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PACKAGING DESIGN THAT REDUCES FOOD WASTE AND INCREASES RECYCLING

Why read this report?
This report highlights the connection between food packaging design and food waste among end users. It analyses the delicate cost-benefit balance between the environmental impact of packaging and the impact of avoided food waste, and how packaging design influences recycling outcomes.
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Introduction

The development of packaging is one of the reasons for the emergence of the welfare state. With increasingly sophisticated packaging, food could be eaten long after it was harvested or slaughtered, and at great distances from where it was produced. Packaging was a boon for human development. However, in recent decades, packaging has seen its reputation increasingly tarnished and its merits forgotten or taken for granted. Media coverage about plastic in the oceans in particular has fuelled this debate.

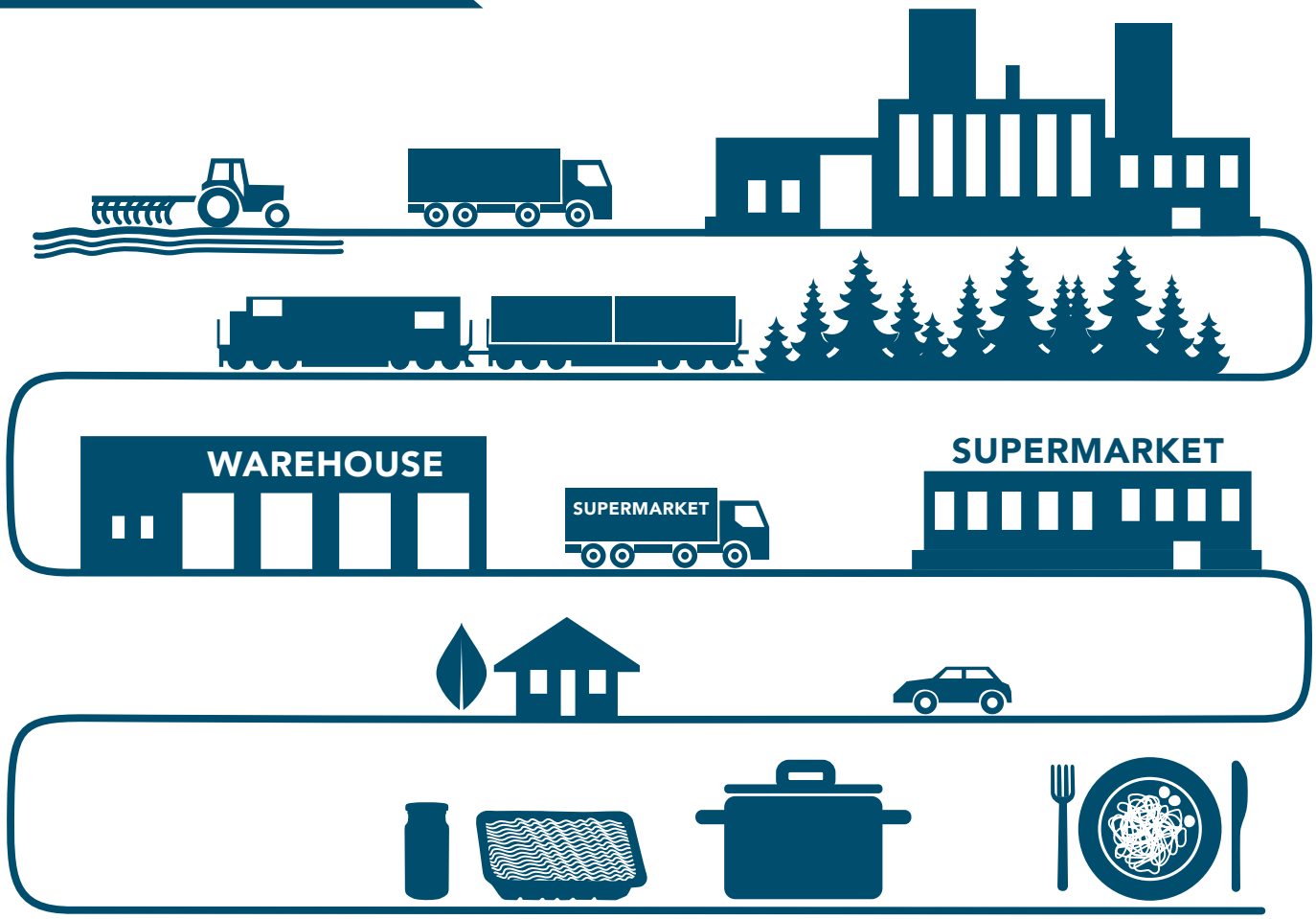
This has created environmental sentiment against packaging which in recent years has resulted in bans on certain types of packaging in some countries. Growing numbers of people are talking in terms of packaging-free stores as part of a green vision for the future. However the consequences of such measures on food waste are rarely discussed. And if packaging is an environmental problem, it is nothing compared to the threat food production poses.

