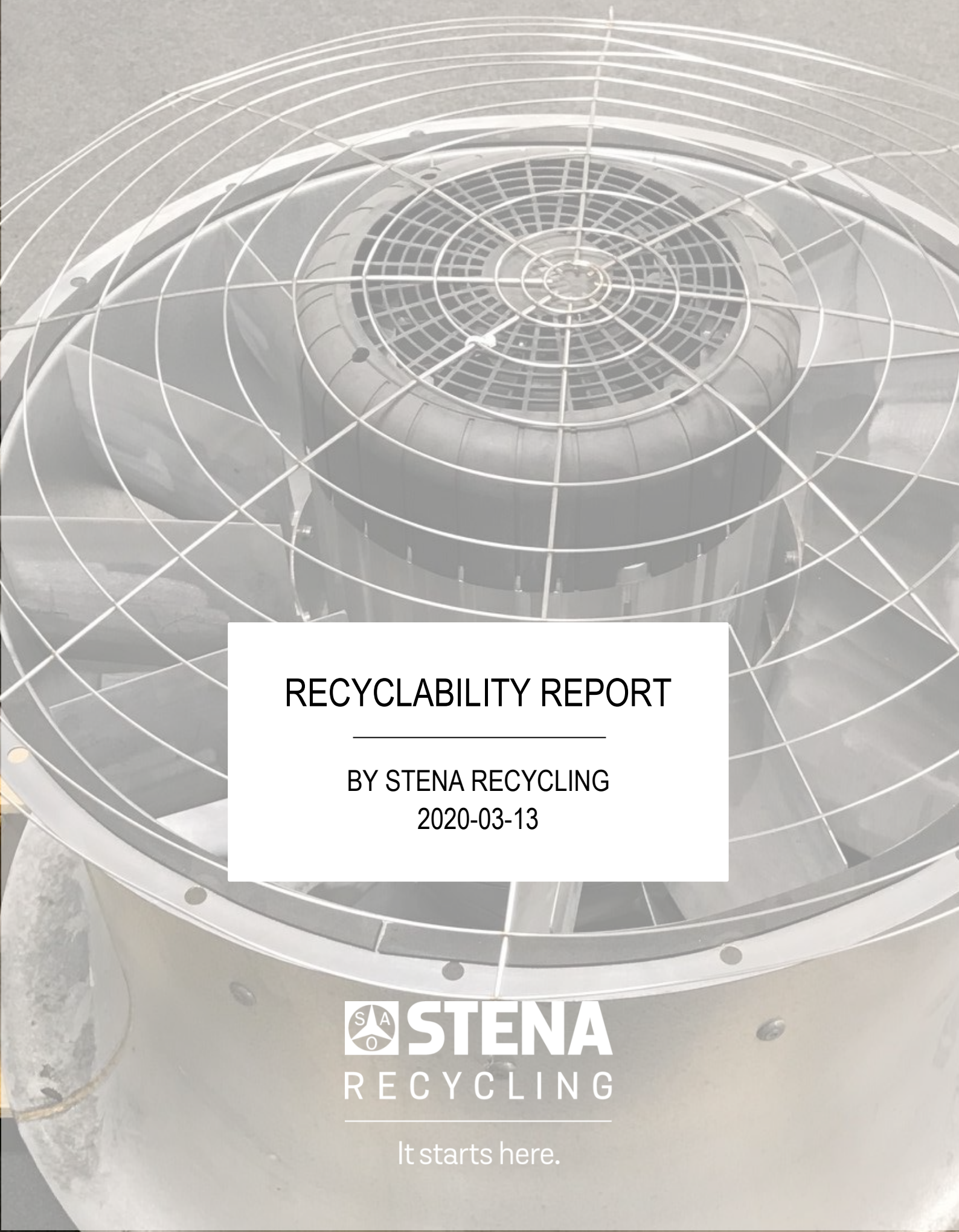
An analysis and report made for NOVENCO Building & Industry A/S



RECYCLABILITY REPORT

BY STENA RECYCLING
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STENA RECYCLING

It starts here.

ABOUT STENA

The Stena Metall Group includes recycling, aluminum production, financial operations and international trading in ferrous and non-ferrous metals and oil. The Group operates in more than 250 locations in Sweden, Norway, Denmark, Finland, Poland, Russia, Germany, the Czech Republic, Romania, Italy, Austria and the U.S. The Stena Metall Group is a part of the Stena Sphere, which consists of the three parent companies Stena AB (publ), Stena Sessan AB and Stena Metall AB.

