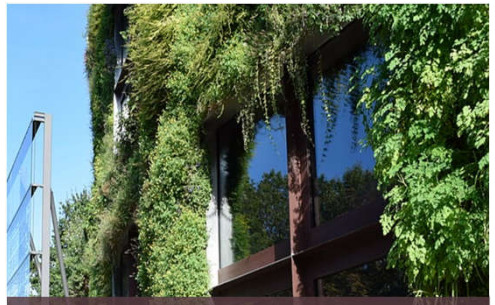
Package Variety desired

Shopping in the Future

Circulation System and Refund

The Master Academy

Special quarters



The Green Metropolis of the Future

TEAM MEMBERS

Architecture
Image & photo
Bridges
Energy

Geoinformation
Green & Nature
Communication
Art & Culture

Urban climate - world climate
Statics
Transportation
Technology & IT

Water
Packing
Webpage & Design

Law
Finance
Implementation

Critical sparring partners:
Professors
Professionals
Inspirers & Supporters

Variety is Possible

Despite the reduction in complexity, the diversity of materials and information in the packaging on the Frankfurt Bridges remains - even without today's abundance of heterogeneous plastic materials

Even if the focus is on packaging made of break-resistant glass, enameled thin stainless steel and bio-based PE - as long as they do not impair the overall disposal process, innovative packaging variants are also included in the bridge system. Materials should be made from agricultural residues or should be microplastic-free in other ways - compostable with little effort or otherwise recyclable.

Content: Marketing diversity can also be ensured with a standardized, reduced-complexity packaging range for different manufacturers

Appearance and design can be applied to the standardized packaging, as can information diversity - whether with films, paper labels or environmentally friendly, easy-to-remove varnishes.

For detailed information around a product, codes can be placed on the packaging for consumers to scan.

The colorful variety to which the eye is currently accustomed in the supermarket may be somewhat limited: But the use of numerous innovative bio-based packaging, which can be made from leftovers from the agricultural industry and other materials that are microplastic-free degradable, contributes at least a little to the visual diversity in colors and design.

Variety is possible - despite complexity reduction in packaging materials and the return to standardized packaging containers

The packaging world on the Frankfurt Bridges has a clear focus on reusable packaging made of glass and stainless steel. The only plastic provided is polyethylene - although in a wide variety of designs such as hard-shell form, softer packaging or film form, but nevertheless always largely pure polyethylene at its core.

The material reduction in the reusable system means that disposal and cleaning processes can be designed efficiently: and by concentrating on just one plastic, an incineration process tailored to it can be used.

The bridges represent a neigbourhood on a second level in the city, in which the complexity of today's packaging world with its thousands of materials can be reduced for the first time to those packagings that fit into the innovative purchasing, and in sustainable life cycle processes, from production, through transport and use, to disposal.

Once you have created this nucleus and its processes, you can and should add more packaging materials. Sustainability can also be better achieved through portfolio systems than through single-track concentration on just three packaging materials.

At the same time, the diversity of product design in terms of marketing, design or product information does not have to be lost at all.

The standard fountain bottle has proven that a variety of marketing, information and quality appeal can be conveyed with the same vessel

Flexible marketing and branding is also easy with the reusable packaging on the bridges, which many manufacturers of a wide variety of products are expected to use together

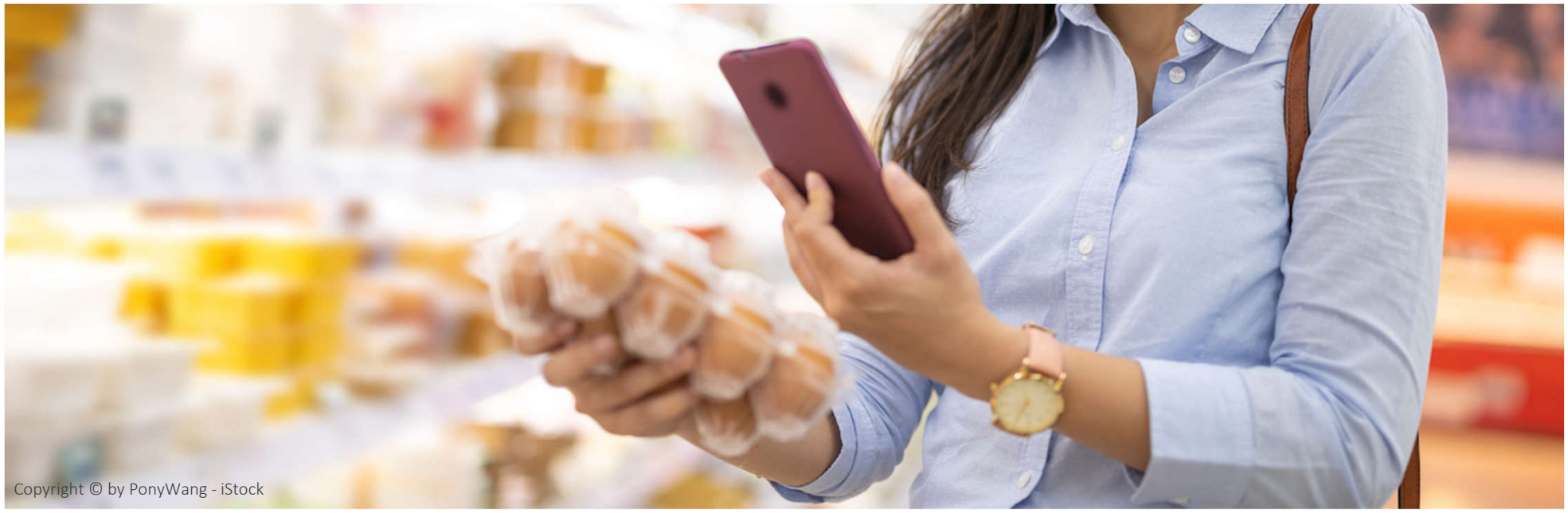
The use of a wide variety of plastics, all of which are made from renewable raw materials but are therefore not reusable, already offers companies a wide range of options for customizing the packaging for their products. Individual branding is also possible for reusable packaging made of sturdy, lightweight glass as well as enameled, thin stainless steel: On the one hand, there is the classic stick-on paper label. When the reusable containers are cleaned, the label is removed and a new one can be applied to the glass or can. In this way, the reusable containers can be used across companies and labeled as needed.

On the standard packaging of the bridge supermarkets the necessary information variety can be provided by appropriate applied codes

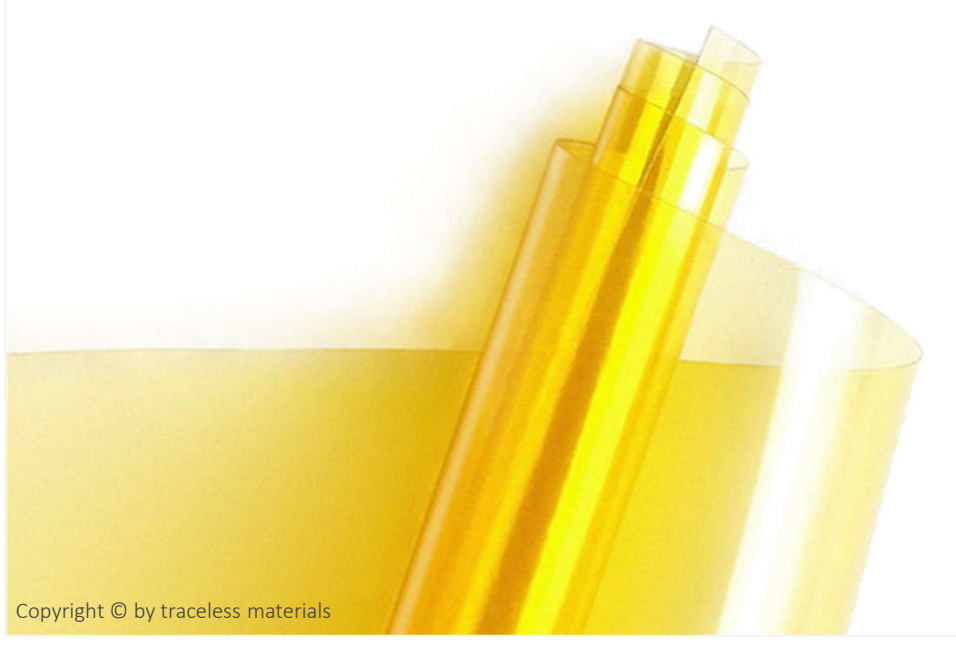
In addition to the company's own branding, all packaging is provided with a QR code. The code is stamped into the stainless steel packaging and lasered into the glass packaging and remains intact throughout the life cycle of the reusable container. Producers fill the code with their product informations each time they fill the containers.

Customers can use the code to access further information about the product, such as ingredients, allergens, calorie information or shelf life. To do this, they can either use their cell phones or the scanners located throughout the supermarket. In this way, companies can also provide customers with information that would normally have no place on packaging.

All information that must be directly visible on the product can either be printed on it or applied via classic paper labels, foils and the like.



Reusable containers can be customized with films, paper labels or even shellac - layers that can be easily removed from the reusable base material of the packaging



Packaging can also be glazed. There are now glazes that are completely biodegradable and based on vegetable waste from industry. Film packaging can also be made from a material that behaves in the same way.

Shellac can also be used as a third option, but only for non-vegan products, as this varnish is obtained from the excretions of the varnish scale insect. Shellac adheres to both glass and stainless steel.

Another way to make the packaging palette more "colorful" is to use all the innovative packaging materials made from renewable raw materials, of which more and more are coming onto the market. The only important thing here is that they can be disposed of in the organic waste garbage can without the use of microplastics.

In the bridge supermarkets there is also a wide variety of innovative packaging materials made from regional renewable raw materials or regionally generated plant residues - this provides a further range of manifestations in the packaging appearance

The focus at the Frankfurt Bridges is on resources that are available in sufficient quantities in Europe, in particular plant residues from the agricultural industry. At Brunel University London, student Denny Handley researched packaging made from orange residues: When dried, the material should be as robust and flexible as plastic.

Plastics based on residual materials from the agricultural industry can now be processed in exactly the same way as conventional fossil-based plastics, including forming them with injection molding technology.

Traditional packaging materials are sustainable alternatives - and used innovatively they enrich the diversity of the packaging palette

New packaging concepts are currently being developed all over the world, some of which make use of traditional packaging methods, such as packaging vegetables in banana leaves in Thailand or palm leaves in India.

Wood fiber-polymer composites are another plastic alternative alongside classic bio-based PE, because they are compostable and leave no microplastics in their wake

On the Frankfurt Bridges, there is not only film packaging made of polyethylene: plastics, so-called wood fiber polymers, can also be produced from wood residues. Since these wood fiber polymers can be produced completely biobased, they also decompose without leaving any residues – and most important: without creating microplastics. Such films made from wood fiber polymers are already being used to package sausage or cheese.

Wood fiber polymers could cover wide areas of the packaging world - as with all bio-based packaging materials, however, it is also important here that the polymers are produced from waste materials

Nuts, muesli or rice can also be packaged in wood polymer. However, plastic made from wood is only sustainable as long as it is created from residues from other processing operations, rather than trees being grown specifically for it or natural land being converted into agricultural land. In the medium term, however, there should still be enough wood waste to consider wood-fiber polymers as a global option.

Film packaging made from sugar and lactic acid are also already on the market as further alternatives

The packaging looks and feels like it's made of plastic, but it's 100% sugar and lactic acid.

But here, too, sustainability is only guaranteed as long as the raw materials are not grown specifically for this purpose, but come from leftover recycling.

The diverse packaging made from plant residues has one thing in common: once used, all this packaging made from renewable raw materials can either be composted without microplastics or incinerated in a CO2-neutral manner.

No extra disposal processes are needed; they find their place in the organic waste garbage can. That's why they are not a disruptive factor in reducing complexity on Frankfurt Bridges, but a way of bringing variety, diversity and marketing differentiation to the product ranges on the bridges.

Another sustainable plastic alternative: polyhydroxybutyric acid (PHB): a plastic that absorbs CO2 during production - and is also fully biodegradable

One plastic alternative, although not necessarily for the food sector, can be polyhydroxybutyric acid (PHB). PHB is a plastic that can be produced from renewable raw materials, methane or even waste fats.