Our food: the real climate threat

Food production has the greatest impact on the planet's ecosystem of any sector of the economy. The production and consumption of food causes a third of human climate impact, 70% of fresh water use, and is the single biggest cause of species extinction and eutrophication. It is therefore not surprising that food plays a key role in Agenda 2030 with the specific goal of halving food waste by 2030.

Food packaging emerged specifically with the aim of providing food safely and to reduce food waste. Improvements to food packaging have focused on preserving food for as long as possible in unopened packaging. There are many more characteristics of packaging that affect food waste, especially in households. However, there has been no incentive to develop packaging to help consumers throw away less food. Reduced waste means reduced sales, and as long as consumers do not demand such packaging there is nothing to gain from being the first to make it available.

8–10 % OF GREENHOUSE GAS EMISSIONS ARE DUE TO FOOD WASTE



But the more food waste becomes an issue, the more likely it is that packaging's role in helping to reduce food waste will attract greater attention. When this happens, it may happen quickly. This report is primarily for those who want to learn more about how packaging can reduce food waste. The challenge is to strike the delicate balance between packaging's environmental impact and to what extent food waste can be avoided. This is especially complicated because the environmental impact of different foods varies considerably, as do the reasons why different foods are thrown away. It is easy to be discouraged by this complexity, but with relatively small efforts it is possible to improve the current situation.

This report provides an introduction to how characteristics of food packaging influence the amount of food waste in households and when it may be justified to use more packaging material to reduce food waste. And when it isn't.

One chapter of this report is devoted to the packaging characteristics that make consumers choose to source sort or not. There is no point in developing fantastic technologies for material recycling if the packaging ends up in the bin.

Packaging features that affect food waste

Packaging has a range of technical features to protect food from contamination and degradation. Today's packaging rarely causes food waste due to insufficient technical protection – before packaging is opened. However, it is common for food to be thrown away from opened packaging for many different reasons. To develop packaging that helps to reduce food waste in households, it is not enough to focus on the protection of food in unopened packaging. We need to learn more about how consumers use packaging and more about the needs of consumers.

In the supermarket, we want to easily recognise products so that we can buy the foods we want, and we

want to receive information about their contents, especially if we are allergic to something. At home, we want to know when food is safe to eat. We want a reasonable amount of food, so we have time to eat it before it goes off. We want to be able to completely empty packaging of food. We want packaging to protect food while it is in the fridge or cupboard. Sometimes we want help measuring the right amounts of food, and packaging should be easy to open and handle. When packaging has served its purpose, we want to be able to sort it quickly and easily for recycling.

The two most important concerns to address with a view to reducing food waste are that packaging must contain the right amount of food and that it must provide information on how long the food it contains can be safely eaten.

As discussed above, packaging has been well designed to protect food – in unopened packaging. As soon as packaging is opened, the level of protection deteriorates, and biological breakdown is accelerated by incoming oxygen molecules. Fresh produce typically goes off when consumers open the packaging it is contained in, use some of the contents and then put the packaging back in the fridge. Before you know it, you have a half-empty pot of creme fraiche with specks of mould on it or salad in a bag with a texture that is more like children's slime than food. Bagged lettuce is a classic example of where delicate lettuce is packaged in a protective atmosphere – a protection that is abruptly broken when the packaging is opened.

Packaging sizes impact food waste

The amount of food in packaging can be decisive for how much of the contents is thrown away. Given that the number of people per household has decreased over several decades – in Berlin and Stockholm, for example, about half of all households are single occupancy households – it is clear that the amount of food in packaging is often too large. And this is not purely the fault of food producers. Another explanation is our focus on comparing prices. When we choose larger packaging sizes, we feel as though we get more for our money. But when we then throw away that food because it has gone bad, we tend not to perceive that as a cost. Mouldy food no longer has any value to the consumer. In addition, few people associate their food waste with the size of packaging or that perhaps they bought too much. You just blame yourself. Or your partner.

Overly large amounts of food results in food waste and sometimes additional energy use. For many consumers, the amount of bread in a single product is too much for them to eat before it dries out and becomes unattractive. Consumers can solve this problem by freezing bread, removing individual slices, and toasting them. However, this means that electricity is used unnecessarily, especially for the toaster – and this is not insignificant! It would be much smarter to buy half the amount of bread at a time and avoid using the freezer and the toaster. Unfortunately, the number of supermarkets has decreased in recent decades – for many people, it's no longer straight forward to stock up on more bread from the corner shop – and then the freezer becomes a rational choice. There are a lot of factors at play here.