Stena Recycling is the Group's leading, innovative recycling company that collects, processes and recycles ferrous and non-ferrous scrap, paper, plastics, electronics, hazardous waste and other production waste. We offer recycling services in five geographical markets through various companies operating under the Stena Recycling name. Through innovative, cost-effective solutions, Stena recycles and processes waste from industry, retailers, offices, municipalities, among others. Stena Recycling also offers related services such as internal logistics, training and safety advice.

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Introduction

This is a disassembly report by Stena Recycling AB, a part of the Stena Metall Group, for NOVENCO Building & Industry A/S on the ZerAx axial flow fan.

The analysis was performed by disassembling the product by hand as far as possible. The report covers both the theoretical recyclability of each component and its included materials, and the actual recyclability of the complete product as it would be handled in the recycling system of today. The report focuses on how the product would be recycled in the Nordics, but there is also a chapter on recycling in other parts of the world.

The weight and material data in this report comes both from observations during disassembly as well as from documentation provided by Novenco.

For questions or comments regarding this report please contact Louise Eriksson, Design for Recycling specialist, and author of this document.

1. Background and product description

1.1 General product description

The product is a fan used in ventilation applications, both on- and offshore. It weighs approximately 120 kg and even though it consists of a few different materials, the main parts are made of steel and aluminium. An electrical motor from Domel is placed in the middle of the fan and the product is used together with a metal grid.

Image 1.

1.2 How the product will be treated at end-of-life

When the fan is worn out, it will be disposed of as mixed metal scrap. That material fraction is typically treated in a mechanical shredding facility in the north European countries. It would be manually treated only in countries with lower cost of labour work.

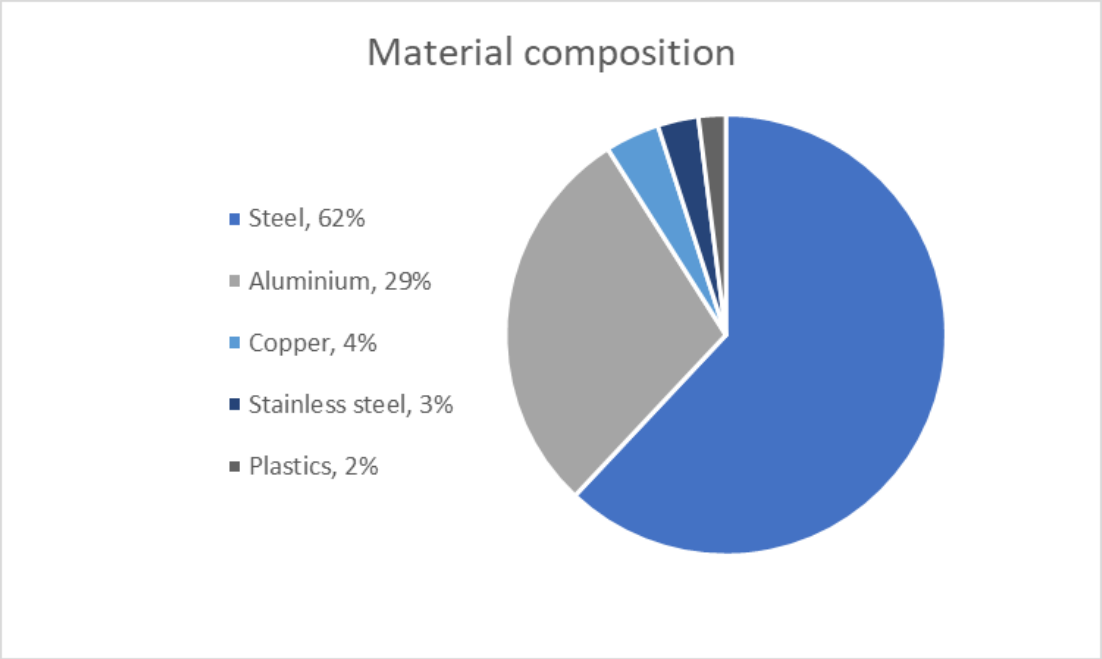
There is a minor risk of an end-user disposing of the product as electrical equipment, a waste fraction which is treated separately and is regulated by an EU directive called WEEE, Waste Electronic and Electrical Equipment. But the fan with the electrical motor is not classified as a WEEE product and should not be treated in that process.

1.3 Included materials

Aluminium and steel stands for 91% of the products total weight. It also contains copper, stainless steel, different plastics and a small amount of brass. The brass content is very low in relation to the other materials and therefore not visualized in the diagram below.