What is special about PHB is that in its production the conversion of the renewable raw materials into a plastic can be carried out by bacteria: Cyanobacteria, which, like algae, have chlorophyll and can therefore convert CO2 into sugar via photosynthesis with the help of solar energy. Although they are bacteria, they are also often referred to as blue-green algae.

PHB is therefore a special material: unlike petroleum-based plastics, no CO2 is released during its extraction/production; on the contrary, CO2 is bound.

PHB, like polypropylene, is more suitable as a hard plastic substitute, e.g. for garbage cans, trash cans and the like. However, it could also be used for some drugstore products that are packaged in boxes or hard plastic molds.

Since the Frankfurt Bridges will be a showcase for innovations, such materials must also be tested for their applicability to the world of products and packaging on the bridges.

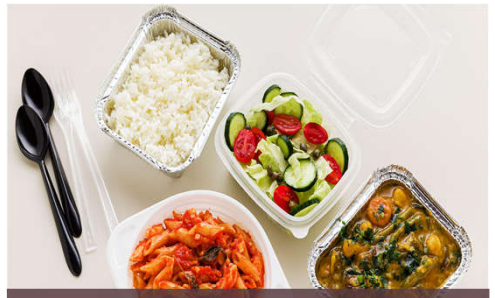
Conclusion: Despite complexity reduction in the number of packaging materials, marketing and information diversity is maintained

While there are thousands of packaging materials available today, a packaging world is being created on the Frankfurt Bridges that uses glass and metal packaging in a reusable system and single-variety polyethylene, the disposal of which can be designed to be low in CO2.

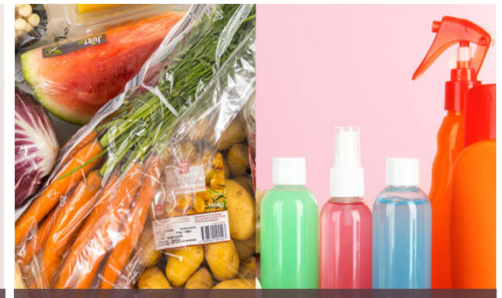
In addition, innovative research results are integrated as part of the preliminary planning, be it PHB research by the Fraunhofer Institute IPK Berlin, or research directions of the University of Konstanz on highly effective recycling of polyethylene etc.

In addition, the packaging world on the bridges is enriched by materials that are made from 100% residues of renewable raw materials and can be composted without microplastics or thermally utilized in a CO2-neutral manner.

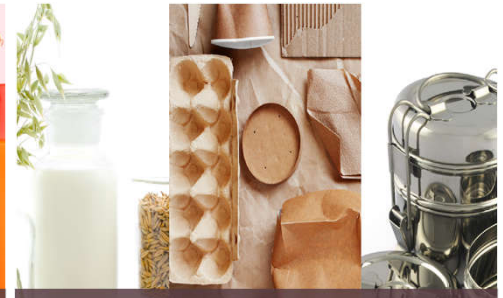
Old New Territory
Frankfurt



Putting an end to plastic takeaways



Supermarket and drugstore



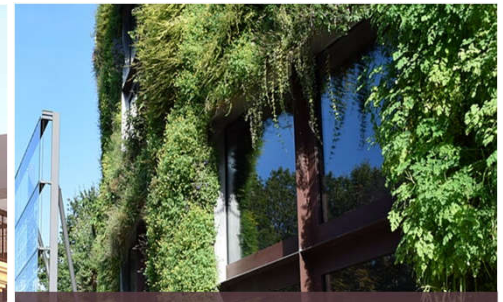
Packaging - suitable for the product

Shopping in the future

Circulation System & Refund

The Master Academy

Special quarters



The green metropolis of the future

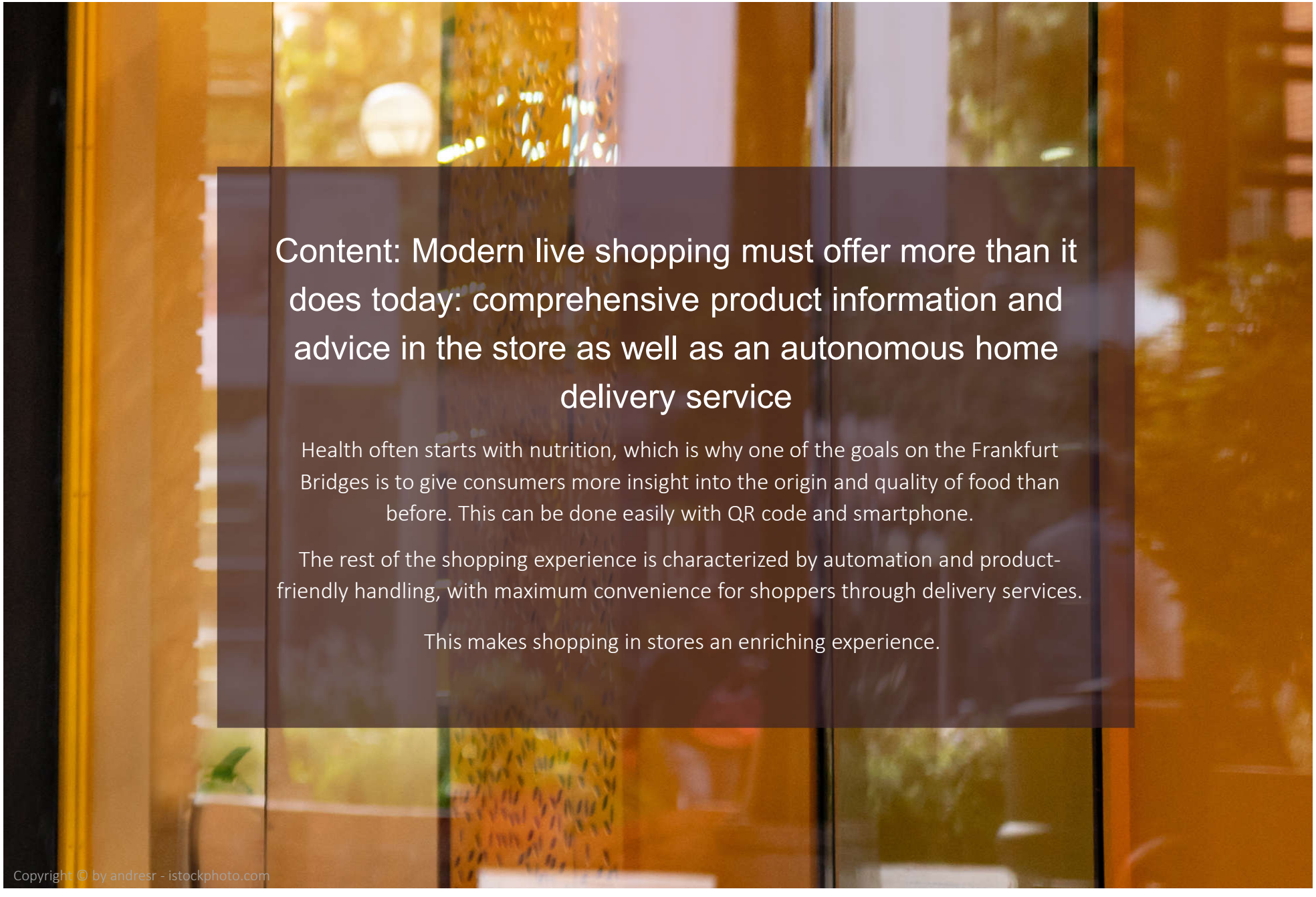
TEAM MEMBERS

Architecture	Geoinformation	Urban climate - world climate	Water	Law	**Critical sparring partners:**
Image & photo	Green & Nature	Statics	Packing	Finance	Professors
Bridges	Communication	Transportation	Webpage & Design	Implementation	Professionals
Energy	Art & Culture	Technology & IT			Inspirers & Supporters

Shopping in the Future

Shopping of the future is an informative and convenient and experience

On the Frankfurt Bridges, shopping is transformed from a chore into a convenient experience: In the store, product information appears legibly on large screens via scan code, prices are already scanned when placed in the shopping cart, and for payment, the cart or basket is simply pushed through a scan tunnel. Further trained staff can advise customers on nutritional issues or care products on the bridges. The intelligent shopping cart travels autonomously to the customer's home and there, if necessary, directly to the kitchen via the freight elevator. Never again standing in line at the checkout, never again lugging - that's the goal.

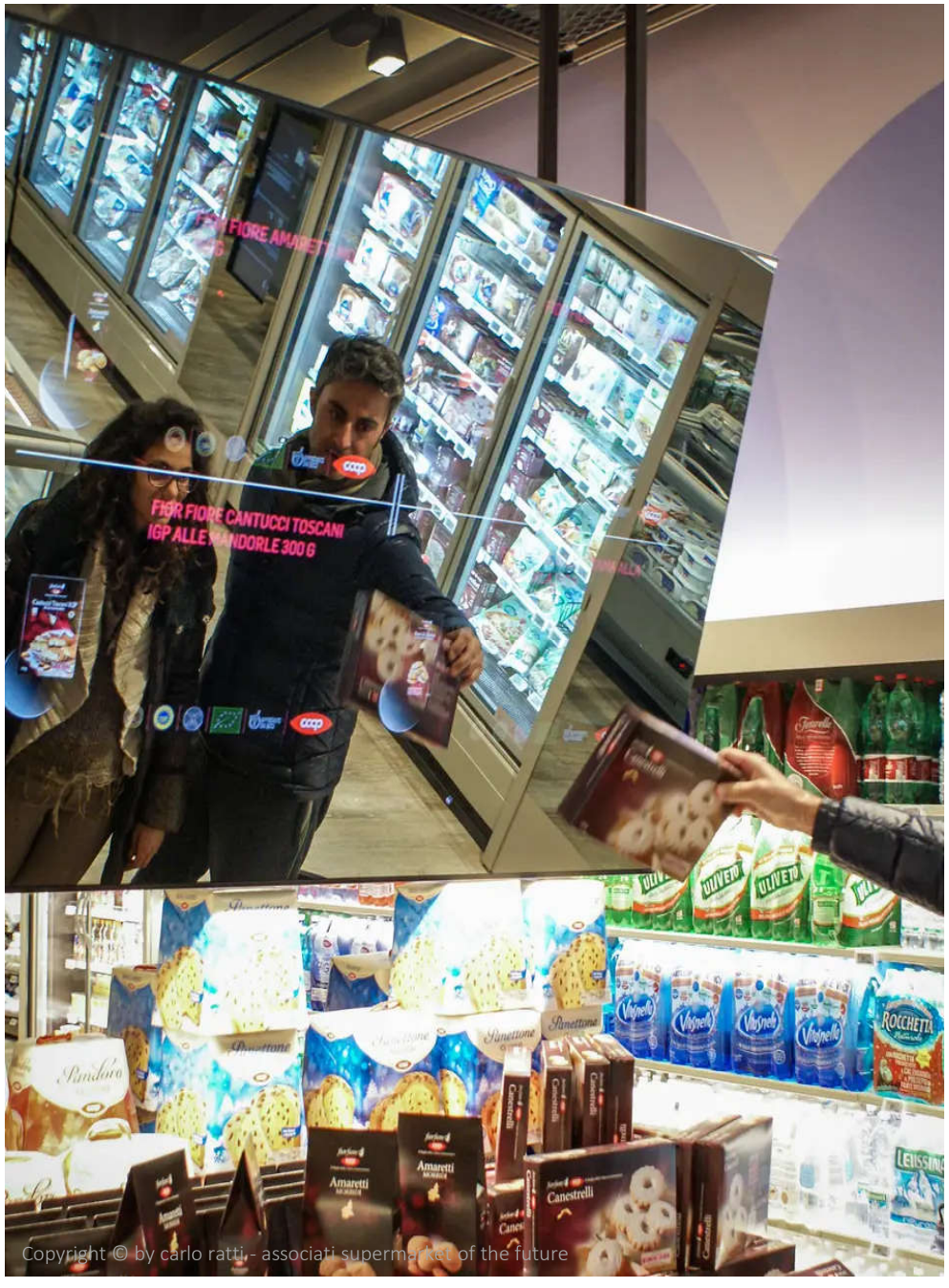


Content: Modern live shopping must offer more than it does today: comprehensive product information and advice in the store as well as an autonomous home delivery service

Health often starts with nutrition, which is why one of the goals on the Frankfurt Bridges is to give consumers more insight into the origin and quality of food than before. This can be done easily with QR code and smartphone.