Misunderstanding best before dates

In addition to quantity, another major cause of food waste is consumers misunderstanding best before labelling. Many people think that the best before date shows how long food is safe to eat. We assume you know this, but if not: for best before products, it is fine to smell and taste the contents of products. Your senses will tell you if a food should not be eaten long before it becomes dangerous. There are of course exceptions if you have a reduced ability to smell and taste. Other exceptions include pregnant women, who should be a more cautious. Some foods are marked with a use by date, and these should not be eaten after the date shown.

What can food producers do to help consumers better understand date labels? In Norway and the UK, an addition has been successfully trialled: "not bad after" on the label to indicate that the food does not automatically go bad after the date shown. Companies in Sweden have also been allowed to make such additions since 2018. Dairy co-operative Arla has chosen to add "often good after" next to the date, for example.

For some products such as milk, there is space to provide information on packaging. Why not provide consumers with information that you can drink milk as long as it smells and tastes good, and that it is possible to make pancakes with milk that has started to go sour? Where there is no space for text, would a QR code be a suitable alternative? Producers could probably communicate more often on products and their websites about the sustainability characteristics of different products.

However – it is not easy for individual food producers to do this on their own. To have a greater impact, it will probably be necessary for food producers, authorities and environmental organisations to work together to obtain more knowledge about how long food actually lasts and how lower temperatures in refrigerators can extend shelf life.

Portioning and resealing may be good solutions

There are other needs to be met in addition to quantity and date. Cheese dries out easily and considering its high climate impact, it perhaps deserves packaging that can be resealed. Some consumers address this themselves with yet another plastic bag – talk about unintended consequences – or stuff the cheese and its packaging in some tupperware. Coffee and ham are two other products where resealable packaging would preserve the foods better.

Considerable improvement potential also exists in developing information on amounts of food. Large amounts of pasta and rice are thrown away because consumers are unsure of how much to use. And what is a normal portion, anyway? Is it suitable for a hard-training judo girl or for a sedate pensioner? (We know that not all pensioners are sedate...). Here too, a QR code could provide more detailed information.

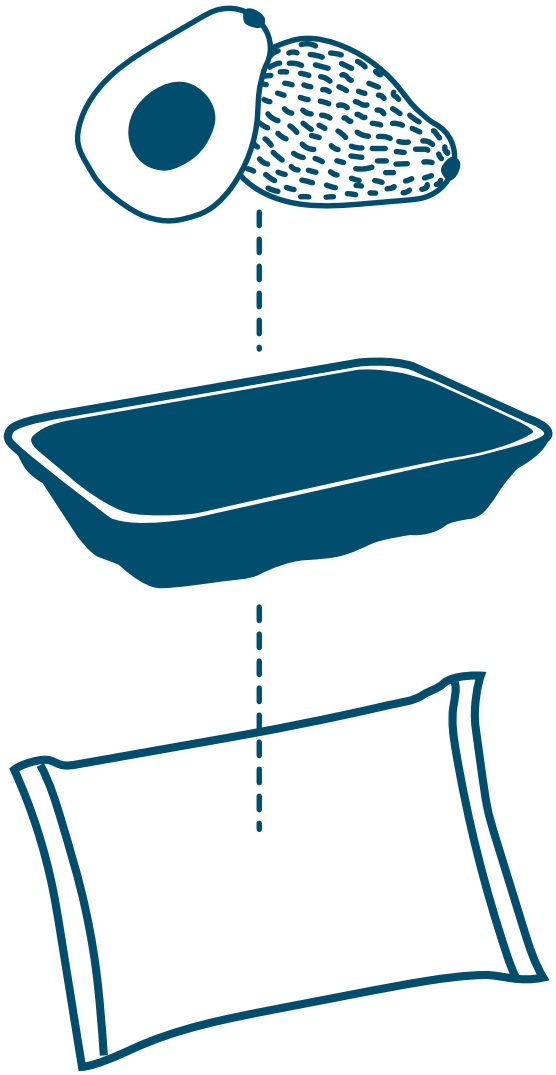
Neither should we forget that packaging must be easy to use for people with different abilities, for example opening packaging causes some problems for people with reduced hand strength. In addition to negative social aspects, some food waste occurs in

GLOBALLY, ABOUT 74 KG OF FOOD IS THROWN AWAY PER PERSON PER YEAR

conjunction with opening packaging when the contents spill out or a bag breaks. For the latter to happen, you don't need to have reduced strength. It can happen to anyone.

The reasons why food is thrown away vary for different products. To develop packaging that reduces food waste, a packaging developer needs to understand more about why specific food products are thrown away and to what extent.