Material	Content, w%
Steel	62%
Aluminum	29%
Copper	4%
Stainless steel	3%
Plastics	2%
Brass	>0.1%

Table 1 – Included materials



Graph 1 – Included materials in weight percent

2. Theoretical recyclability of the included materials

2.1 Generally

In this chapter the included materials of the fan are analysed separately and isolated from each other and their theoretical possibilities of getting recycled are described. In the following chapter it will then be described how recyclability is not only decided by choice of material but also affected by five other parameters. This will finally lead to the actual recyclability of the product.

2.2 Material by material

Steel – A majority of the included components in the product are made of steel. Steel is recyclable and relatively easy to separate from other materials in a mechanical recycling process due to its magnetic properties. Magnets are used for extracting steel and iron components from various waste streams and it is then made to new steel by melting it in steel mills. All types of steel can be material recycled. However, the alloying material in them and surface treatment might or might not be wanted in the new steel product. That means that these additional materials can be both an asset and a nuisance being either utilized or reduced in the melt.

Image 2.

Aluminum – The hub rear and front, guide vane, blade and some more components are made of aluminium. Aluminum is also material recyclable. In a mechanical recycling process for mixed metal products, such as the one this product would be treated in, aluminium is separated through an eddy current magnet and finally made into new cast aluminium products in an aluminum smelter.

Image 3.

Copper – The copper content of the product mainly comes from the electrical motor which has copper threads in the stator. Copper is taken out by either an eddy current magnet or by hand after the mechanical process and is material recycled and becomes new copper at a copper smelter.

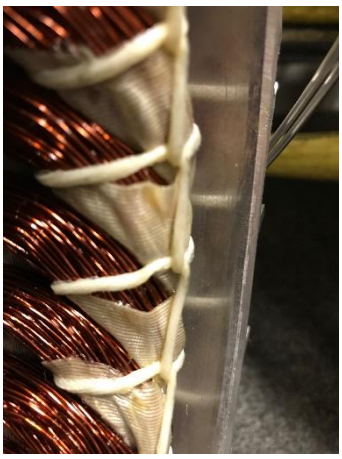


Image 4.

Stainless steel – The product contains a few weight percent of stainless steel. Stainless steel is separated with an eddy current magnet. As for other types of steel it can be material recycled and is made into new steel by melting it in steel mills. However, also here, the alloying material in them might not always be wanted in the new steel product, which means the alloying material can be both an asset and a nuisance being either utilized or reduced in the melt.

Image 5.

Mixed plastics – The fan also contains smaller amounts of plastics. In general there are only four types of plastic being recovered from products in Northern Europe today; ABS (acrylonitrile butadiene styrene), PS (polystyrene), PP (polypropylene) and PE (polyethylene), but in the mechanical treatment of mixed metal waste these plastic types are currently not separated for material recycling but sent for incineration with energy recovery.

Image 6.

Brass – The brass components can be sorted out in the mechanical treatment process and will be made into new copper-containing products at a copper smelter.

Image 7.

2.3 The electrical motor

The electrical motor mainly contains steel, copper and aluminium. In Stena Recycling we have made a large scale test including 4 000 tons of electrical motors and through the learnings from that test we know that a motor such as the one used in this fan, typically consists of 82% steel, 10% copper, 6% aluminium and a mixed fraction of 2% which is sent to incineration.

The copper and aluminium are currently not separated in the recycling processes but sent together to a secondary aluminium smelter, but in Stena Recycling we are currently developing a new process to be able to separate those two materials from each other. Thereby we will enable to recover cleaner fractions of materials, which can be used in a larger variety of applications, as well as increasing the value of the materials.

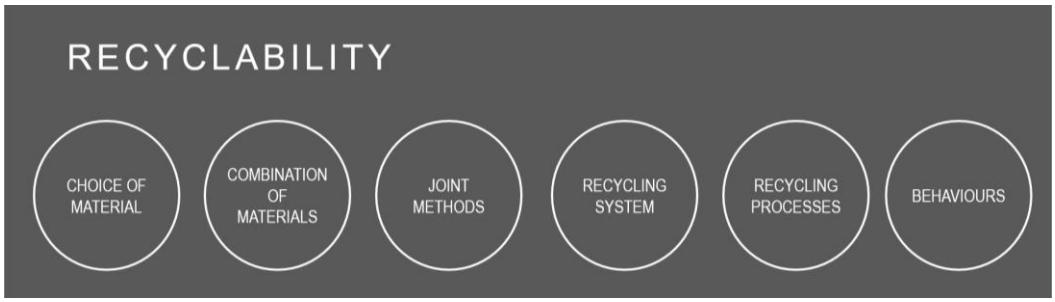
Image 8.