The rest of the shopping experience is characterized by automation and product-friendly handling, with maximum convenience for shoppers through delivery services.

This makes shopping in stores an enriching experience.



Comprehensive information is provided for all products

A scan code on the packaging contains on the one hand the price of the product. In addition, it also contains all other information:

(1) Extended description of the ingredients (legally required description is wirtten on the packaging)
(2) Information on allergens in the product
(3) Food chemical and nutritional information of interest about the product
(4) Information on correct storage conditions that extend shelf life
(5) If applicable, promotional information, recipes, preparation tips, etc.
(6) Separate from this and completely anonymized, the code can be used to trace how long a package has been in circulation and how many cycles of use it has already undergone.

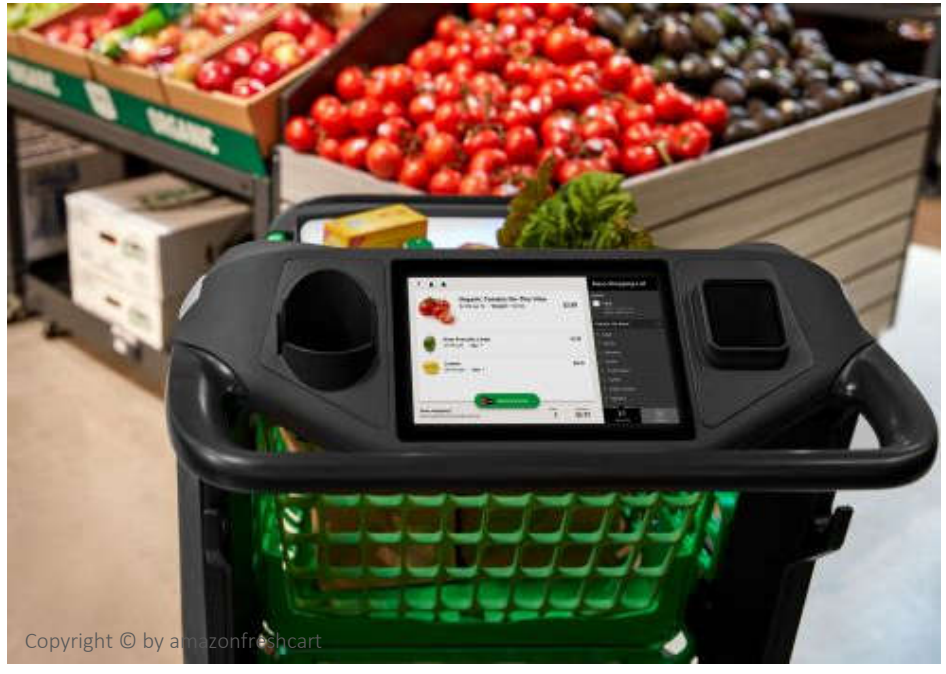
The content can be accessed by holding the product's scan code up to a scanner. The complete information, which would have no place on the product itself, appears on the cell phone. For vegetables and fruit, the scan codes can be found on collection trays, collection bags or on the food itself.

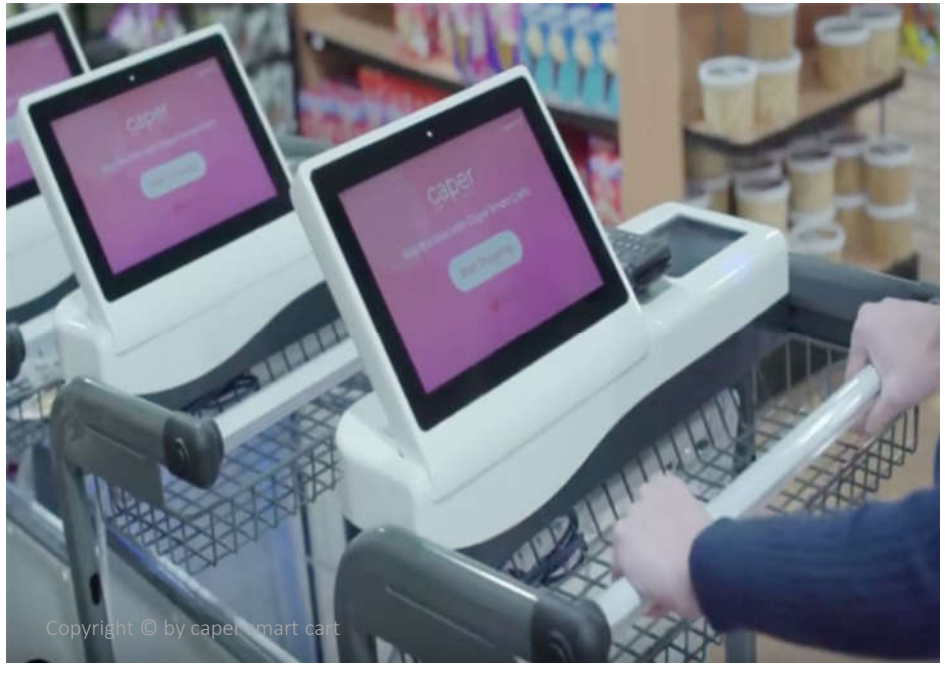
Optimal consumer information, however, goes beyond mere product description

Extended product information, such as allergenic ingredients or valuable minerals, etc., can be read via the code, which is stamped into the stainless steel packaging containers and lasered into the glass containers, and is recoded accordingly in each case during the filling process. In the case of PE packaging, this important product information is conveyed via a printed code.

All additional information can be found on the information screen boards above the products: Not only the origin of a product, but also the fair trade conditions, farming cooperatives, transport and processing chains can be described there.

The aim is to create maximum transparency for consumers, so that consciously sustainable shopping is supported and particularly environmentally friendly and fairly producing companies can justify their higher prices if necessary.





No waiting time at the checkout

Intelligent shopping carts are used on the bridges, as they are already being tested in retail today: The moment a product is placed from the shelf into the cart (or basket), it is scanned. Integrated scales in the shopping carts and alarm systems on the shelves prevent the scanning system from being bypassed. They register when an unscanned item is in the cart or removed from its shelf location unscanned and alert to scan the item.

This eliminates long queues at the checkouts; at the end, customers only need to push the total of their purchases through a verification scanner (similar to a barrier) and pay at the checkout machine: either contactlessly via their bridge EC or credit card or also in cash via a vending machine.

The smart shopping system also relieves supermarket and drugstore staff of work at the checkout. The freed-up capacity can now be used elsewhere: Employees can be trained to advise customers on nutritional issues or care products.

Another goal on the bridges: shopping with comfort and flexibility

There is a delivery service for supermarket purchases on the Frankfurt Bridges. This means that no one has to walk home loaded down with heavy shopping bags. Especially in an aging society, this is an important aspect for maintaining people's autonomy for a long time.

The delivery service also increases flexibility in everyday life: if you spontaneously decide you need something while you're out and about, you don't have to carry the products you've bought around with you; instead, you can have them delivered to your home, with precise delivery times.

A similar concept already exists at some subway stations in South Korea: There, you can scan everything you want to buy with your cell phone. While you then continue your journey on the subway, the delivery is put together in a warehouse and brought to your place at the desired time.

The very special "delivery service": on the Frankfurt Bridges, you can send the shopping cart you personally put together in the supermarket directly to your home - while you go your own way

Shopping online or scanning products behind windows eliminates the selection process, which is especially relevant for fruits and vegetables, but also for packaged meat, for example, when choosing preferred cuts.

On the bridges, you can personally pick out your purchases in the cart, and as soon as the payment process has taken place at the check barrier, in larger supermarkets you can have the goods lifted by a lifting system into a lockable delivery box on rollers, which drives the shopping home - in smaller supermarkets, on the other hand, you can put basket inserts in the cart at the beginning, which can then also be lifted out relatively easily when filled and placed in the delivery box.

The delivery box then drives home autonomously.

The gentle shopping cart

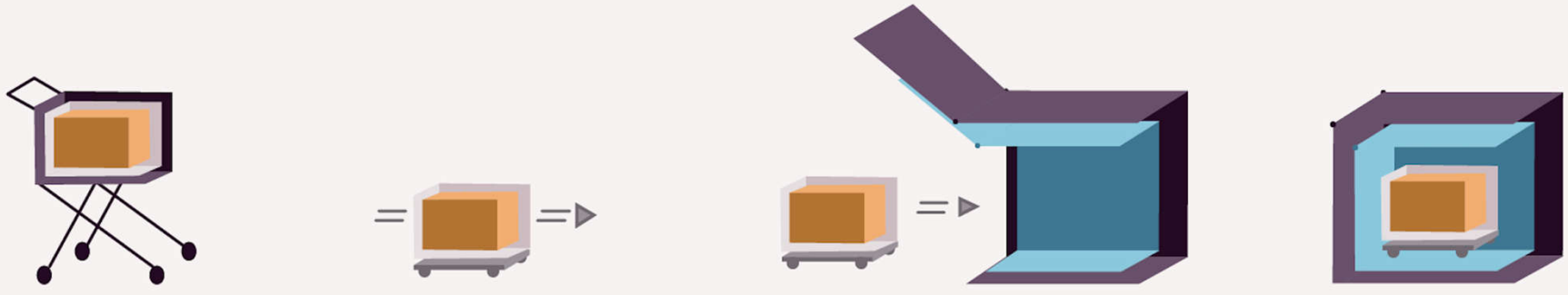
For bulk purchases of the future, shopping carts must be designed to handle reusable glass packaging gently

If one can go shopping extremely flexibly in between without having to worry about transporting the shopping home, then large weekly purchases are also no longer necessary so often. That's why the shopping carts in the Frankfurt Bridges‘ supermarkets are planned to be somewhat flatter than in today's supermarkets, which is gentler on the products packaged in (sturdy yet breakable) glass.

In larger supermarkets of the future, the customer should be able to choose between two sizes: a flat trolley as described above, or a large trolley with the conventional depth, to be equipped with a special mechanism: The shopping surface of the trolley is supported there on springs. The more goods you put in the cart, the deeper the shopping cart surface sinks, freeing up space for more shopping. The reason for this design: it prevents customers from dropping the reusable glass containers into the shopping cart from too great a height. Because even if shatterproof glass is used, every effort should be made to extend the service life of these reusable glass containers.

The autonomously driving delivery box on the bridges waits for its owners at home

Once the delivery box is filled, closed and locked, you can enter the information in the „bridge shopping app“ about when you want it delivered and where. By scanning with the bridge shopping app, the delivery box is secured against theft: Only those who have the scan code for the purchase can take or open the delivery box when it arrives at their home.



The delivery boxes either drive home directly on the small pallets, or drive into a refrigerated area in the supermarket before they set off - sometimes hours later. This function is particularly helpful in extreme weather temperatures: the groceries do not have to roll home through the midday heat when you yourself only get home hours later.

On the Frankfurt Bridges, an early arrival at home would not be problematic even in hot or freezing temperatures, as there are parcel boxes with cooling function in front of the houses, into which the pallets drive. However, if the system is to be applied in existing city streets, where houses are built flush with the street without a front yard, no parcel boxes can be built where the pallets could wait for their owner.

Delivery robots drive autonomously to their destinations

The delivery service costs 1€, pensioners, pupils and students pay 50 cents. On the Frankfurt bridges, however, you can only have your shopping delivered to your home if it weighs more than five kilograms.

The upper part from the shopping cart is first lifted onto a small, mobile pallet - or rather onto an autonomously driving delivery robot - as described.

Customers only need to have their bridge card scanned by the delivery robot and specify the desired delivery time - and the robot knows when and where to deliver the purchase.

The delivery robots travel at walking pace on the sidewalks. At around 45 centimeters, they are relatively narrow and leave enough space for pedestrians. Sensors detect whether there are pedestrians or obstacles in the way and they take evasive action.

