Recycling and sustainable environmental practices in the plastics industry

Jonatan Autio

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Author: Jonatan Autio

Degree Programme: Environmental Engineering, Vaasa

Supervisors: Charlotta Risku, Novia University of Applied Sciences and Mats Albäck, Rani Plast Ab Oy

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Summary

This thesis work is done for the company Oy Rani Plast Ab. The thesis explains the fundamental concept of sustainable environmental practices and then proceeds to concentrate more on methods used to minimize environmental impacts from industrial operations. The main focus lies on possibilities of using recycled plastic in film extrusion.

The project started with studying literature about sustainable development, environmental legislation, standards, and methods for measuring, reporting, and controlling these. Once the theoretical part was done, focus was shifted towards getting comments and information from people involved in these matters using interviews. The information gathered was used to describe the current situation in the company. The results of the work are a few identified development ideas that could be implemented with relative low investment cost if seen as worthwhile.

In conclusion, some areas where development could be carried out were identified, and by addressing these there might be some added value to company operations through new business possibilities which may result from upcoming changes in legislation.

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Författare: Jonatan Autio
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Handledare: Charlotta Risku, yrkeshögskolan Novia och Mats Albäck, Rani Plast Ab Oy

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Abstrakt

Detta lärdomsprov gjordes åt företaget Rani Plast Ab Oy. Lärdomsprovet förklarar det grundläggande konceptet bakom hållbar miljöverksamhet och fortskrider sedan till att koncentrera sig mera på metoder använda för att minimera miljöpåverkan från industriell verksamhet. Huvudfokus är på möjligheterna för användning av återvunnet plastmaterial vid filmextrusion.

Projektet startade med litteraturstudier om hållbar utveckling, miljölagstiftning, standarder, samt metoder för att mäta, rapportera och kontrollera dessa. När teoretiska delen var klar, skiftades fokus till att genom intervjuer insamla kommentarer och information av människor involverade i dessa frågor. Den insamlade informationen användes för att beskriva situationen i företaget. Arbetets resultat är några identifierade utvecklingsidéer som kunde implementeras med relativt låga investeringskostnader ifall de anses lönsamma.

Sammanfattningsvis kunde sägas att några utvecklingsobjekt identifierades, och genom att ta dessa i beaktande kunde företaget kanske få mervärde i sin verksamhet genom nya affärsmöjligheter som möjligen kan uppstå på grund av kommande ändringar i lagstiftningen.

Språk: engelska Nyckelord: plast, hållbarhet, återvinning

OPINNÄYTETYÖ
Tekijä: Jonatan Autio
Koulutusohjelma ja paikkakunta: Environmental Engineering, Vaasa
Ohjaajat: Charlotta Risku, Novia AMK ja Mats Albäck, Rani Plast Ab Oy

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Tiivistelmä

Tämä opinnäytetyö tehtiin yhtiölle Rani Plast Ab Oy. Opinnäytetyön tarkoitus on selventää kestävien ympäristökäytäntöjen konseptia ja sen jälkeen keskittyä enemmän teollisen toiminnan ympäristövaikutusten vähentämiseen. Pääpaino on uusiomuovin käytön mahdollisuuksissa kalvoekstruusiossa.

Projekti alkoi tutkimalla kirjallisuutta koskien kestävää kehitystä, ympäristölainsäädäntöä, standardeja, ja näiden mittaamisen, raportoinnin ja kontrolloinnin käytäntöjä. Teoreettisen osan jälkeen työ keskittyi näiden asioiden kanssa työskentelevien ihmisten haastattelemiseen. Kerätyt tiedot käytettiin yhtiön tämänhetkisen tilanteen kuvaamiseen. Työn lopputuloksena on muutama identifioitu kehitysidea, joita voisi toteuttaa ilman suuria kustannuksia, jos ne katsotaan sen arvoisiksi.