LARGE PACKAGING CREATES MORE FOOD WASTE



Does it make sense to use more packaging material to reduce food waste?
Ideally, it would be possible to change packaging design so that food waste was reduced at the same time as packaging's own environmental impact is also reduced. Often, however, you end up in a difficult trade-off: to achieve reduced food waste, more packaging material is required, for example in the case of smaller packaging sizes or adding resealing functions. Then the delicate question becomes how much packaging material it can be environmentally justifiable to add.

To tackle this issue, first we need to know how much reduced food waste it is reasonable to expect from a new packaging solution. The first step is therefore to map how much of a given product is wasted today and why.

Once the level of food waste and the causes of the waste have been identified, it is time to form an opinion about the environmental impact of the food and the packaging. The environmental impact of food is complex and includes climate impact as well as species extinction and much more. However, it may be sufficient to analyse the climate impact alone. If more packaging material can be defended from a climate perspective, it is very likely also better for biodiversity, eutrophication, etc., because food production often affects other environmental factors significantly more than packaging materials.

Food's climate impact determines packaging choices
For foods with a considerable climate impact, such as meat, fish and dairy products, it is almost always justified to add more packaging material if food waste is reduced. On the other hand, for food products with a low climate impact, it can sometimes be wise to focus on reducing the climate impact of the packaging even if food waste increases.

The ratio between the climate impact of a food and its packaging serves as a useful guide to which strategy is best suited to reducing the product's total climate impact, including food waste. In the figure below, the ratio between the climate impact of the food and its packaging is shown for a selection of products. For products with a quota of around 100, you can safely add packaging material if food waste can be expected to decrease.

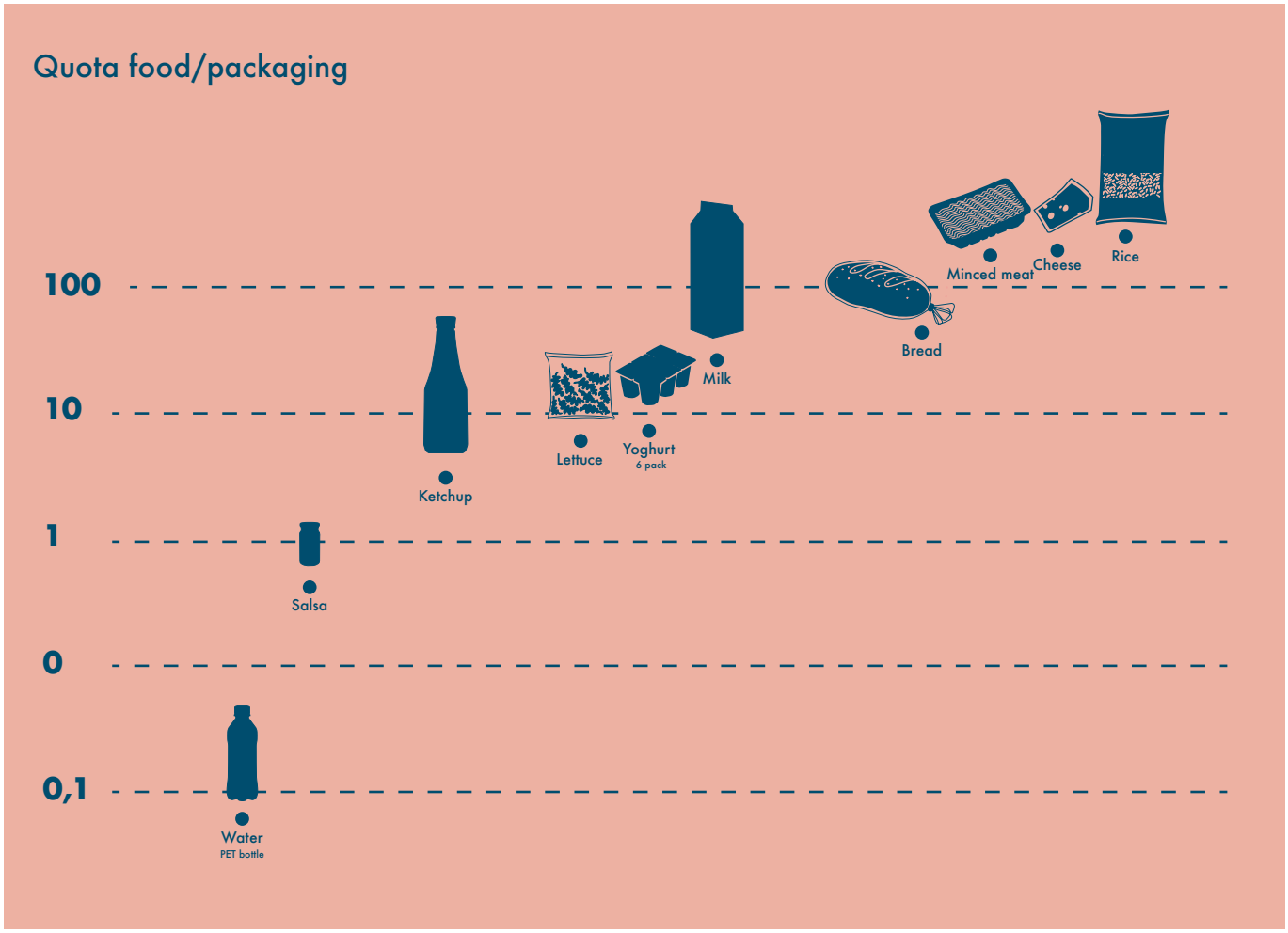
In that case, a reduction in food waste of one percentage point corresponds to a doubling of the climate impact from packaging. (To be precise, this ratio also depends on the scale of the initial food waste.)