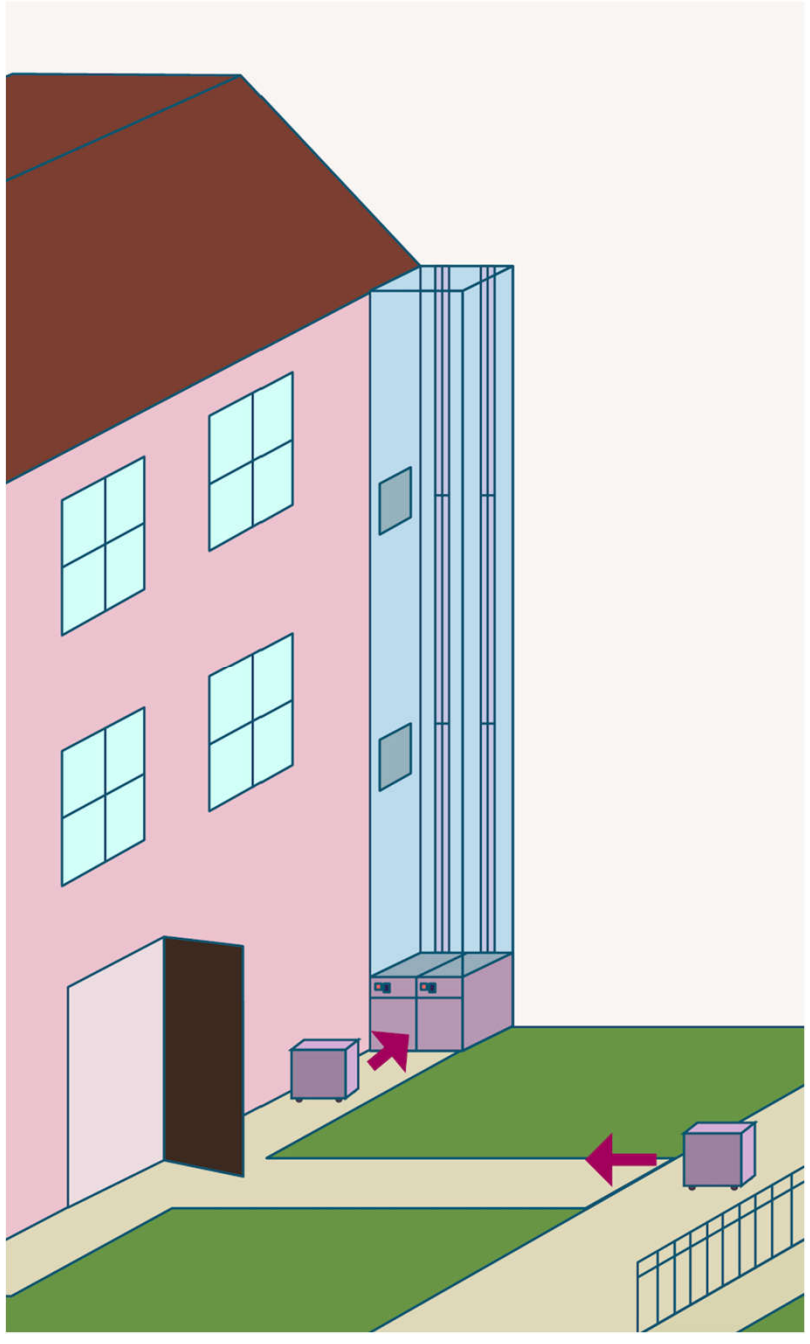
Delivery robots on the streets are nothing new, as there are numerous experimental projects about them.

The cold chain is maintained uninterrupted

The possibility of delivery service allows you to shop on the go and the goods are delivered to your home while you go somewhere else yourself.

It is then already waiting there until you are back home yourself - or only arrives then: In order to minimize cooling capacity in the waiting boxes, one can give after purchase its home drive pallets also a time, at which one will be in any case already again at home. The pallets then wait in the supermarket's cold storage rooms until they can be optimally integrated logistically into the single file of shopping pallets on the paths of the Frankfurt Bridges.

If the supermarket's storage area is full, so that the delivery robots have to be sent on their way earlier than booked, they drive home to wait in parcel boxes. These only open for the robot on the basis of a signal and also switch on a cooling system when it arrives, depending on the outside temperature.



Freight elevators for the purchases: the comfort of the future

To make the most of the new packaging world, multi-story buildings on the Frankfurt Bridges all have small freight elevators with a maximum footprint of 80cmx80cm, which either lead to the stairwell landing of the floors or open directly into the kitchen.

However, the packaging world of the Frankfurt Bridges should also benefit residents near the bridges - and most of the houses along the bridges currently have no elevator, certainly not for smaller loads.

However, the retrofitting of such an elevator is possible in many cases: The only questions are the architectural integration into the building facade, the distance regulations to neighboring buildings, and the insulation of cold bridges at the entry points from the elevator into the house.

Are so many small self-propelled pallets and shopping carts with electronics, etc. sustainable?

While "self-controlled" houses may seem creepy to some people, people will probably get used to self-controlled and automated delivery systems -especially in the age of online shopping- more quickly, at least in urban infrastructure.

It is not only a great relief for the individual - the mother with three small children or the pensioner with limited mobility, etc. - but it is also sustainable for society, since many grocery purchases by car are eliminated.

The advantage over buying supermarket and drugstore items online is that the shopping experience is not lost here: you can pick out goods yourself, which can play a role with fruit and vegetables, for example, or you can be inspired by the shampoo selection as you stroll past shelves.

Because live in the store, you can see everything clearly in an overview next to each other on the shelf - in online retail, on the other hand, this is usually not the case - you can click through offers to a certain extent, but you already have to know relatively precisely what you're looking for, because you can't call up every product to be shown at the same time – at least not to the extend as products are displayed in the shop when walking along them.

THE PLAN

BUILDINGS & BRIDGES
GREEN & NATURE
WATER

ENERGY
TRANSPORT
URBAN CLIMATE - GLOBAL CLIMATE

ART & CULTURE
PACKAGING INNOVATIVE
Take-Away Packaging
Supermarket & Drugstore
Packaging - Suitable for the Product
Variety is Possible
Shopping in the Future
Circulation System & Refund
OLD NEW TERRITORY WORLDWIDE

LAW
FINANCES
IMPLEMENTATION

SPECIALIST INFORMATION

Search
The team
Contact & Legal Notice

Conclusion: shopping on the Frankfurt Bridges preserves the valuable aspects of live shopping and at the same time is very convenient

Shopping is a cultural part of our everyday life and, especially for older people, often the only regular occasion to go out and do something.

The shopping world of the future brings the valuable aspects to the fore, such as engagement with food selection, conscious engagement with the products or even conversations with the sellers - all experiences that online shopping does not offer in this form.

At the same time, the tedious aspects of standing in line at the checkout or having to lug everything home are eliminated. The individual elements of "shopping in the future" described here are by no means utopian, but are all already being tried out by retailers today.

Old New Territory

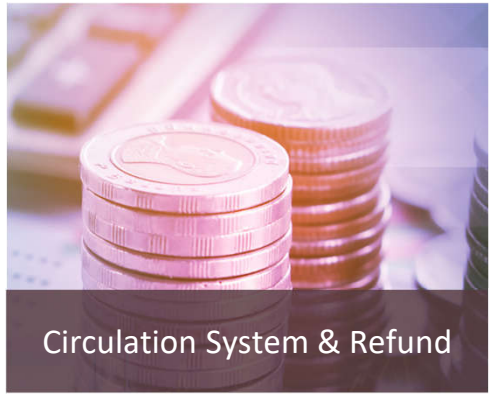
Frankfurt

Putting an end to plastic takeaways

Supermarket and drugstore

Packaging - suitable for the product

Diversity desired



Circulation System & Refund

The Master Academy

Special quarters

The green metropolis of the future

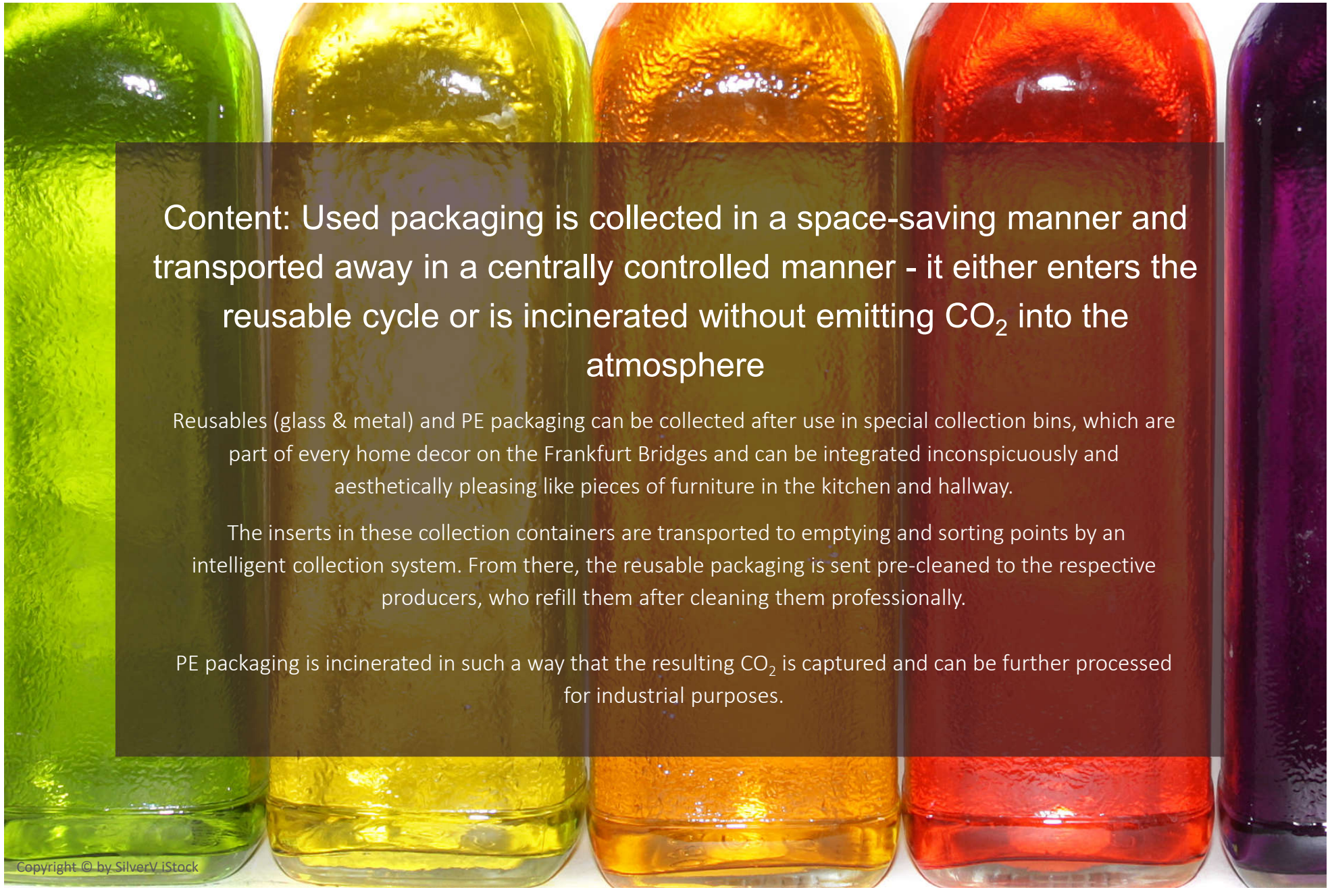
TEAM MEMBERS

Architecture	Geoinformation	Urban climate - world climate	Water	Law	**Critical sparring partners:**
Image & photo	Green & Nature	Statics	Packing	Finance	Professors
Bridges	Communication	Transportation	Webpage & Design	Implementation	Professionals
Energy	Art & Culture	Technology & IT			Inspirers & Supporters

Circulation System & Refund

An innovative system ensures the deposit and refund cycle for reusable packaging as well as CO_2 -neutral disposal for residual waste

In the apartments on the Frankfurt Bridges, empty PE-packagings with the sustainable combustion option are collected just like empty reusable containers in designer bins known as "Renomats". For these, as for the rest of the bridge waste garbage cans, there is a collection system that functions largely autonomously. In the case of the reusable packaging, a disinfecting pre-cleaning process is carried out at the municipal disposal company, and from there the packaging is returned to the product manufacturers. A deposit system ensures that the reusable packaging is handled with care.