Tiivistettynä identifioitiin muutama alue, joita voisi kehittää. Huomioimalla nämä, yhtiö voisi mahdollisesti löytää uusia liiketoiminnan mahdollisuuksia uuden lainsäädännön johdosta.

Kieli: englanti Avainsanat: muovi, kestävä kehitys, kierrätys

Contents

1. Nomenclature

- CO_2 - Carbon dioxide
- EMS – Environmental Management System
- GHG – Greenhouse Gas
- HDPE – High Density Polyethylene
- ISO – The International Organization for Standardization
- LDPE – Low Density Polyethylene
- LLDPE – Linear Low Density Polyethylene
- PE – Polyethylene
- PET – Polyethylene Terephthalate
- PHA – Polyhydroxyalkanoates, linear polyesters
- PLA – Polylactic acid
- PP – Polypropylene
- PS - Polystyrene
- Rani – Ab Rani Plast Oy
- Reg. – Re-granulated plastic
- RMS – Rani Management System

2. Introduction - Aim and objectives

The main aim of this thesis is to investigate the potential for reducing the environmental impact of plastic film extrusion through sustainable environmental practices. The secondary aim is to briefly explain the theory and terms used when talking about environmental performance. The thesis in short describes the fundamental concepts of life-cycle assessment, recycling, down-gauging and other related techniques used to minimize the environmental impact of plastic materials while remaining cost efficient.

One of the challenges when talking about environmental performance in a corporate environment is that it is questionable whether these bring any value in themselves. This leads to these values often becoming secondary. They might exist and may be worked on, but most often a good environmental performance is simply the result of an all-around efficient activity. Green values are not always seen as development goals themselves, due to limited resources. A sound environmental policy is also something that is expected of companies operating within the EU and is not considered to be anything groundbreaking.

The plastics industry is often not seen as a model example of sustainability and is often blamed for the pollution in nature that plastic products give cause to. However it remains a fact that plastic is the best packaging product currently available. It is a very efficient and environmentally friendly packing material. It keeps food fresh, it is lightweight, and its' recyclable –allowing it to be used over and over again. And when it comes to the end of its life cycle, it has a very high energy density and can be recovered to produce energy and heat. Recycled plastic is a valuable raw material and the upcoming legislation might make plastic waste even more interesting.

2.1. Ab Rani Plast Oy

Ab Rani Plast Oy is a company producing plastic films. Rani is a second generation family owned business, and ranks among the 20 largest companies in the industry in Europe. Rani Plast is one of the leading suppliers of plastic film in the Nordic countries, and one of the world's largest producers of agricultural film.

The Rani Plast-group owns nine factories in five countries. These countries are Finland, Sweden, Russia, Ukraine and Slovakia. The turnover of the group is over 200 million euros, and goods are exported to more than 40 countries. The subsidiary Art-Pak makes plastics hoods for timber, the joint venture company Terichem makes electrical isolation film and the joint venture HP Rani Plast makes plastic bags on rolls. The prefabricated modular house manufacturer Teri-Hus also belongs to the group.
This thesis was written for Ab Rani Plast oy and does not take the subsidiaries or joint ventures into account.