3. Recycling in practice

3.1 Generally

As described in the chapter above, theoretically the Zerax fan is well suited for recycling since all the metals are recyclable and should be possible to separate through mechanical recycling processes.

However, when analysing the actual recyclability of a product there are six parameters to take into consideration; Material choice, Material combination, Joint method (between different materials), Recycling processes, Recycling system and Behaviours (of end-users), see picture below, and many times the actual recycling rates are lower than the theoretical.



Picture 1.

3.2 Actual recycling of the product

Choice of material – The material choices for the fan are not hindering the recycling. All metals are possible to recover and the rest of the materials will be sent for incineration with energy recovery.

Combination of materials – For parameter number two, combination of materials there is nothing in particular hindering the recyclability of the product.

When it comes to **Joint methods**, a large number of screws are used to attach different components to each other. In a mechanical process there will be a certain amount of material which will not separate from those screws. So when the surrounding material is the same as the screws it doesn't cause any problems but if the screws are of different material than the surrounding ones the separation will not be perfect. For this product it will most likely mean that some aluminium will end up in the steel fraction.

Recycling processes - Regarding the electrical motor there might be a challenge to get full recovery of the copper wires in a mechanical recycling process. The thinner the copper wires in a product are, the more likely they are to end up in the energy recovery fraction instead of being material recycled. The motor has rather thin copper windings in the stator, and it is likely that all of the copper would not go to material recycling. Some wires will get bundled together, increasing the chances of getting caught in the right

material recycling stream and some wires will get stuck in plastics, foams and other materials that eventually end up in an incineration fraction.

Recycling system – There is a recycling system in place for collection and treatment of the fan, and this parameter is not causing any problems for the recyclability.

Behaviours – It is considered to be relatively easy to understand how to dispose of this product. It is clearly visible that it contains a lot of metal and therefore should be sorted as mixed metal waste. The only risk is that someone believes that the product is classified as electronic and electrical waste.

3.3 Summary of recyclability

The table below describes the material recyclability of the Novenco fan compiled in a simple model. The graph below the recycling rates for the product divided on Recycling, Energy recovery and Landfill.

Parameter	Product evaluation	Comments
Material choice		All the metals in the product, together representing 98% of the products total weight, are all recyclable.
Material combination		There are no obvious material combinations that hinder the recyclability.
Joint method between different materials		Screws as joint methods are not optimal from a recycling perspective since they will not separate properly from the surrounding material in a mechanical recycling process.
Recycling processes		There are recycling processes in place to treat this product.
Recycling system		The product can be disposed of as mixed metal waste and taken to the mechanical recycling process by a recycling company.
Behaviors		It is considered to be easy to understand how to dispose of this product once it is worn out.

Table 2.

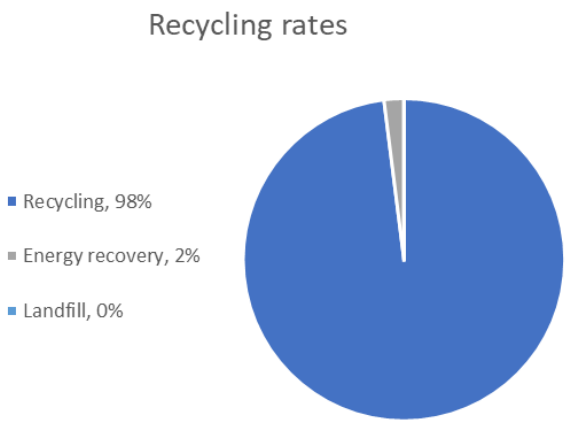


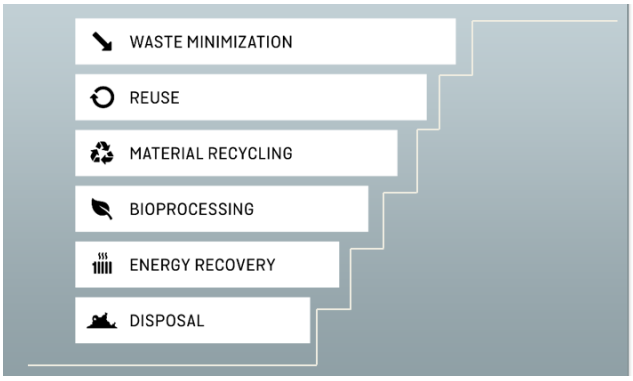
Diagram 2.