Content: Used packaging is collected in a space-saving manner and transported away in a centrally controlled manner - it either enters the reusable cycle or is incinerated without emitting CO_2 into the atmosphere

Reusables (glass & metal) and PE packaging can be collected after use in special collection bins, which are part of every home decor on the Frankfurt Bridges and can be integrated inconspicuously and aesthetically pleasing like pieces of furniture in the kitchen and hallway.

The inserts in these collection containers are transported to emptying and sorting points by an intelligent collection system. From there, the reusable packaging is sent pre-cleaned to the respective producers, who refill them after cleaning them professionally.

PE packaging is incinerated in such a way that the resulting CO_2 is captured and can be further processed for industrial purposes.

The "Renomat" - the solution for returning reusable containers to the cycle

Empty reusable containers made of glass and stainless steel have one disadvantage from the consumer's point of view: they cannot be folded to save space. So where to put them when the contents are used up? Very few people have room for huge stores of deposit containers behind kitchen doors, on shelves and under the sink.

The next problem in everyday life: the next time you go shopping, you want to return the deposit containers but you forget them at home. To prevent this from happening, the reuse cycle of the returnable containers is included in the construction of the houses on the Frankfurt Bridges.

Accordingly, for each household on the bridges there are two "Renomats" aesthetically matching the apartment furnishings when tenants move in. The artificial word "Renomat" stands for Renaissance or Reuse Automat.

Renomats are collection bins disguised as designer furniture. The garbage cans are used to collect deposit containers or reusable packaging on the one hand and to dispose of plastics on the other, which are incinerated with residue-free CO2 filtration. Neither may be mixed with waste paper, organic waste or residual waste.

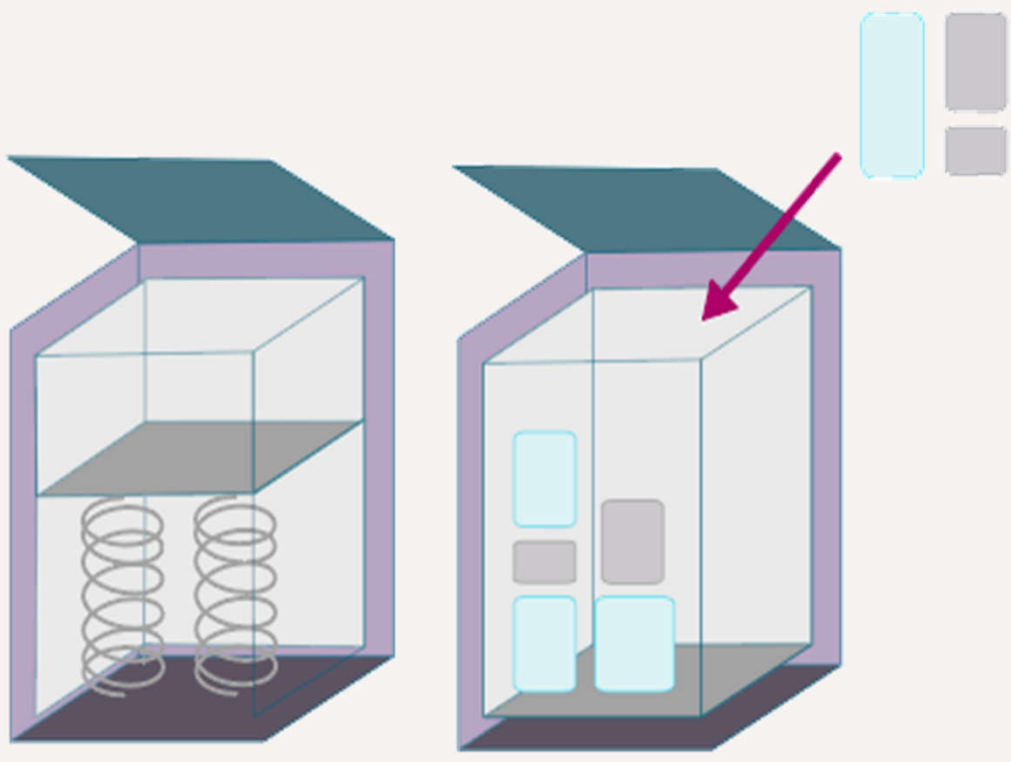
The design collection containers are available in all possible variants

"Trash cans" are not a nuisance if they do not look like trash cans. Renomats have the look & feel of a piece of furniture - you can choose the Renomat that suits your home according to your personal taste.

The Renomat must not get in the way and take up too much space

Additional pieces of furniture in the kitchen can be a nuisance not only because of their appearance, but also because they take up space. Therefore, in addition to its function as a storage container, a Renomat can also be used as a stool, a sideboard or a shelf; for this purpose, it is available in two different heights: 50 cm high for sitting and 70 cm high as a sideboard. Accordingly, the Renomats are sturdily built and stand on lockable casters: As long as you fill it with reusable packaging and other sustainable packaging in the kitchen, you can lock the casters; and when you don't need it in the kitchen because it's full, you release the casters‘ lock and push it into the hallway, where it can again serve as seating or storage until its insert filled with packaging is removed and carried to the garbage cans in front of the house.

The Renomat has a removable insert so that you do not have to carry out the comparatively heavy piece of furniture.



The structure of the Renomat protects reusable glass packaging by cushioning

The base of the Renomat insert is mounted on springs. If the Renomat insert is empty, the base is at the top; if reusable containers are now placed inside, the weight presses the base downwards. This prevents the glass deposit containers from falling into the Renomats from too great a height.

The Renomat closes with an airtight lid to prevent odors from escaping. When the Renomat is full, you can simply take the insert outside to a compartment system next to the trash cans.

To ensure that there is always room in the household for reusable packaging and sustainable plastic packaging, you need reserve Renomat inserts

Each household on the bridges - as well as the direct residents along the bridge - receives two Renomats including inserts at the beginning together with the bridge card. Households with more than four household members, receive 3 Renomats. While full inserts are taken out of the apartment, the Renomat - as a piece of furniture with individually selected design - remains in the apartment.

For every insert that is in a Renomat, there is an empty counterpart outside by the garbage cans waiting to be replaced, so it shouldn't happen that all the inserts are full and there is no more room for empty packaging.

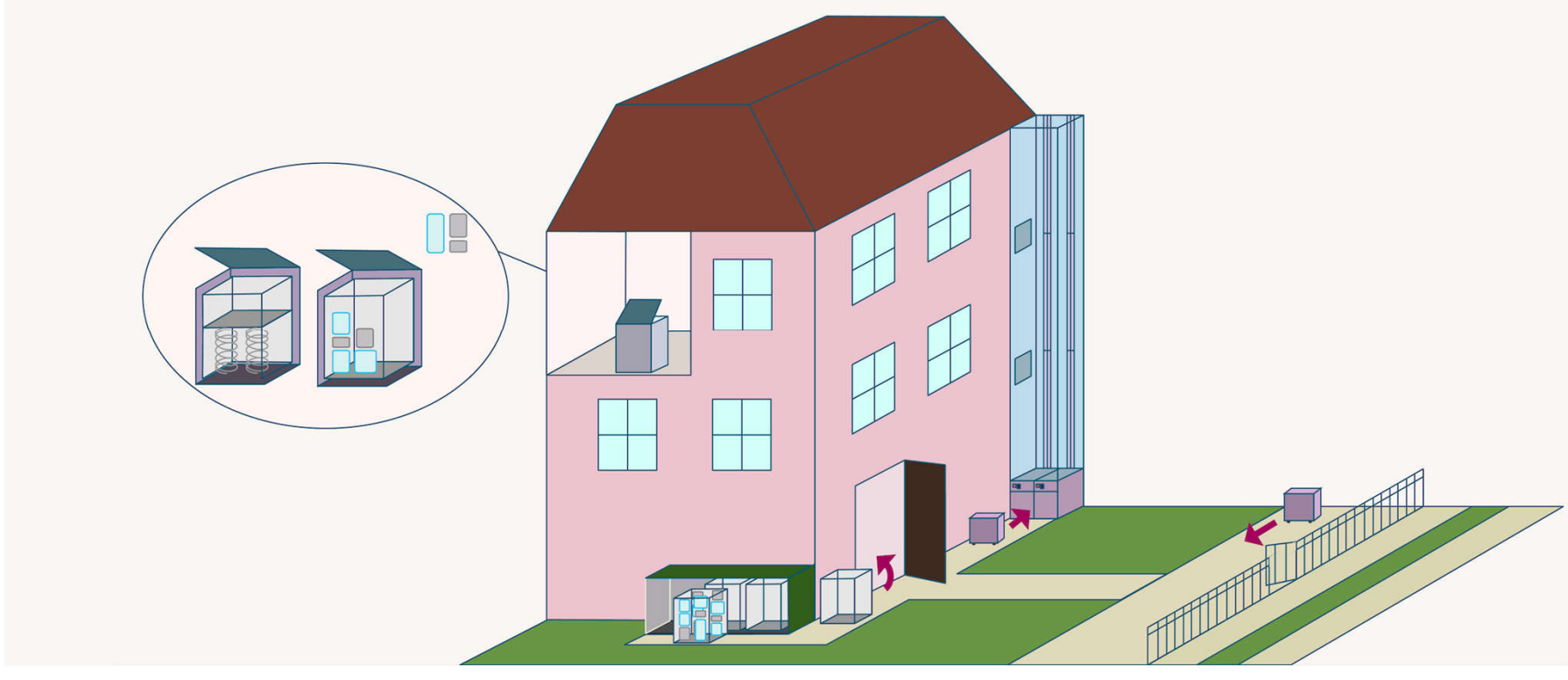
On the Frankfurt Bridges even the garbage cans are attractively designed

Waste garbage cans on the bridges correspond to conventional garbage cans in size and shape, with the difference that they are much more attractively designed and - where possible - are located under overgrown arbors. The compartments for replacing the Renomat inserts are also located there.

Two to three Renomat inserts per household have space in specially designed compartments in front of the front door

Since the Renomats are slimmer and smaller than conventional trash cans, six Renomat inserts can be placed in a compartment system next to the trash cans.

If you carry the renomat insert filled with empty reusable packaging outside, you can exchange it for a clean one at the compartment system. Lids for the inserts are in a narrow compartment above, so that the insert with empty packaging is protected against cats or other animals.



Full Renomat inserts are regularly exchanged by the garbage collectors for empty clean ones - but only when they „report“ appropriate filling

Renomat inserts are not emptied by tipping their content into a refuse collection vehicle. Full garbage cans or full Renomat inserts are exchanged for empty ones by the bridges‘ waste collection service. This protects the reusable glass containers and is much quieter. This is also important because emptying takes place at night, as the driving lanes on the bridges have to be used by autonomous traffic without any traffic jam during the day.

Full garbage cans or inserts are not only exchanged for empty ones, but above all for clean ones: this is because empty packaging containers are placed in the insert directly by the consumer, without a trash bag, which causes the insert to become regularly soiled. All inserts are cleaned by the garbage collector as soon as they have been emptied at the industrial cleaning facility.

The Renomat inserts are only replaced when they are full. This requires a smart control system for waste collection: An integrated scale in the compartment system at the waste garbage cans detects full Renomat inserts and reports this to the central coordination center. This is how the exchange is planned.

The exchange on the bridges - quiet and centrally controlled

On the Frankfurt Bridges, no garbage collectors roll the garbage cans and Renomat inserts to their places at the houses, but all bins sit on small pallets that travel autonomously, i.e. are controlled centrally.

At the beginning of his tour, the garbage truck is filled with empty garbage cans (or better say: Renomat inserts). It drives to the groups of houses on the bridges one after the other, as soon as he stops a sliding door of the garbage truck opens, the floor sinks and a ramp comes out so that the empty garbage cans (i.e. Renomat inserts) can drive out of the garbage truck one after the other to their exchange partners at the group of houses. The Renomat inserts there are also placed on pallets.