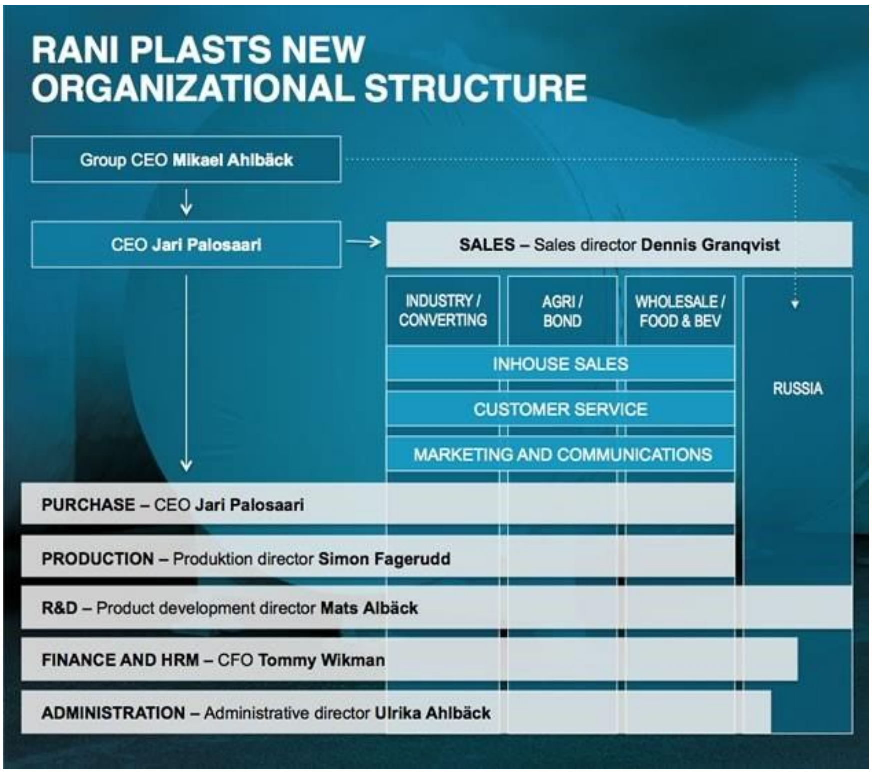


Figure 1. Management of Ab Rani Plast Oy (Ab Rani Plast Oy, 2015)

The company Ab Rani Plast Oy was founded in 1955 by Nils Ahlbäck, together with his brother Alf Ahlbäck and partners Runar Svartsjö and Ingmar Albäck. The name Rani comes from the first letters of these respective given names.
Throughout the years, business has evolved and Ab Rani Plast Oy is now producing a multitude of different plastic products. The company has since its start grown through acquisitions and through bold decisions and investments in automation and machinery. Today there is a new 13 million EUR investment being constructed in Teerijärvi, which when finished will be the largest production line of agricultural films in the world.

Products

- ***Industry***

The industry sector contains a very wide range of products. Generally these are products that are used in industrial processes. Each of the subcategories mentioned have their own range of specific products, and those products are also often tailored the suit the needs of customers or end-users. These products are mostly different kinds of stretch films or hoods, laminating films, shrink films, steam protection films and such. The products from this category are for instance shrink films for food and beverage packaging, insulation materials, tissue and paper products, wood and building materials, products for waste handling, soil construction, and such.

- ***Agriculture***

As one of the world's leading producers of agricultural films, the agricultural range of products is very important for Rani Plast. The brand RaniWrap is well known among farmers all around Europe. Most of the agricultural films are used for preserving the optimal nutritional value of forage through different methods. The company produces films e.g. for bale wrapping, silage and compost bagging and cultivation.

- ***Pallet handling***

Rani Plast is a big producer of stretch films and hoods which allow for the safe and durable packaging of materials on pallets. These stretch films are produced either through cast or blown methods.

3. Plastics

The term plastics refer to construction materials that are based on polymers. These polymers are treated with additives such as colors or softeners to gain the characteristics needed for each application. Polymers are usually divided into groups such as elastomers (rubber materials), thermosetting plastics, or thermoplastics. Elastomers are elastic, while thermosetting plastics are rigid. Thermoplastics retain their plastic characteristics and can be remade to new products by using heat.

Plastics are one kind of polymers. Polymers are chemical compounds that consist of extremely long chains of monomers. Polymers differ from other compounds in organic chemistry by being much longer than the chains in for instance alcohols or organic acids.

Plastics are organic materials, just like wood, or paper, or wool. In today’s society plastics can be found everywhere, and they make it possible to balance modern day needs with environmental concerns. In Europe, the biggest users of plastics are the packaging, building & construction, and automotive industries. Together these stand for more than 68% of the total plastics consumption.

