



Green

End of life for circular economy:

End of life for circular economy must be kept in mind while designing, in this case, a product service system. This means that there is thought about the environment consequences and all stages in the life cycle of the product-service system. In our project, there is thought about different questions concerning end of life and other environmental aspects.

1. recycled paper bags or plastic bags?

Why are we using a bag? A bag is used to make for the ease of use during the walking to the next train and next to that to make the hygiene higher and keeps the heat longer around the meal during transporting it to the lockers and to the train.

The choice between recycled paper or plastic give different options and benefits. A recycled paper bag can be made from recycled paper and if it is well separated when throwing away, it can be recycled another time. A plastic bag can also be recycled but this depends on the waste disposal.

The waste disposal depends on the place where the most bags are thrown away. We assume that this will be mostly in the trains or the train platforms. At this moment, in the trains, there is one sort of trash can. The NS and ProRail are taking initiatives right now for collecting and separating trash. This is done in the trains and on the platforms. On the platforms are new trashcans for organic, rest, dry paper and PMD (plastics, metal packaging and drink cartons). This is also implemented in their new trains and will be in every train in the future. There are also promo-teams hired to make people aware of trash disposal and separating in trains and platforms. The benefit of separating trash is that it is more energy-efficient. Separated trash is converted into a raw material rather than a non-separated waste in a few energy steps. Residual waste is burnt, which also gives some energy, but much more energy is saved if the waste can be more easily converted into a raw material for new products. The aim of the NS is recycle 75% of the waste in 2020.

The collection of waste is one point to draw attention to. This collection takes care of the separation already, causing the waste treatment to see more potential in separate materials. Other points to draw attention to is the choice between plastic or recycled paper bag production. The impact on the environment is different for both materials. For the production of plastic bags, greenhouse gases are created and you are exposed to raw material depletion: to create plastic, you need petroleum. For the production of paper bags is ground needed for the production woods. That is why we choose to first of all use recycled paper, so there is needed to only cultivate ground once. For a paper bag there is needed much more material to achieve the same "carrying capacity"



as with a plastic bag. Moreover, with a paper bag, you need them more often, because when it gets wet, you can't use it anymore. These factors cause that the environment impact of paper bags is much higher than that of plastic bags.

With the purpose of why we need bags, all the factors are not that strong to say don't use paper bags. We use the bags for a short time (restaurant to locker - locker to train). When it gets wet, this is for a short time and the firmness doesn't have to be extremely high because it is used for a very short time. Another point is that in the Netherlands, you have to pay an additional amount of money for the use of a plastic bag. They want to reduce the use of plastic bags because when they end up as litter, it takes 35 years for they're gone. Because in the trains and on the platforms, there is a waste separation rise, all the already recycled paper used for bags is coming bag into the cycle where people can recycle and reuse it.

This probably makes it more environmentally friendly than plastic bags.

Any add-on (slogan or text such as: separate me, etc.) that encourages and reminds people to separate the bags would also benefit to the waste disposal and separation. That is why we choose for recycled paper bags for our product-service system.

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2. Materials of the lockers and their end of life / how long is there lifespan

When the locker system is done after many years, there needs to be considered on what to do with it. Every part must be looked at separately on how to recycle or reuse this part or material. To make this the easiest and best recyclable or reusable, it needs to be with pure materials and not composites.

The following materials are used in the lockers:

1. PP (polypropylene)
2. Coated steel, steel
3. Polyurethane Foam (PUR)

There are also recycled paper bags in use in the product-service system. (see also point 1). For each material is looked at the end of life.

1. Recycling polypropylene goes as follows:

First, separate PP from other plastic polymers. This is done by sink-float separation what means that PP has a unique density and therefore floats, while other polymers sink. This is done because in the real world PP is often mixed with PET to produce for example: water bottles. After separating PP from the rest, it must be sorted by colour, because this will increase the value. Next is shredding the colours into flakes. This flakes can be resold as recycled goods. Another thing that can be done after the shredding is processing the PP further into plastic pellets.

This recycling cycle is a closed loop and can be done 4 times. A reason for this is the thermal degradation, what means that heat can make the bonds between hydrogen and carbon become weaker. Of course the PP can be used after the 4 times, but will then be mixed with 'new' plastic (this is plastic that is not been produced by recycling).