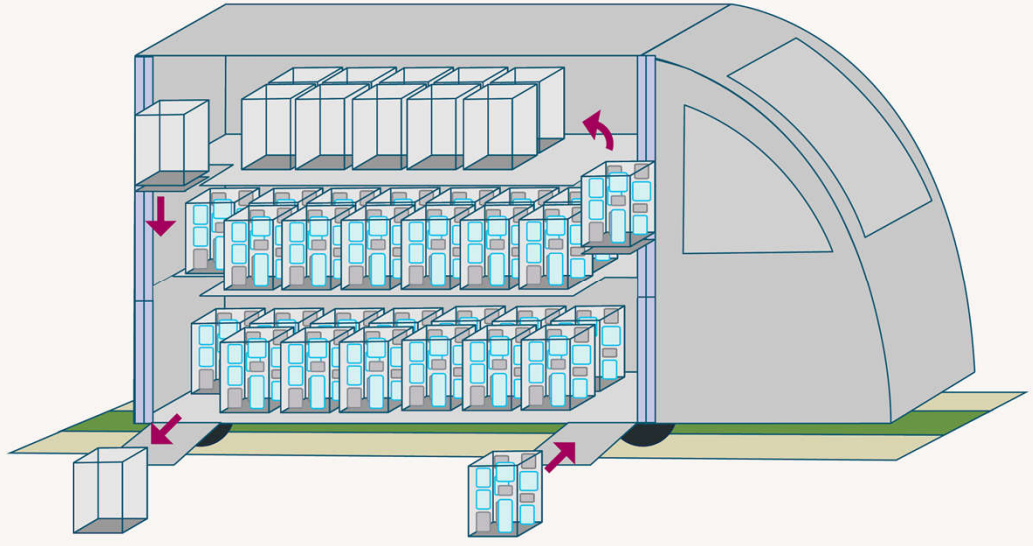
When the Renomat insert is replaced, the full Renomat insert first rolls out of its compartment, and the empty Renomat insert rolls into the empty space and becomes the new garbage can.

The full Renomat insert can move autonomously to the garbage truck on ist pallets, through a rear sliding door into it, and when this has been done for all Renomat inserts of the group of houses, the garbage truck (or better say „Renomat truck) closes its sliding door and moves on.

Structure of a renomat vehicle

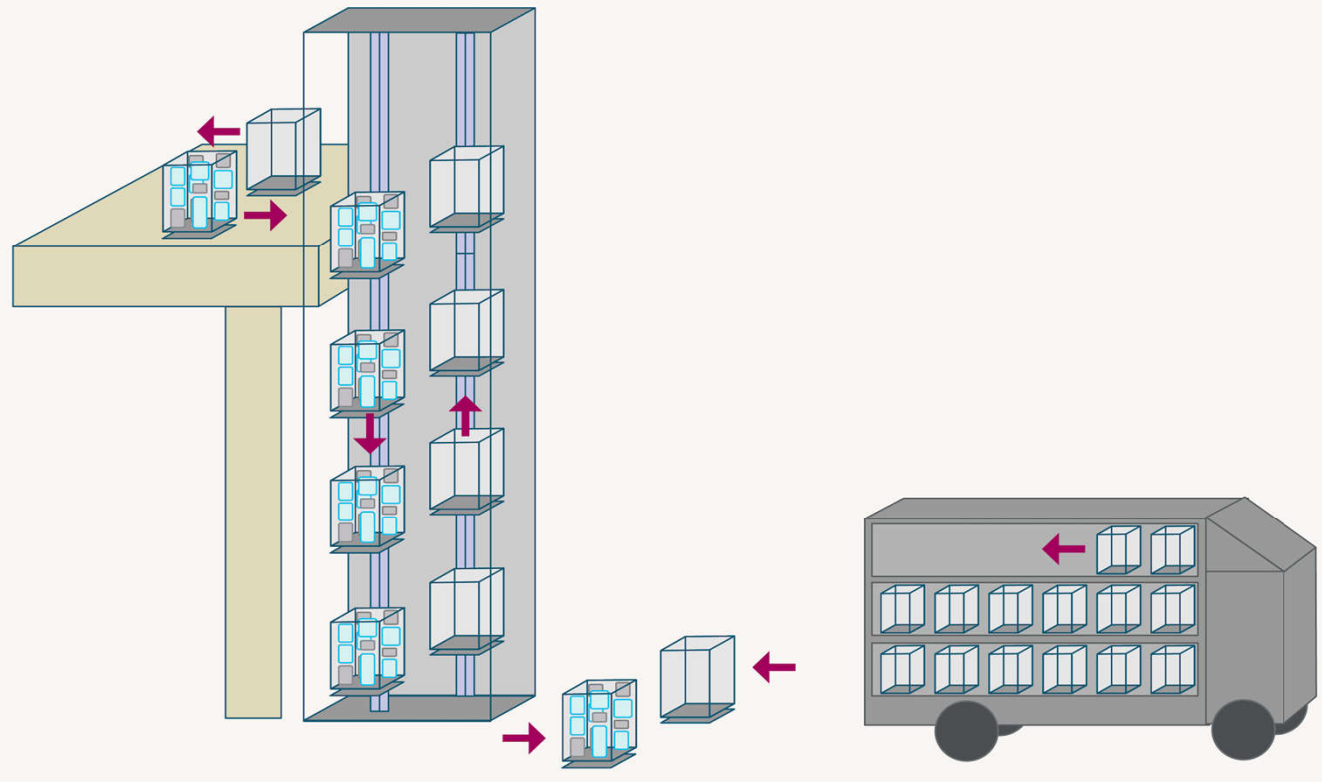
Since the Renomat inserts are comparatively small, each Renomat vehicle can operate with three levels: When the refuse truck sets off, it is filled with empty, clean inserts. Empty inserts are exchanged with full ones during the journey. The exchange is carried out by means of a reloading system in which full inserts on one side and empty inserts on the other side are transported up or down via small lifting platforms (similar to the elevators attached to automated racking systems).

A total of 108 inserts (width x length 40x40cm) can be transported in a pickup truck with 3 levels, each with an area of 12 square meters. If 35,000 bridge residents, living on average in pairs, need 2 inserts per week, then 35,000 inserts must be exchanged every week. This equates to approximately 280 exchange trips, or 40 per night. If each car makes 2 complete exchange trips per night, then 22 pickup cars are needed, plus 1 if another fails.



At the end of the bridge arms, the Renomat inserts are driven to trucks that take them to the municipal disposal unit - the separation point

At the end of a bridge arm, the full Renomats leave the bridge vehicle. Via a freight elevator, they travel to the road below the bridge, while empty renomats are brought onto the bridge from below. The latter are taken to the bridge houses and are thus available to the residents again. The full renomats are transported in a truck to the municipal disposal unit, where they are emptied and cleaned to return to the respective manufacturers of the food or drugstore products they came from. There they are cleaning according to the respective hygiene regulations and are refilled.

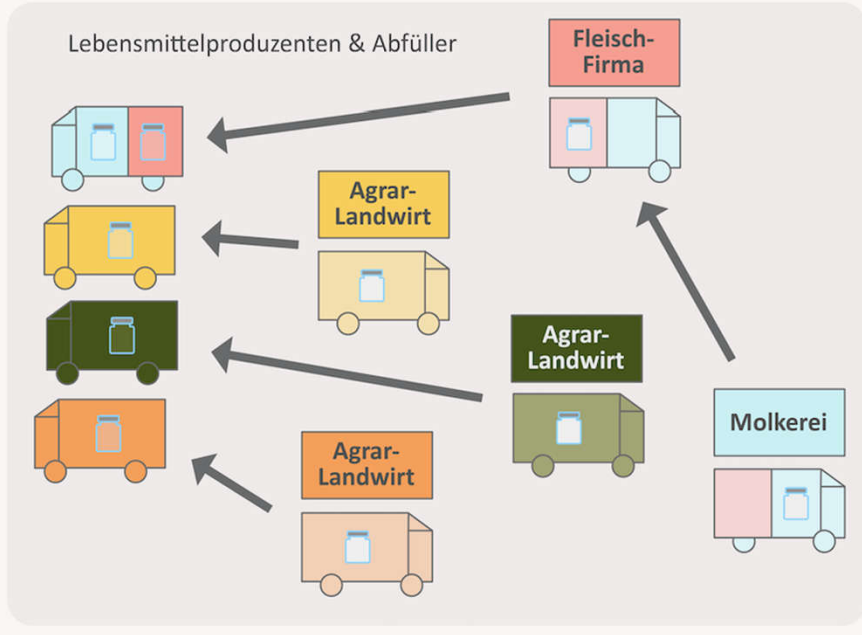


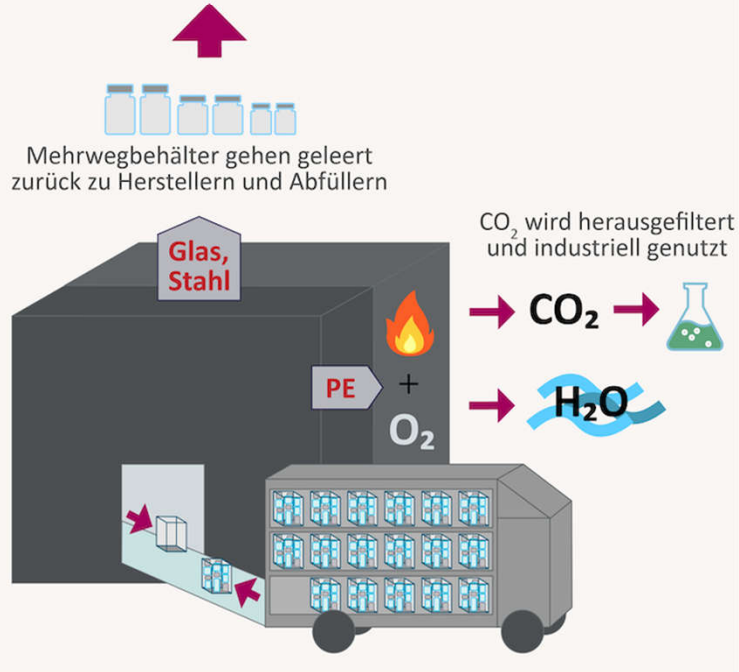
Brought down from the bridges, the separation, forwarding or disposal of the packaging takes place

At a certain unit of the municipal waste disposal company (FES in Frankfurt am Main), which is specially aligned for the Renomat contents of the Frankfurt Bridges, the Renomat inserts leave the truck. The full Renomaten inserts are emptied - care is taken to ensure that the deposit containers made of glass remain intact. The Renomat inserts are cleaned separately and transported back to the bridges.

Meanwhile, the various returnable containers are sorted, pre-cleaned, disinfected with UV radiation and thus prepared for transport. This is because the final cleaning before refilling does not take place at FES, but at the manufacturers, who also refill the deposit containers with their respective products.

All PE packaging is separated from the reusable containers and thermally recycled, i.e. incinerated. Since only one type of plastic is now involved, a standardized CO_2 filtering process can be established. This means that the CO_2 can be reused - and is not released into the atmosphere. Incineration can take place at municipal waste management plants if there is a CO_2 collector in the immediate vicinity, or it can be transported to companies that process CO_2 to be incinerated there first.





The standardized reusable packaging system of the Frankfurt Bridges also reduces the empty run rate of trucks

The share of empty runs by German trucks on the roads is just under 40%, since after delivery of goods to retailers or their storehouses, on the return trip, in more than half of the cases no goods are transported back.