There are several types of different plastics, and they all have their own characteristics. At Rani, over 90% of all the products are based on PE. The thesis will however also shortly describe the other most common plastics.

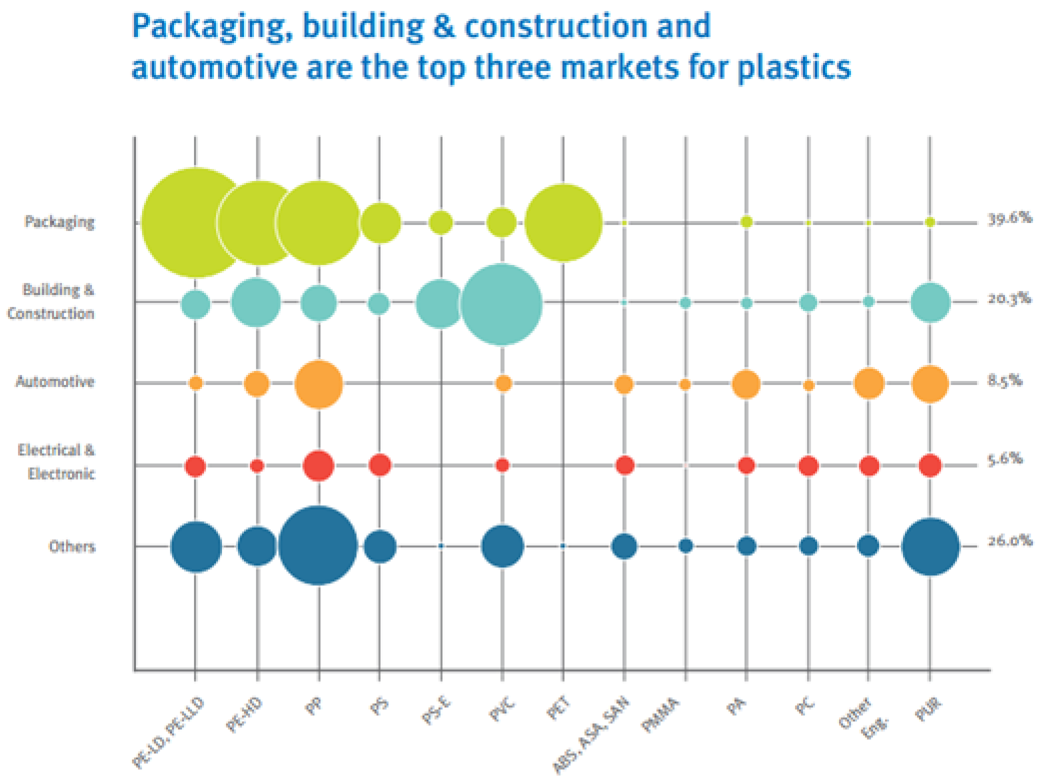


Figure 2. European plastics demand (EU-27+NO/CH) by segment and polymer type 2013. (PlasticsEurope (PEMRG) / Consultic / ECEBD, 2015)

3.1. Polyethylene

Polyethylene (PE) is the most common plastic in the world. It is a thermoplastic polymer. It is a material with which almost everyone has a daily contact. The first use of this material was as insulation of electrical wiring, but until today the material and applications where it is used have been drastically developed. Today we are all reliant on polyethylene, which has found its place through its discrete reliability, and almost unlimited uses. As we can see from figure 2 on the previous page, most of the PE is used by the packaging industry.

Polyethylene can be processed to all kind of shapes and forms. It can be made soft and flexible, or hard and tough. PE is found in all kinds of products, from simple shopping bags to complex pipes, everyday appliances, cling foil and toys. The material is all around us. The groceries we buy are protected by it, while fuel that powers our society is contained by it. PE is a reliable and solid material. When properly disposed of, it is also environmentally friendly.