The recycling of PP is important because it reduces the consumption of raw and finite sources like oil and gas. 8% of the oil is used for the production of plastics. Next to this, the recycling of PP helps with 88% reduction in energy use for producing plastics. Recycled PP is used for industrial fibres, food containers, dishware, speed humps, etc. That means that when our lockers are ready to be recycled, the PP can be used for new products in a closed loop.



2. Recycling and the end of life for coated steel:

Steel is for almost 100% recyclable and it can be recycled over and over again to create new steel products in a closed material loop. This can be seen in picture XX. Recycled steel has the same properties as the original, 'new' steel. One of the key properties of steel that is a sustainable material because of the durability. It lasts very long.

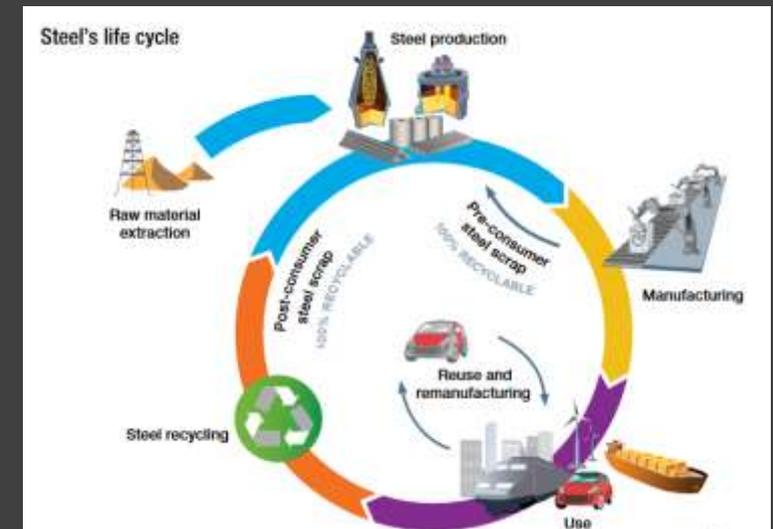
Steel can be reused and recycled. Re-using is the most advantageous one, because there is little or none energy required for reprocessing. Steel's durability ensures many products can be partially or fully reused

on the end of their life. This can extend the life cycle of the steel product significantly..

An example of reusing steel is the following: *Reuse through repurposing involves a specially designed collection and reprocessing system to make the product fit for a new application. The amount of energy and resources required for reuse applications can be significantly lower than producing a new application from raw materials. For example, steel plates used to build ships can be re-rolled and used in the construction of new vessels. The only input is the energy required to reheat, re-roll and transport the steel.* (World steel)

Remanufacturing can also be a part in the material closed loop of steel. It involves the disassembly of a product, where each part is cleaned and examined for damage. Then it can be replaced in a new part or reconditioned to original equipment. This process differs from repair, which is limited to making the product operational as opposed to thorough restoration. Another thing about steel is that steel also facilitates its own longevity. Steel-framed products can be easily adapted if the configuration of the structure needs to be changed. Lockers for example made out of steel can be easily converted into modern shapes or shapes where new technology can be placed in. This extends the useful life of the locker (and the life of the steel it contains) to save resources and reduce costs.

Recycling is also an option for steel. As said before, steel can be recycled for 100%. Steel is separated by using magnetic separation. Recycling steel helps with keeping the value of steel as high as possible to the steel lasts far beyond the end of a product's steel life. In this way, steel remains in the material closed loop.