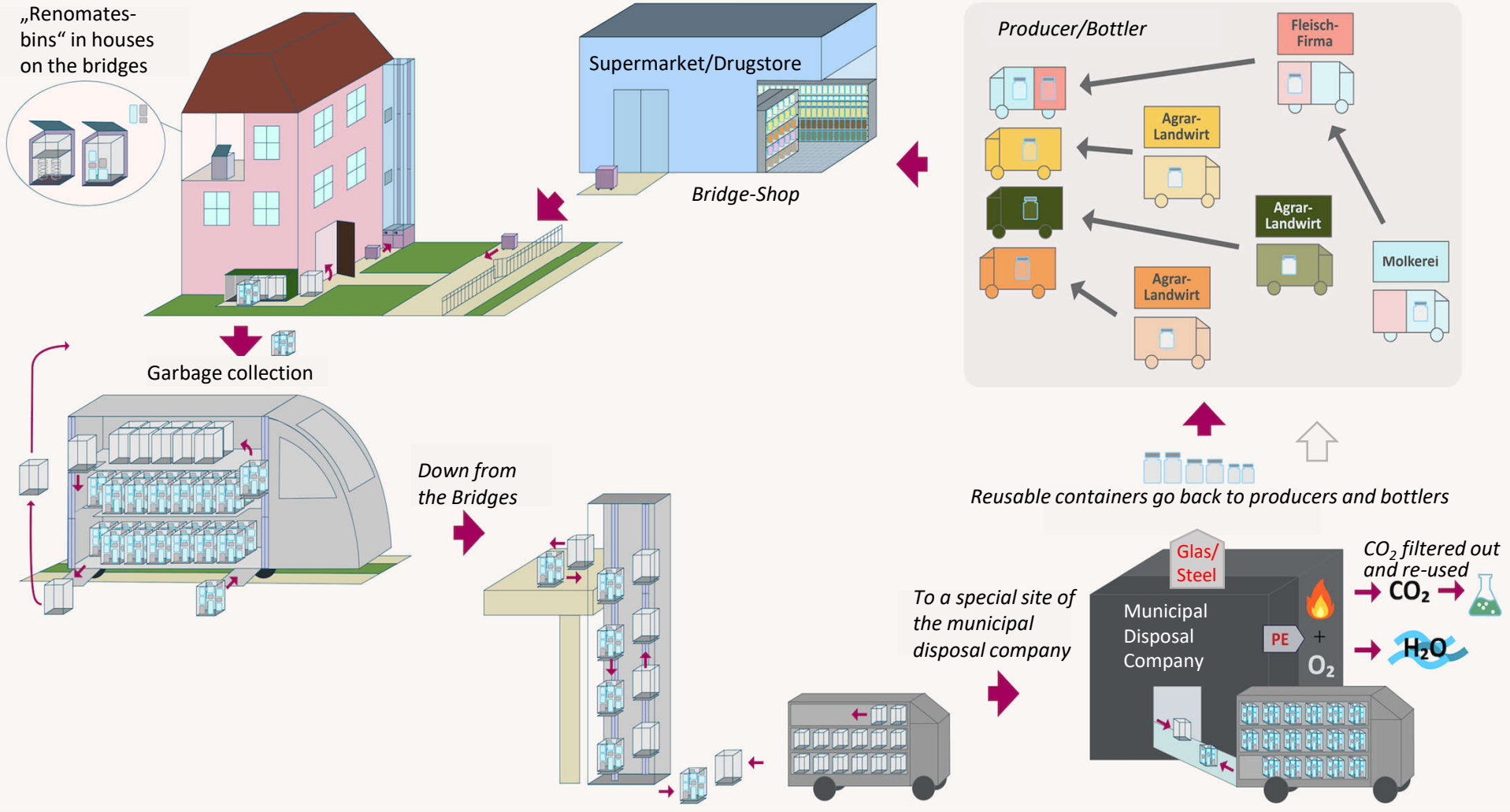
On the Frankfurt Bridges, the reusable containers made of sturdy glass or wafer-thin enameled steel are diverse, but ultimately still limited in their designs: Many models can be used by a wide variety of product manufacturers for filling or packaging.

In the case of the bridge's reusable containers, this enables an optimized circulation system: The trucks of the companies that previously supplied the bridge stores with goods pick up the pre-cleaned reusable containers suitable for their products for the return trip, which would reduce the current empty trip rate.

The companies then take care of industrially cleaning and refilling the containers.

The whole packaging system automatically favors primarily manufacturers from the region and then manufacturers from Germany or Europe.

The circular system of the bridges completely covers the entire reusable cycle as well as the sustainable disposal of PE packagings



Deposits will be refunded only if reusable containers are treated considerately

The scan code on the packaging is not only used for product information and payment, but it is also part of a deposit system: When shopping, the code is scanned and the corresponding deposit is deducted from the bridge card. As soon as the container has been returned in one piece, the deposit is credited back to the bridge card.

The deposit per package varies between 5 cents and 30 cents. It is estimated that 30 reusable packages are in use per person each week, of which around a third remain in the household for longer periods with longer-lasting products (e.g. flour or rice), so that only 20 reusable packages are in permanent rotation.

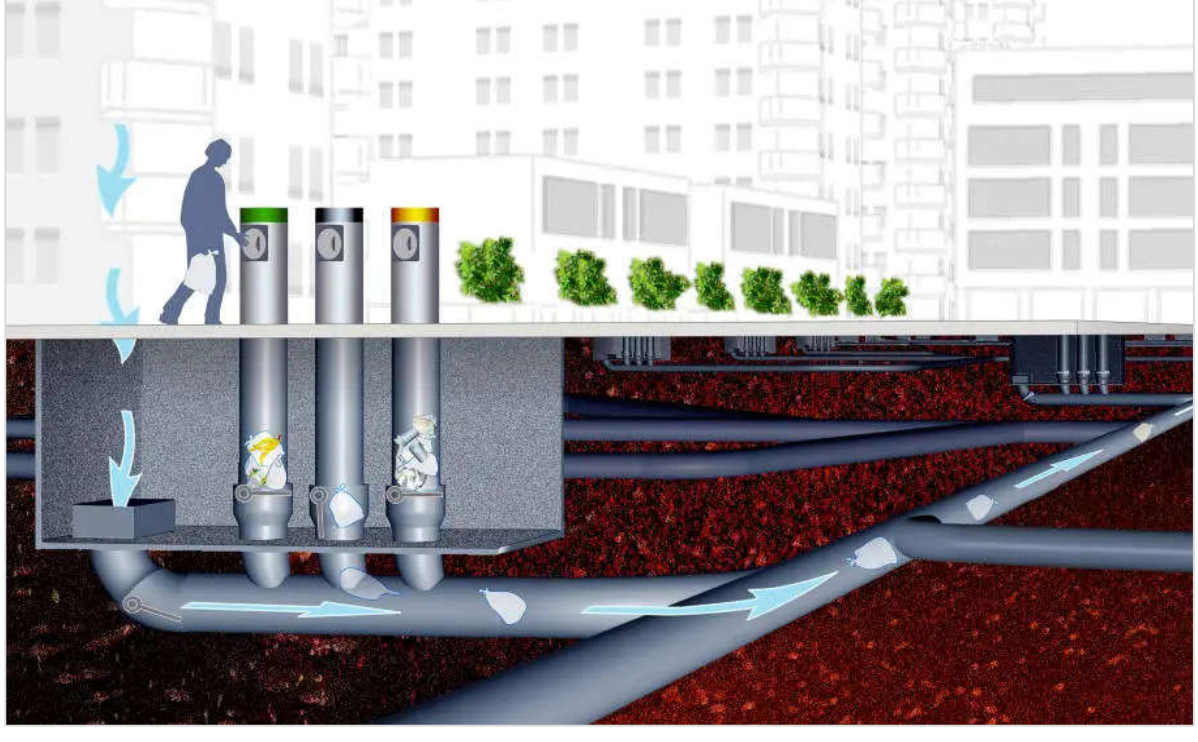
To ensure that people living on the bridges as well as residents along the bridges do not find the system on the bridges more expensive than supermarkets in the wider city area, they receive a start-up deposit credit on their bridge card in the deposit equivalent of 150 euros.

The background to the measurement is that it can be assumed that each person has approx. 20 packages in use per week. If they did not return any deposit packaging over a period of approx. 6 months, but kept it in their home, they could theoretically (26 weeks x 20) accumulate 520 returnable packages there. Assuming an average deposit value of 30 cents per package, someone could hoard packaging for 156 euros before being forced to return it to the cycle: This is because once the deposit credit is used up, one must pay the real deposit for all reusable packaging with every purchase. But if you have always returned most of it undamaged to the cycle, the deposit credit is always replenished.

Everything that is booked on the bridge card over and above the €150 starting credit can be paid out in cash - except for the initial bonus, which can only be "used up".

35,000 bridge residents produce over 20,000 tons of waste per year - with bridge visitors and businesses, it's likely to be almost double that: The Renomat system can only handle part of it - for the rest there is another innovative solution: pneumatic waste disposal tubes

A large part of conventional packaging is eliminated through the system of reusable f glass and metal containers as well as pure PE packaging in the Renomats. However, plastic packaging of products purchased outside the Frankfurt Bridges and their neighbourhoods, paper waste and organic waste as well as residual garbage will remain until the nationwide roll-out of the bridges' packaging system in the distant future. For these four categories of waste, a system of pneumatic tubes is to be installed, to which public waste garbage cans as well as waste bins on the bridge-properties will be connected. These tubes will suck the waste from the garbage cans (like pneumatic mail tubes) and transport it to large containers, where it will be compacted so that the filled containers can be taken away.



In order to dispose of the four types of waste (residual waste, foreign packaging waste, organic waste and paper waste) separately, you do not need several separate pipes, but valve flaps on the downpipes of the waste garbage cans are controlled in such a way that across the entire bridges, the valve opens towards the main pipe for only one type of waste at a time and the waste is sucked away

Accordingly, , the waste arrives separated in batches at the large container receiving stations, which are mainly located on the east arm of the Frankfurt Bridges in the immediate vicinity of the FES: It is then compacted there per container to be taken to the appropriate FES processing sites

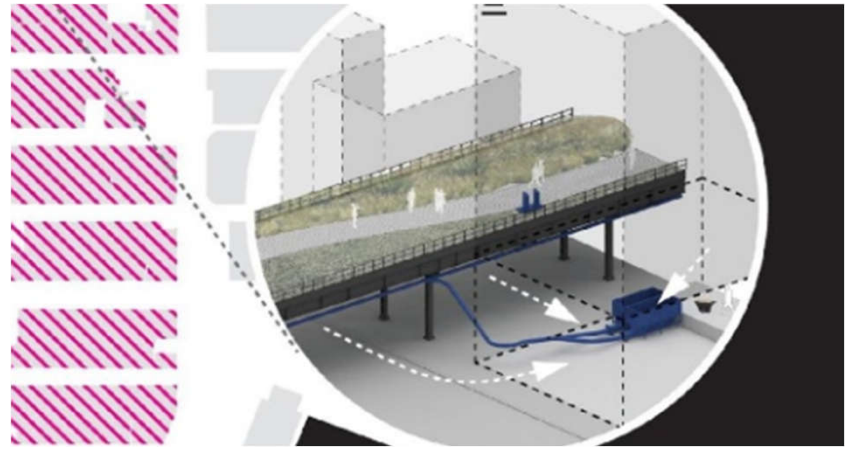
What sounds like dreams of the future is already reality in Scandinavia, the USA and above all in Asia

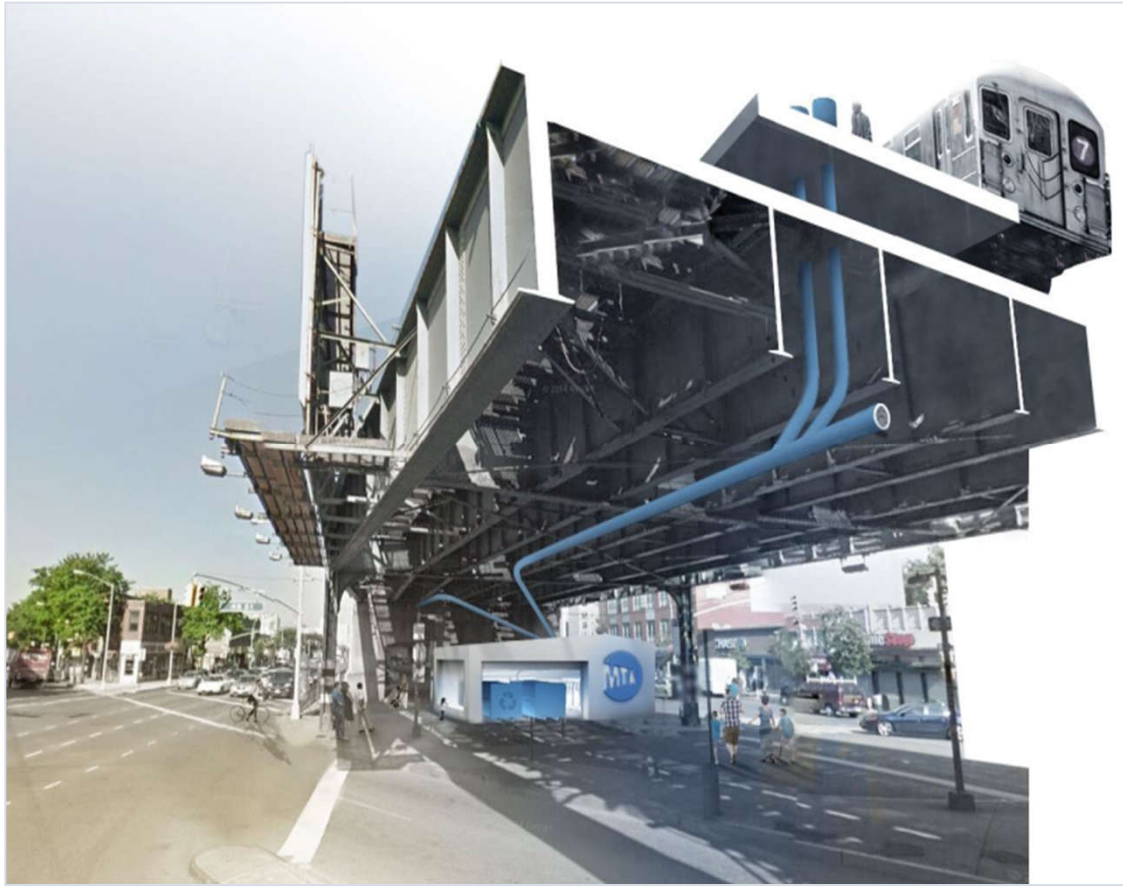
The pneumatic waste collection systems, first developed in Scandinavia, are, of course, mostly used in new construction areas, as it is difficult to create a pipe system under an existing dense development. As early as the 1970s, such a pneumatic waste pipe system was installed in New York during the redevelopment of Roosevelt Island.