It is widely agreed that no matter in what form PE is used, it is an excellent material. It is almost unbreakable, it resists caustic materials, it is a good insulator and it is reliable, no matter if used in tropical heat or in the arctic cold. It is also a remarkably light material while being tough wearing.

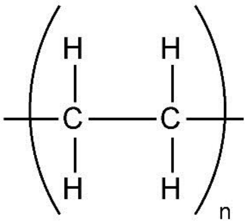


Figure 3. Chemical structure of PE

The raw material for polyethylene is naphtha, or other light feedstock hydrocarbons such as LPG, ethane, propane, or butane. This feedstock is most often extracted from crude oil, but there are also alternative sources such as ethanol derived from plant fermentation. The saturated hydrocarbons are then cracked in so called “steam crackers”. Cracking means that the long hydrocarbon chains of the feedstock are broken down into shorter chains. In the steam cracking process, the hydrocarbons are diluted with steam and briefly heated in a furnace without the presence of oxygen. The reaction takes places at pressures slightly above atmospheric and at very high temperatures around 850°C. The reaction itself is very brief. In modern crackers the gases are moving at supersonic speeds to increase the yield of the plant. After the cracking temperature has been reached, the gas is quenched to stop the reaction through transfer line heat exchangers or inside quenching headers using quench oil. After the cracking has taken place, the ethylene gas is chemically synthesized into polyethylene. The word polyethylene literally translates to “many ethylene parts”.

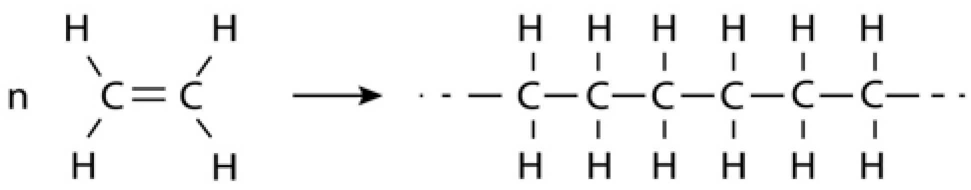


Figure 4. From monomer to polymer

There are three main types of PE. These are divided by their characteristics and the way in which they are produced. The main types are LDPE, HDPE, and LLDPE. The low density PE's are produced under high pressure, while HDPE is produced under low pressure.

LDPE is a low density PE, which is produced under high pressure. It is the oldest type, and is soft, tough and flexible. It is being used mainly for foils that are used as carrier bags, agricultural films and packaging material. It is also used as screw caps and lids due to its characteristics.

HDPE is a high density PE. It is the least flexible and sturdiest among PE's. This material is used in everyday products such as clothes pegs, bottles and such. HDPE can also be made into a thin foil that is commonly used for instance in sandwich bags and fruit packaging. A thin HDPE foil feels crispy to the touch.

LLDPE is a linear low density PE. It is basically a mixture of the two previous types. It is very tough and inflexible, and is often used when making extremely thin foils and in multi-layer packaging. The tough and inflexible features are also used for production of large products such as types of containers, storage bins, covers and the likes. (Plastics Europe, 2015)

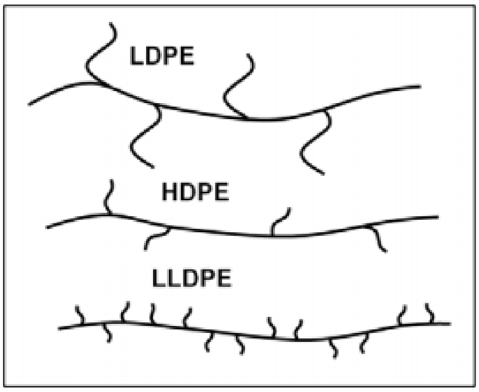


Figure 5. The method of ethene polymerisation results in different structures in the molecular chains. Fewer branches give a higher crystallinity, molecular weight and density.