When this quota falls to 10, a substantial reduction in food waste is needed to justify more material per packaged item, alternatively very modest increases in the packaging material's climate impact. When the ratio is around one, it is the packaging's environmental impact that should be reduced. The extreme example is bottled water, where packaging accounts for more than 90% of the product's climate impact. Perhaps we should introduce a refill system for this type of product?

Difficulties associated with calculating the environmental impact of materials

It is not that difficult to find environmental data on the production of various packaging materials. It is considerably harder to find data for the recycling step – and without this it is not possible to obtain an accurate picture of packaging's environmental impact. On the one hand, there are uncertainties associated with how much of a certain packaging will be source sorted by consumers (more on this in the next section). How much of the packaging that is collected can be separated into pure material fractions? For a liquid carton with a screw cap, for example, the screw cap and the plastic film on the inside of the packaging will not be recycled for its constituent materials but will go to incineration, (although at the time of writing, there is a lot happening in this space). What is the environmental benefit of incineration? If fossil energy is replaced, it is easy, but in the Swedish system it is usually bioenergy that is replaced, so carbon dioxide emissions are reduced marginally. On the other hand, biomass could replace other energy if it is exported, or replace fossil material in other products.

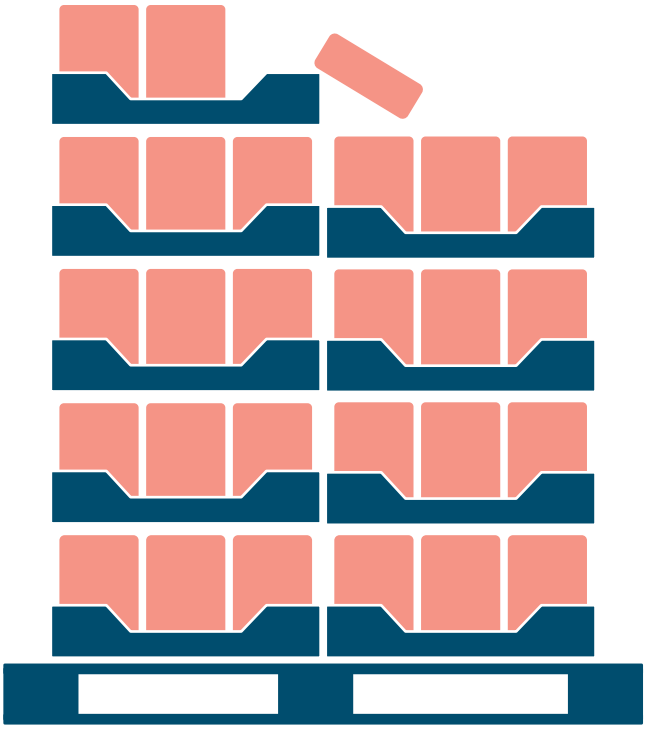
How should the environmental impact of material production and final incineration be distributed between products made from virgin and recycled materials? The results from different life cycle analyses vary widely on how this distribution should be made, which is itself based on subjective valuations. If you want material recycling to appear good, you can show that; if you want to show the opposite, that is also possible. This is an issue that researchers grapple with. At present, we simply have to accept that all recycling data for materials' environmental impact is inconclusive.



Functional losses limit material recycling
What is the material quality of sorted materials? Alloys and laminates often result in quality losses, which means that they cannot be recycled that many times. The small percentage of plastic packaging that actually becomes material for new products is usually of such low quality that virtually all of these second-generation products are incinerated. But these quality losses are rarely seen in life cycle analyses, where it is often assumed that materials can be recycled multiple times.

How can all these uncertainties be managed?
You can work it out with maths, but it's pretty complicated. We recommend using the precautionary principle: more material should not be used unless a) the food's environmental impact is relatively high; and b) there are good reasons to assume that waste is reduced with a packaging solution. And packaging should be designed so that it has a sporting chance of being recycled into new high-quality materials!