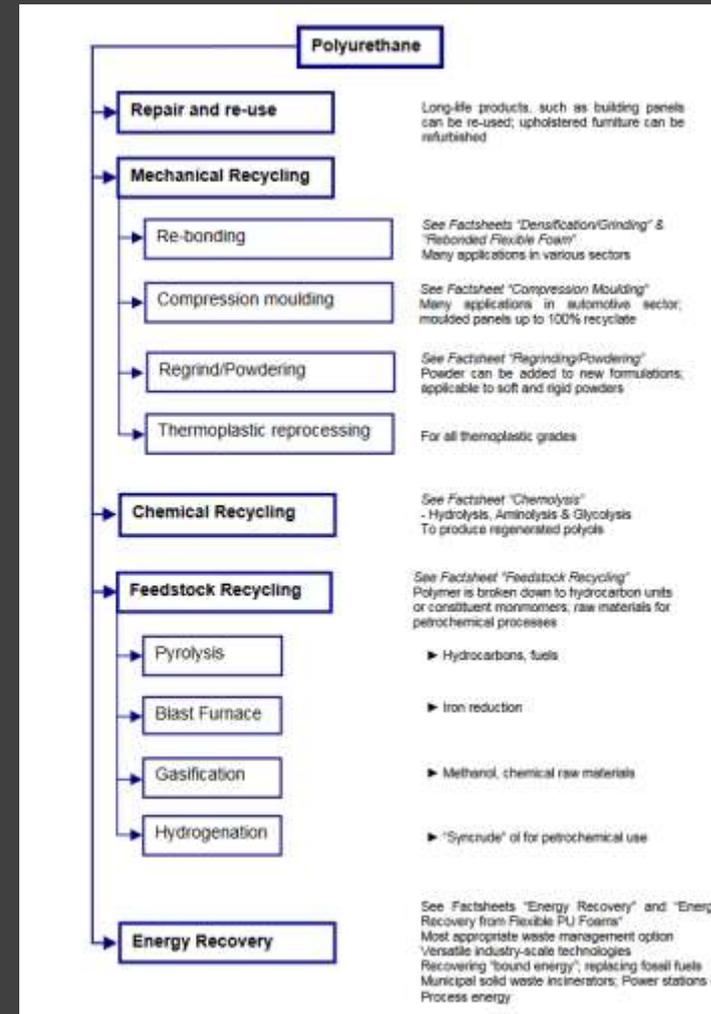
Another advantage next to the end of life and environment is that when steel is in a closed material loop, the price of steel will be low because less raw steel has to be made

3. Recycling and the end of life for polyurethane foam:

Before the end of life of the PUR is reached, it must be said that polyurethane starts with a major advantage: it is made to last as long as the product it is used in, from several years in beds, up to decades for furniture. Another benefit of PUR is that it is light-weighted, what means that it will reduce transport costs.

It is one of the few industries with no production waste because it is very long-lasting and is used in new products. When it comes to an end, there are different ways of recycling and the end of life of polyurethane foam. It can be grinded and re-used or particle bonded. For re-using an example is that PUR is used for carpet underlay. When it is not recycled it can be used for energy recovering. PUR contains the same amount of energy as coal, which makes it a very efficient feedstock for heating public buildings. The least desired option is landfill. This should be avoided wherever possible. In the picture XX on the right can be seen other options for recycling or reuse for PUR.

All the materials can be separated from each other when the lockers are done. After that, each material can be reused or recycled. This means that every material used will have a function after the lockers. Some materials can even be used again, when new lockers are made because of the long life and reusability. This contributes to an end of life for circular economy and a sustainable product.



3. Heating or cooling and energy efficient kept in mind

The most sustainability can be obtained with the heating and cooling process and the lockers. In the process is energy needed and this needs to be as energy-efficient as possible.

The lockers can be heated or cooled. This is of course dependent on the meal that is placed in it. If the lockers are empty, it does not make sense to heat or cool them, and if the opposite (the locker is heated the whole time, but must be cooled suddenly) is to be done, this will add additional, unnecessary energy. We therefore choose to heat or cool only when a locker is in use. There is calculated how much energy is needed to heat or cool the box when there is one meal inside of the locker. This calculation show how much energy is needed to heat from the start to the optimal, low temperature. To keep the temperature this way, only 10% of the calculated power is needed. This means that it is more energy-efficient to heat or cool a specific number of lockers all the time during peak-times. The change from cold to warm or otherwise costs a little bit more power, but if the numbers are estimated and tried out, it is more energy efficient to heat continuously during peak hours. In the non-peak hours it is more energy-efficient to heat or cool only when a locker is in-use.

We also thought about the sizes of the lockers and the room we need to heat or cool. It is not necessary to put energy in meaningless, unused space. The lockers will have a size where 1 or 2 meals can be put in the locker. Because of this, there is no use of senseless space of the station and meaningless, unused space in the locker. This is better for the energy saving and in addition it reduces the energy and space rent costs.

4. Modular lockers or modular modules?

Are all lockers individually detachable or are the locker modules of a number of lockers together modular? There are different advantages and disadvantages. This is discussed earlier why we choose modular locker modules. In short:

- Adding one module of lockers (2 nests together, 10 lockers total) is more logical because there will be plenty of lockers and adding one by one doesn't add up.
- One general energy point can be used for one module. (All the lockers can be connected separately to the source, so switched on if needed)
- You just roll 1 module (10 lockers) to the place. It costs less time to install it at the final place.
- You can still repair one locker is it is broken. The rest of the lockers can still be used because they have their own system for heating or cooling. They only share an energy source.