The numbers in the graph above are theoretical and assume that 100% of the product goes through the process. The product design does not give any reason to believe that the actual recycling rates would differ considerably from this. But in reality a small percentage of the product can be assumed to get stuck in the machines in the different steps of the process as well as ending up in the wrong fraction. But if, for instance, a small piece of copper ends up in the aluminum fraction, it could be both an asset and a poison depending on the aluminum alloy that is intended to be produced. Therefore it is useless to try to approximate the precision of the process.

3.4 What could be changed to increase recyclability

The recyclability of this product is already very high, therefore the question is probably not how to further increase recyclability but rather how to improve the product in a hierarchy of waste perspective. The hierarchy of waste is an EU directive visualizing how to prioritize when it comes to waste treatment and the top priorities, before recycling, is waste minimization and reuse. Perhaps it is possible to work with those two aspects for the Zerax fan? Is it for example possible to reduce the material consumption in the product?

It is assumed that the product already has a fairly long lifetime, but could it be prolonged further through repairability and is it possible to work with spare parts and replaceable parts?



Picture 2.

Another aspect could be to find out how much recycled content there is in the different components? Is it possible to specify a higher degree? To increase the level of recycled content in the product would impact the overall sustainability of the product in a positive way. Not only by reducing the need for virgin raw material and saving the finite natural resources of this planet, but also because it reduces the carbon dioxide footprint of the product since recycled material requires less energy to produce. By specifying a certain degree of recycled content in their products a company can also contribute to creating a well-functioning market for recycled material. Because if there is a demand for recycled material, there are incentives for the recycling industry to invest in more research, process development and new technology to further increase the quality of the recycled materials.

Finally, to decrease the risk of an end user disposing of the product as electronic and electrical waste perhaps there could be a text around end of life treatment in the product specification?

4. Recycling in other countries

The fan would be recycled in a similar way as in the Nordic countries also in Germany, the north of France, the Netherlands, Switzerland and Japan. In those countries the same fractions are taken out for material recycling and many materials are being energy recovered rather than landfilled. In Finland, Spain, south of France, Italy and Poland the steel could potentially have been taken out in mechanical processes, but the remaining two percent would have been put on landfill. In Finland this is currently changing, and more incineration plants for energy recovery are being built.

In the US some states, such as Florida and California, have come further in developing their recycling system and have a system almost similar to that of northern Europe. The same goes for China where in most parts of the country manual disassembly of metals and valuables along with landfilling is most common, whereas in some parts there are mechanical processes and energy recovery in place.

In most developing countries the fan would be disassembled manually as much as possible and the metals that can be separated would be taken out for material recycling. The electrical motor is difficult to disassemble with hand tools and a reasonable effort. It can be disassembled to an extent, but to get to the copper winding and the shaft is difficult. The stator would probably be disassembled by burning off the plastic around the copper, and sawing or pounding the steel and aluminum apart since they cannot be removed by just levering a screw driver. Since the steel and aluminum are attached so well, there will probably be some material losses in the harsh treatment needed. This is also true for the copper, since the wires are thin they are fragile and will break. The rest of the product would end up being landfilled.

5. Future recycling

The statements in this chapter are educated assumptions of what might happen in the future.

In the next coming years it is certain that more plastics will be recovered from the mixed scrap fractions which are mechanically treated in the Nordic countries today. New technologies will be developed and existing technologies will be improved, all driven by the EU directive to reach 95% reuse and recovery targets for end of life vehicles, which is already in place but not yet successfully adopted in many places. The four most common plastics (PE, PP, ABS and PS) will be in focus and if more plastic types are to be recovered than that; PC and PA are most likely to follow since they are fairly common, have high values and can be material recycled.

The common metals such as steel, aluminum, copper etc. will be extracted to the same extent as today; there might be slightly purer fractions, but no larger changes. Cobalt, gallium, indium as well as the platinum group metals are metals that are either hard to replace in product use, decreasing in supply or both, which means that they might be eligible for recycling in the future. REE (rare earth elements) are likely to be both increasingly needed in products as well as extracted to a larger extent from the scrap flow.

The ongoing development of an improved recycling process for electrical motors, mentioned earlier in this report, is an example of a movement away from fragmentation as primary mechanical recycling process. This is a trend which is not yet strong but which is seen and heard of in more and more contexts and it is likely that more examples of a more gentle and customized treatment will follow in the next coming years.

6. Summary

The Zerax fan is an example of a product which is already highly recyclable. The common metals steel and aluminium stands for a big share of the product waste and that material will be recovered to a very high degree in a mechanical recycling process.

Therefore this report instead suggests to focus on improving other aspects of sustainability and of moving the product further up in the hierarchy of waste. This can be done through looking in to possibilities of reducing material consumption for the product, enabling repairability and use of spare parts as well as by using more recycled content in the components.