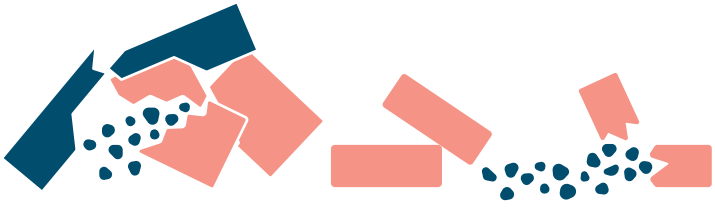
Which packaging material is best?
The answer, of course, is that it depends. All materials have their pros and cons. Glass is attractive because it is easy to reuse and because there can be no exchange of substances between the food and the packaging. Unfortunately, glass packaging is heavy, and its environmental impact increases rapidly when transported. If glass packaging can be reused with short efficient transports, it can be a good alternative, otherwise it is better to choose light packaging materials that are recycled or incinerated. One alternative that would be interesting to look at would be to sell more food in refill packs and pour it into glass containers at home.



In this way, refill packaging would not need to have packaging features for handling, resealing, etc. Paper is a renewable material – the other materials are taken from the Earth's finite crust. From a sustainability perspective, paper is thus the best material. Another advantage is that material recycling already works relatively well today. However, bio-raw materials are a limited resource, so even if a material is renewable, we need to use it responsibly. Paper also needs help from other materials to handle wet food. Plastic - perhaps the most reviled material - is the material that can provide the most protection per gram of material by far. A refill pack for jam weighs 6 grams, while the corresponding glass jar with a metal lid can weigh 200 grams. It is difficult to imagine a future without plastic packaging. However, major changes are required in the entire packaging system to achieve functioning material recycling of plastic - see next section. In the long term, plastics should be made from bio-based raw materials.

Metals have such a high environmental impact that their use can only be defended with an extremely high degree of material recycling. Many metal packaging consists of alloys, which means that their quality is low and that it is unable to survive many recycling cycles. There are plenty of reasons to avoid using metals in packaging.

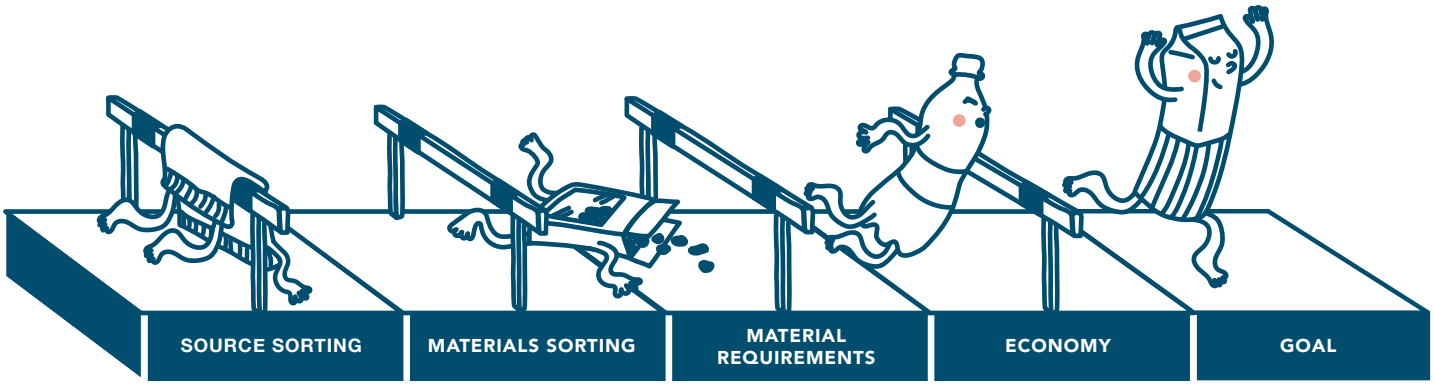
Don't forget secondary packaging!
Secondary packaging – the plastic trays and cardboard boxes in which consumer packaging is delivered – is often overlooked in the environmental debate. However, there are examples of undersized secondary packaging not being able to protect food sufficiently, especially after shipping to wholesalers where a variety of secondary packaging in different formats are piled onto a pallet for transport to individual stores. Less packaging material in primary packaging may mean that secondary packaging has to be reinforced. A packaging redesign may give rise to an unnecessary amount of air in trucks, resulting in increased environmental impact. Worst case, as with some soft drinks bottles, the shape gives rise to unnecessarily large material use and transport inefficiencies.