3.2. Polypropylene

Polypropylene, PP is a linear hydrocarbon polymer. PP is one of the most versatile thermoplastics, and can be used in a wide range of applications. It can be used both as fiber and as a plastic. PP is very often used in moldings such as automotive components, as fibers in carpets or clothing, or as structural foam and in low-density packing. It is one of the most common materials used for film extrusion together with PE.

PP is a semi-rigid, translucent material which is tough and has good chemical resistance. It also has good heat resistance, and good resistance to fatigue. It offers very good electrical and chemical resistance at higher temperatures compared to PE. However, due to a methyl group attached to every alternate carbon atom that provide a site for oxidation, PP is not as stable as PE.

In manufacturing, propylene is obtained along with ethylene in the same process as described for PE. PP has a usual melt temperature of 210-290°C.

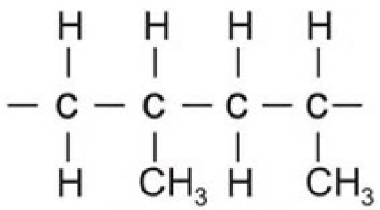


Figure 6. Polypropylene structure

3.3. Polyethylene Terephthalate

Polyethylene terephthalate (PET) is a thermoplastic polymer resin, and the most common type of polyester. It is a combination of two monomers –modified ethylene glycol and purified teraphthalic acid. PET was discovered in England and patented in 1941. It is today most known for being the material from which most soft-drink containers are made.

PET is a colorless and semi-crystalline resin. It can be either rigid, or semi-rigid depending on how it is processed. It is also a very lightweight material. It is commonly recycled due to its high value, either as raw material for new bottles, or shredded and made into textiles (for instance polar fleece).

3.4. Polyvinylchloride

Polyvinylchloride (PVC) is one of the most common thermoplastics. It is used in a variety of applications, such as building, transport, electrical, and healthcare. It is a very long lasting and durable material and can be colored in many ways and can be made either rigid or flexible. PVC is very often used in industry due to its nature.

PVC differs from other thermoplastics in that it is not derived only from oil, but is based on two different materials. These are common salt, and hydrocarbon feedstock. 57% of the molecular weight derives from common salt, while 43% derives from the hydrocarbon feedstocks. Increasingly, bio-based ethylene is used for PVC production.

PVC causes some problems after its end-life, as it is not easily recycled. It is also not possible to use it for energy recovery unless the incineration plant is equipped to handle the harmful compounds such as cadmium that result from combustion. This means that at least in the Stormossen regional waste management company in western Finland, PVC is still considered a landfill waste. There are technologies to recycle the material but they are still not commonly used in Finland. Among such techniques is the “Vinyloop” closed-loop process. It is a mechanical recycling system which uses a solvent to separate the PVC from other materials. According to EU guidelines PVC should be used more often in certain construction products as this allows the reuse of old recycled PVC.

3.5. Polystyrene

Polystyrene (PS) is a thermoplastic polymer which softens when heated. PS was discovered in 1839. It is a synthetic aromatic polymer made from the monomer styrene. Polystyrene can be either rigid or foamed, which makes it a very versatile material. General purpose polystyrene is hard, brittle and clear. It is often used for packing audio cassettes and cd’s. PS is very expensive per unit weight. It is a poor barrier against water vapor and oxygen and its melting point is relatively low. PS is naturally transparent, but can be colored.

4. Bio-based plastics

Bio-based plastic is the common name for plastics that are based on feedstock made from renewable sources. The most common source is biomass from sugar cane or corn plants, but also other sources can be used, e.g. cellulose. The biomass can be hydrolyzed and used as fermentation feedstock in polymer production.

The terms “biopolymer” or “bioplastic” are widely used, but there is some confusion in the usage of these terms. Often they are used to describe two different concepts at the same time. These concepts should however be differentiated. Firstly there are material-source bioplastics, which are based on renewable resources. The second group are functional bioplastics, e.g. plastics that can be composted and/or are biodegradable.