It has also been decided to build the lockers with a skeleton frame. This is the outside with the laminated part, the insulated part and the impact resistant outer housing. The doors can be clicked on and changed. Just like the opening way (in this case the barcode scanner). In the lockers there is an internal perforated shelving of coated steel. This can be also clicked in and can be changed if necessary. In the skeleton is space for technical parts or systems and can be changed. This also helps with ensuring a long-life span and changing demands, techniques and updates in the future.

5. Changing customer needs and a long lifespan

We are also responding to the customer needs that are constantly changing over time and the lifespan of the lockers. To respond to the changing customer needs, we thought about the changing demands and wishes of the customer in the (near) future. This can be the types of meals, the look of the station/lockers and the changing visiting numbers. The types of meals can change from nowadays wish for (warm) fast food, to healthy (cold) salads for example. Our lockers can heat AND cool so change to the demands of customers meal wishes. This PSS may also attract new, healthier restaurants to the station. We join this changing demand by providing the possibility for modifying the lockers, so adding and removing modules and also that each locker provides the possibility of heating or cooling of food making it suitable for all types of food. This helps ensuring a long-life span. It is smart to keep ensuring a long-lifespan in mind because it is more economical and better for the environment and sustainability. Other things that ensure the long lifespan of the lockers are to make sure they're adaptable over time and that to make sure people want to use these lockers for more than 15 years. We do this by using LED lighting on the outside, which results in an appearance that always can be adjusted. Also the rest of the design is timeless and simple so it does not get out of time. In addition, the barcode scanners, which are used in the beginning. They must be easy to install and to be detachable. This allows them to be replaced when they're broken or if there is a newer technique that will work better or faster in the future. There is also chosen to have skeleton as lockers. This is the outside with the laminated part, the insulated part and the impact resistant outer housing. The doors can be clicked on and changed. Just like the opening way (in this case the barcode scanner). In the lockers there is an internal perforated shelving of coated steel. This can be also clicked in and can be changed if necessary. In the skeleton is space for technical parts or systems and can be changed. This also helps with ensuring a long-life span and changing demands, techniques and updates in the future.



6. Include the business model

In the business model we also take into account the end of life. We start small and with a(n) (estimated) small surplus of lockers. We will determine the surplus after a 2-month trial period. If it works then the surplus lockers can be used to start the business at a new station. This is done every time with the surpluses. This way we do not produce unnecessarily too much and the lockers do not have to be unnecessarily switched off and just standing there. This means we have modular lockers. Also, there will be fewer or more users in the future, so this is also asking for modular locker modules.

7. End of life when the company grows big

In other areas we can also think about the environment and sustainability in the future. Suppose the company is growing and it is also building offices, some things can play a role in sustainability. For example, a company that meets LEED-conditions may be chosen. This makes it sustainable and economical for the environment. In addition, if there are more premises and meetings taking place, there may be chosen to reduce travel as much as possible by using video conversations and meetings. Another point is to reduce the amount of printed papers and printing. Staff should also be encouraged when they travel, to use as much as possible the public transport ways to office or meetings. If they will still be travelling by car, promote as many electric or environmentally friendly cars as possible. As another point, you can as a company also choose to donate an amount of money annually or monthly. It could be done by setting an amount at the beginning and in the app or on the website to offer a number of agencies. People can then receive points by order or amount they can afford to the organization of their choice. The points determine the distribution of the amount determined.

Sources used in this document

<http://www.azocleantech.com/article.aspx?ArticleID=240>

http://www.steelconstruction.info/Recycling_and_reuse
<https://www.worldsteel.org/en/dam/jcr:00892d89-551e-42d9-ae68-abdbd3b507a1/Steel+in+the+circular+economy+-+A+life+cycle+perspective.pdf>

<http://www.europur.org/sustainability/recycling>

<http://www.polyurethanes.org/en/why-choose-it/sustainability-2>



<http://www.polyurethanes.org/blog/2015/12/the-benefits-and-history-of-polyurethane-flexible-foam/>
<http://www.polyurethanes.org/uploads/documents/OptionsPractise.pdf>