Designed for material recycling
As mentioned above, a packaging material faces many obstacles before it becomes a new product. Firstly, the packaging must be source sorted and collected. Secondly, it must be technically possible to recycle the materials contained in it. Third, the quality of the recycled material must be high enough to meet the material requirements for new products. Fourth, the recycled material must be able to compete economically with newly produced raw materials. It all sounds rather like to an assault course - see chart below.

To understand what is required to overcome these Material Sorting and Material Requirements obstacles, we refer to the national organisations that are responsible for collection and material recycling.

The economic obstacle depends a lot on political instruments. In many cases, higher taxes on new raw materials are needed to ensure that there are sufficient incentives to develop infrastructure for material recycling.



In this report, we concentrate on the first obstacle, ensuring that packaging is easy for consumers to sort. There is surprisingly little research on how packaging design affects consumers' decisions to sort or not. However, a lot of work has been done on how the design of collection systems affects how people sort, but this falls outside the responsibility of packaging developers, even if it's appearance may be considered.

It must be easy for consumers to do the right thing
You can summarise the little research that is available as that anything that consumer experience as laborious or creates uncertainty reduces the likelihood that packaging will be source sorted. Many people have busy lives and devoting time to working out how packaging should be source sorted is rarely at the top of their list of priorities.

Having to wash packaging is perceived as labour-intensive. Furthermore, uncertainty exists over whether it is environmentally justified to use water and sometimes even washing-up liquid. There is also uncertainty over how clean and dry packaging needs to be prior to recycling.

Separating packaging into different parts and different materials is perceived as labour-intensive. The more parts to a piece of packaging, the lower the likelihood that the entire packaging will be sorted. Sometimes the largest part is sorted while the rest goes into general waste.

There is uncertainty over what materials packaging is made from. This applies especially to laminates of thin plastic, metal and paper layers. More often than not, this uncertainty results in packaging ending up in the bin.

IT MUST BE EASIER TO SORT PACKAGING

Lightweight materials, such as clingfilm, are often not perceived as valuable and go in general waste more often than a heavier material such as glass.

There is also a "yuck factor": if consumers think the contents of packaging are unpleasant, the packaging often goes straight in the bin. This can apply to fresh meat or chicken with a little meat juice left in the packaging or if food has become mouldy in packaging, such as half a tub of creme fraiche.

Recycling instructions must be easy to follow

A study of relatively environmentally conscious people revealed that none of the survey participants read the instructions on packaging about how it should be sorted. This shows how important it is that it is intuitively easy to sort correctly and that instructions are very clear. Despite few people reading instructions, perhaps it would make sense to include QR codes on packaging that explain how to sort in detail. Perhaps this would contribute to spreading the word about how to sort packaging to a wider audience. Different countries are also testing simple labelling on sorting. It will be worth keeping track of how these tests perform.

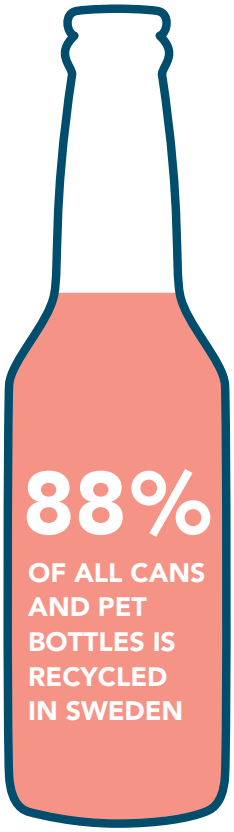
It is positive if materials are recycled, but sometimes you end up in a compromise between making a material recyclable, (mono-material), or minimising the amount of material by making a laminate. Currently, it makes more sense environmentally to prioritise material minimisation over recyclability if you have to choose between the two.

We need to take consumer behaviour into account
The same applies to cases where packaging ends up in the bin because the contents are perceived as disgusting. In such cases, it might be best to prioritise fewer materials than recyclability. At the time of writing, political momentum is shifting towards all materials being recycled, but there may be reasons to think about whether some packaging should be designed for energy recycling.

Good packaging design takes the above factors into account as much as possible. It should be easy and intuitive to sort packaging. Sometimes, other good intentions conflict with source sorting. One company switched from all-fossil plastic packaging for one of its well-known products to one where the top of the packaging could be separated from the bottom and sorted like paper. The intention to use more renewables for this product resulted in making it more complicated for consumer to source sort, which probably leads to more people throwing it straight in the bin. This illustrates the value of testing new packaging designs with consumers to see how easy they think it is to sort.

How do we change perceptions of packaging?
Among many who are environmentally aware, there is a view of packaging as something unequivocally bad or bad for the environment. Few people realise all the functions packaging has in reducing food waste. This means that a packaging developer who wants to increase packaging's environmental impact to reduce food waste has no easy task.