Bio-based plastics represent only a small fraction of all plastics. Today this fraction is about 1% of total plastics production. This is mostly due to high cost and questionable environmental benefits. However as the methods for producing bio-based plastics evolve, and the cost of fossil raw-material rises, a change towards increased use of renewables is seen as a future alternative. It is forecasted for the production capacity of bio-based plastics to see a growth at around 20% per year. Even so, bioplastics will remain a niche segment in the next few decades.

Bio-based plastics are sometimes marketed to be more environmentally friendly than their fossil counterparts, but this is not always the case. It is not correct to assume bio-based plastics automatically have a lower environmental impact. Comprehensive LCA studies must be undertaken to measure the actual impacts on the environment by taking all product stages into account. Even then, the results are highly dependent on which areas are focused on and how the study is performed. (PlasticsEurope, 2015)

The most common bio-based plastics are PLA, bio-PET, and bio-PE. Bio-based PET or PE cannot be differentiated from their conventional versions other than by scientific analyses and they possess the exact same properties.
It is important to note that bio-based plastics are not necessarily biodegradable to any higher degree than their conventional versions. It is all depending on which type of polymer is in question. Bio-based PHA is biodegradable, while bio-based PE derived from sugar cane is not.

5. Sustainable development

Sustainable development can in short be described as *“an ongoing and structured process where society undergoes changes with the aim of securing desirable living conditions for the current and future generations.”* (Ministry of the Environment, 2013).

Sustainable development is a long-term vision that integrates the ecologic, economic and social aspects on both a local and global scale and integrates them as inseparable and interdependent components. Integrating sustainable development as a fundamental pillar for society is nothing that will be brought about by policies alone. It is a principle that has to be taken on by society at large, to guide the everyday choices of ordinary citizens, as well as being a leading principle when making large political and economic decisions. (European Commission, 2015)

The EU has set a hierarchy for the reduction of waste, called the 4R-rule, which sets the priorities as follows:

Reduce – Reuse – Recycle - Recovery

What this means in practice, is that society should strive to move from a linear towards a circular economy, as pictured in figure 7 on the following page.

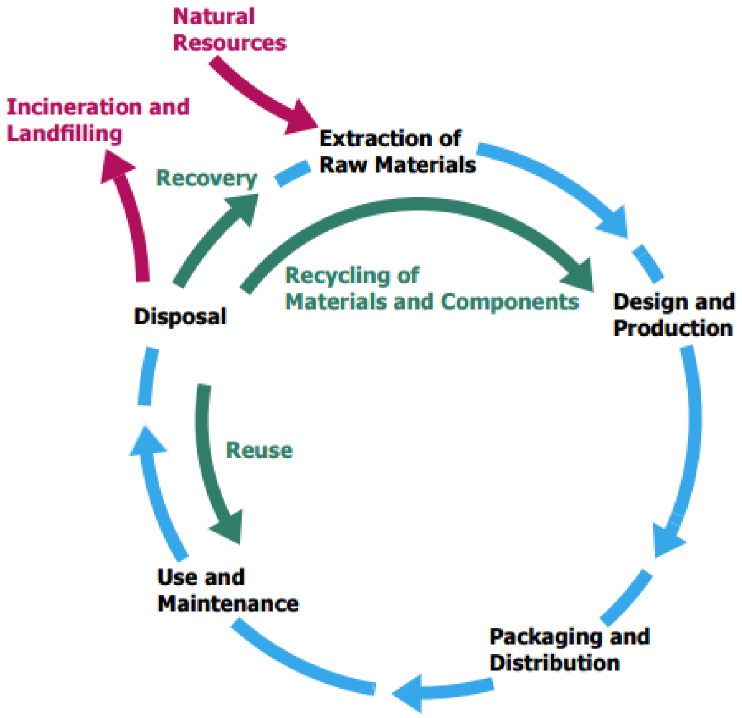


Figure 7. A circular economy (United Nations Environment Programme, 2007)

In order to develop methods of measuring or analyzing the environmental performance of a company, there must be a way to define it. This chapter presents the most common methods used for reporting on environmental performance. In general, environmental performance meters aim to measure the impacts of any operation on the climate or environment, and present it in a way that is directly comparable between different actors when the same methods for data collection are used.