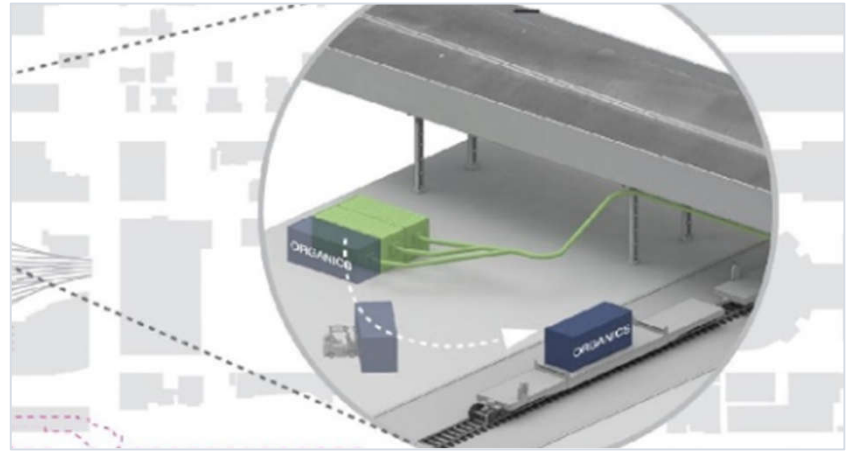
Modern smart cities such as Songdo near Seoul, for example, plan waste disposal with the aid of pneumatic tubes right from the start in order to avoid cumbersome systems with garbage trucks in these (mostly low-car) new development areas.

In New York, a pneumatic waste pipe is currently being planned, attached to the bottom of the NY Highline

Depending on the section and local conditions, it must be examined in detail where the waste can be channeled to, and where it can be directed to (intermediate) larger containers for further transport.







New York's final case study of this project from 2019 concludes that this waste system can save nearly half of all costs (primarily energy and labor costs) as well as significant amounts of CO2

The savings from eliminating garbage trucks, personnel, and also mitigating congestion on the roads stands to reason. In addition, however, there is a special sustainability effect due to a separate pneumatic pipe for biowaste - be it catering waste, takeaway leftovers or the organic waste from households: The biowaste is piped to small biogas plants at the ends of the bridge arms for energy recovery. According to the calculations of the New York study, the resulting electricity can cover the energy required for the pneumatic system and its control units. For the Frankfurt Bridges, it would be necessary to analyze or simulate in the course of the preliminary planning to what extent this effect can also be achieved for them.

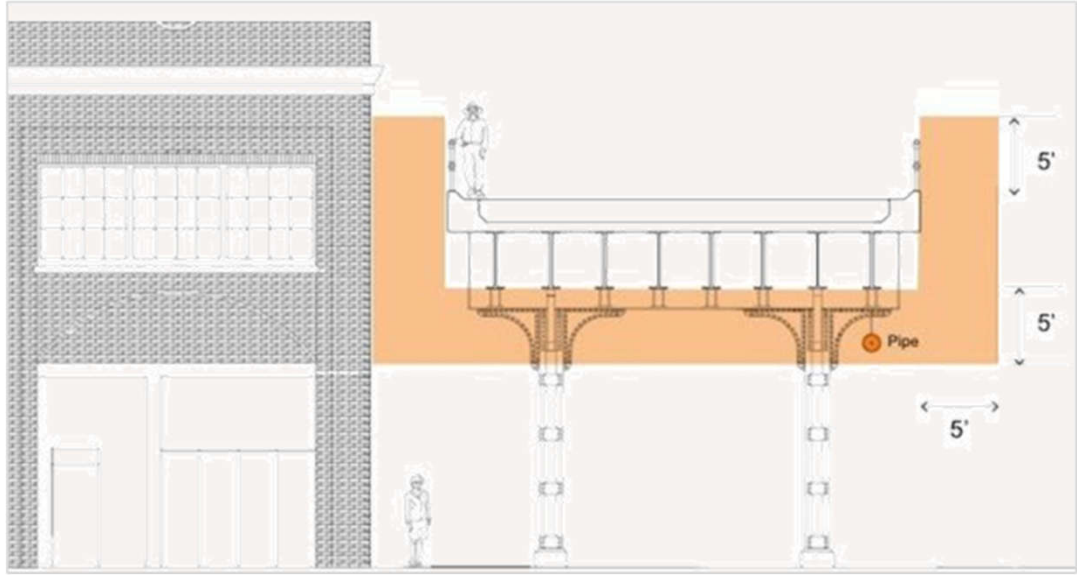
Special solutions must also be developed for sturdy paper and cardboard

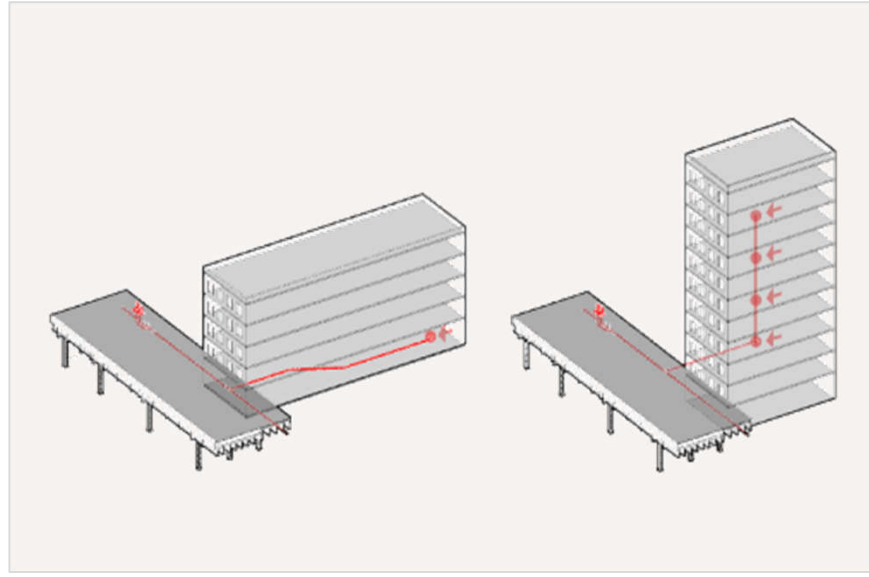
A high volume of online shopping is to be expected on the Frankfurt Bridges, and with it considerable quantities of cardboard and cardboard waste. Having them removed by personnel on the bridges and then transported by elevators to the ground level to paper containers (as it is still the case with waste on the NY Highlines) is costly and energy-intensive. Nor can they be easily disposed of in appropriate waste containers in the pneumatic tube system, where they cannot be smoothly extracted, but must first be shredded. For this purpose, shredders are installed at regular intervals on the bridges. Half of these shredders are sunk into the substrate, and are thus not very high and do not take up much space: The cardboard shredded there can then also be transported through the pneumatic main tube to the disposer at the ends of the bridge arms.

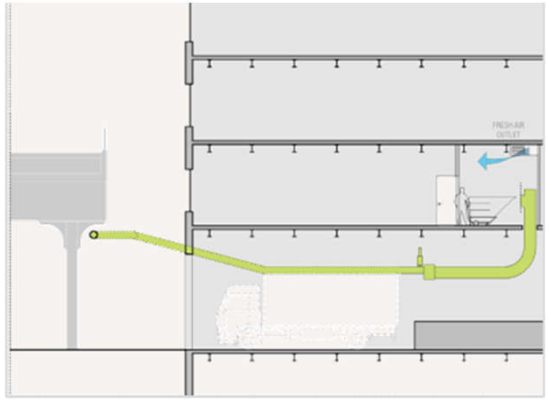
However, the pneumatic drop tubes of the Frankfurt Bridges differ from those of the NY Highline in two respects

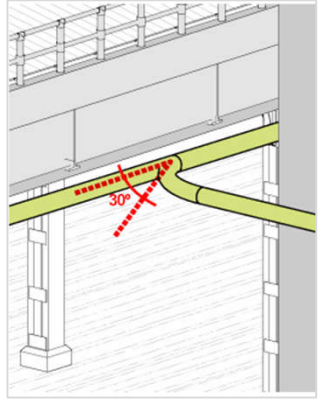
(1) They are not simply hung visibly under the bridges, but are integrated in an aesthetically pleasing way, and

(2) they only serve the Frankfurt Bridges: Neighbouring buildings will not be connected as well, since they are too many meters (at least 7m) away from the bridge corpus of the Frankfurt Bridges (unlike the NY Highline) - even at the narrowest points.









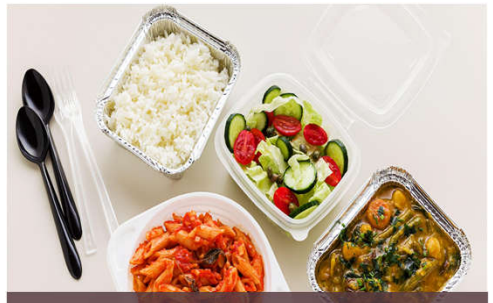
Conclusion: The innovative recycling system is space-saving, unobtrusive, environmentally friendly and includes a comprehensive deposit system

Beautifully designed renomats, quiet nightly collection on mobile pallets and careful handling of reusable packaging characterize the recycling and deposit system of Frankfurt Bridges.

The entire system is successively transferable to the surroundings of the Frankfurter Bridges and the city. In principle, everyone can participate in the reusable packaging from the beginning via the deposit system, but they still have to bring their reusable packaging back to bridge stores until the bridge collection system is also introduced in the extended city area one day.

The sophisticated packaging cycle with a large proportion of reusable packaging relieves the bridges' waste system so that the remaining types of waste can be disposed of by pneumatic tube systems.

Old New Territory
Frankfurt



Putting an end to plastic takeaways

Supermarket and drugstore

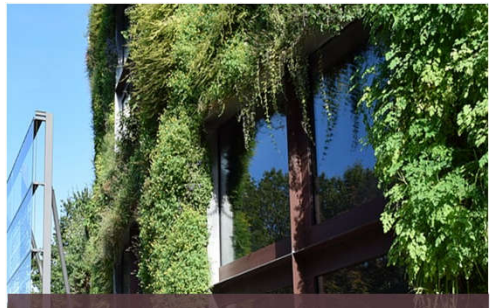
Packaging - suitable for the product

Diversity desired

Shopping in the future

The Master Academy

Special quarters



The green metropolis of the future

TEAM MEMBERS

Architecture	Geoinformation	Urban climate - world climate	Water	Law	**Critical sparring partners:**
Image & photo	Green & Nature	Statics	Packing	Finance	Professors
Bridges	Communication	Transportation	Webpage & Design	Implementation	Professionals
Energy	Art & Culture	Technology & IT			Inspirers & Supporters