This task does not become easier given the prevailing focus on comparison prices. Convincing people that a packaging saves the environment and money while also reducing food waste is critical in making a product successful.



Collaboration between companies, authorities and environmental organisations is probably needed to change and encourage a more nuanced view on packaging. We look enviously to the UK, where the WRAP organisation has received substantial resources on a long-term basis to work with companies and consumers to reduce food waste. Several of their reports are goldmines for data and for gaining greater understanding of the issue.

Perhaps the need to reduce environmental impact will also lead to more structural changes. Perhaps more local or regional cyclical programmes for standardised returnable bottles would create significantly less environmental impact than the current system? Perhaps we will see a trend towards more and smaller food stores, so people do not to have to drive to do their food shopping and be able to stock up on fresh food more in line with how they consume fresh food? One thing is certain, in the coming decades our view of the food supply will change drastically as climate change and species extinction seriously affect our ability to put food on the table.

Should we package everything in the future?
There is also reason to reconsider which products we should have and package. Bottled water is an example. Maybe we should have reusable bottles and fill them up in stores? Another example is chicken in aluminium trays where the trays are difficult to recycle to high standards due to the alloys they contain. Is the convenience worth the cost?

Vegetables wrapped in plastic often create less waste than those sold without packaging. But should we continue to eat products that have to be vacuum wrapped to stay fresh between producer and consumption? Would more seasonal consumption reduce the need for packaging? In the transition to sustainable development, there are many options that need to be reconsidered.

We hope that this brief report has given you more insights into how packaging can help reduce food waste. What will you take from this report into your daily routine?

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ISBN 978-91-7867-352-0

Ilustration & layout
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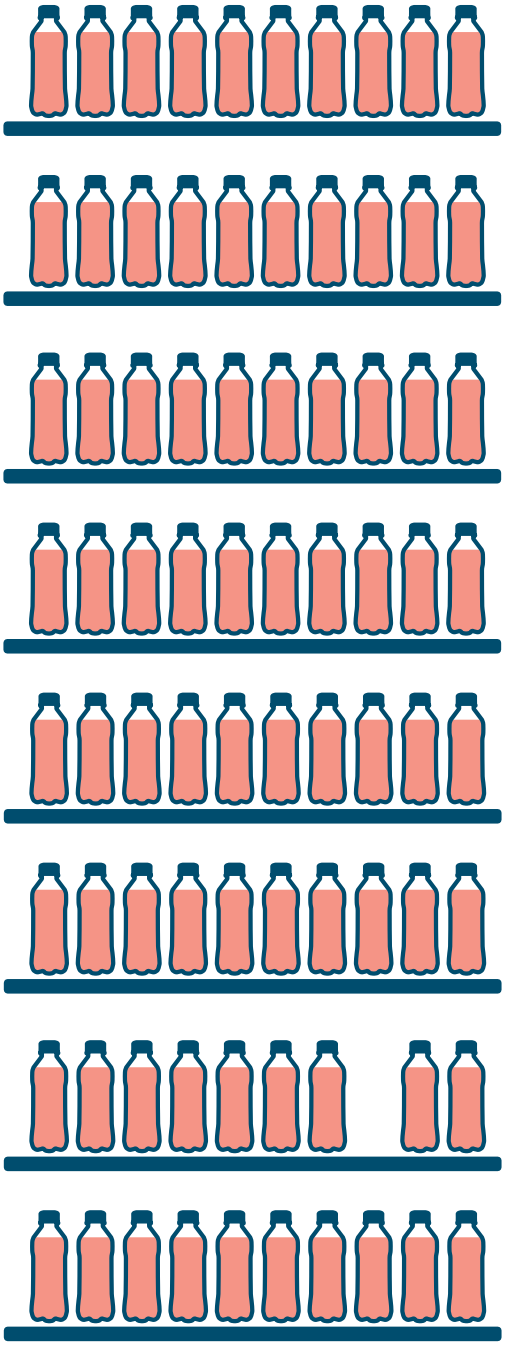
Thank you!
Production of this document was financed by the Swedish Environmental Protection Agency. We would like to thank Åsa Stenmarck for her invaluable input throughout the production of this report. Translation and adaption of the English version of this report was funded by Swedish Forest Industries.

All opinions expressed in this report are the authors' own.

Fredrik Wikström and Helén Williams have for two decades explored the influence on packaging design on food waste in households and the environmental consequences. They are highly cited in academic journals and UN reports. Their mission is to reduce the environmental footprint of the food we eat and are committed to spread their knowledge in the society. Fredrik Wikström is Professor and Helén Williams is Associate Professor in Environmental and Energy Systems at Karlstad University, Sweden.



Further reading:

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