3.1. Carbon Footprint

According to T. Wiedmann and J. Minx in their research report “A definition of ‘Carbon Footprint’”, the carbon footprint is defined as *"a measure of the exclusive total amount of carbon dioxide emissions that is directly and indirectly caused by an activity or is accumulated over the life stages of a product."* (Wiedmann & Minx, 2007). The carbon footprint is a term that is widely used in today’s society, but which is not clearly defined in the scientific community. In general it can be described as a way to measure all direct and indirect CO_2 emissions that result from human activity.

Carbon footprints are used to link together the relationship between the alleged climate change and individual goods, services, their consumption and manufacture. A carbon footprint provides the basis for companies to develop their GHG reduction strategies, and allows them to manage product/process development and implementation in an explicable manner. This allows communication within the supply chain.

The standards that control all relevant product carbon footprint methods are based on the full life cycle approach, and build on the ISO 14040/44 standard for LCA practices. The standard which is most widely adopted is the GHG Protocol Product Life Cycle Accounting and Reporting Standard, which was published in October 2011. (PEF World Forum, 2015)

3.2. Environmental Footprint

As a term, environmental footprint relates to the above mentioned, more established term "carbon footprint". It denotes the environmental or aggregated environmental impacts on systems instead of the impact on the climate alone. Any product may cause environmental impacts over its life cycle. Typically these occur through emissions to water, air or soil. These may lead to environmental impacts such as climate change, ozone depletion, toxic effects, acidification and eutrophication.

Environmental impacts can also be caused by the use or depletion of rare resources such as fresh water, minerals, organic matter in soil, biodiversity etc. Other impacts on the environment are for instance noise, land-use for construction, farming, logging and such.

Environmental footprint models are used in the same way as carbon footprint models. The difference is that the environmental footprint models more comprehensively address the impacts of products and value chains. A PEF is very similar to a specific LCA as defined in the ISO 14040/44 standard. Further specifications for the communication of environmental information on products for different purposes are defined in the ISO 14025 standard. (PEF World Forum, 2015)

3.3. Eco efficiency

Eco-Efficiency is a way to describe the balance between producing more services and goods while producing less emissions and waste.
According to literature, the most eco-efficient ratio of recycling plastic is between 35-50%. Rates higher than this are no longer considered economically or ecologically feasible. The reason for this ratio is that recycling higher percentages of the plastic waste requires energy-intensive processing steps. This leads to the environmental impact from the processing of waste being higher than the impact from manufacturing of virgin material. The material not feasible to recycle should preferably be used for energy recovery to produce electricity and heat.

In a study done by TNO (Eggels, P.G.; Ansems A.M.M.; van der Ven, B.L., 2001) for the Association of Plastic Producers in Europe, it was found that the most positive eco-efficiency impacts came from a diversion from landfill in favor of mechanical recycling of relatively clean mono-material waste combined with energy recovery in relatively efficient and modern incineration plants (over 30% energy recovery efficiency). Other solutions with direct positive environmental impacts were increasing the efficiency of the energy recovery systems (upgrading old incineration plants), and increasing recycling rates up to a total of 50% while decreasing the amount of waste going to energy recovery. (P.G., et al., 2001) (PlasticsEurope, 2015)

5.4. LCA

Life Cycle Assessment is a tool that has mainly been used on industrial materials and products since the 1990s. To describe it very simply, an LCA is a methodology to identify, measure, and evaluate all the energy and material flows that result from making, using and disposing a given product or material. By approaching the problem with this kind of methodology, the most important ways of minimizing waste, energy usage and the overall environmental footprint of a target product or a group of similar materials can be realized. (Tolinski, 2012)

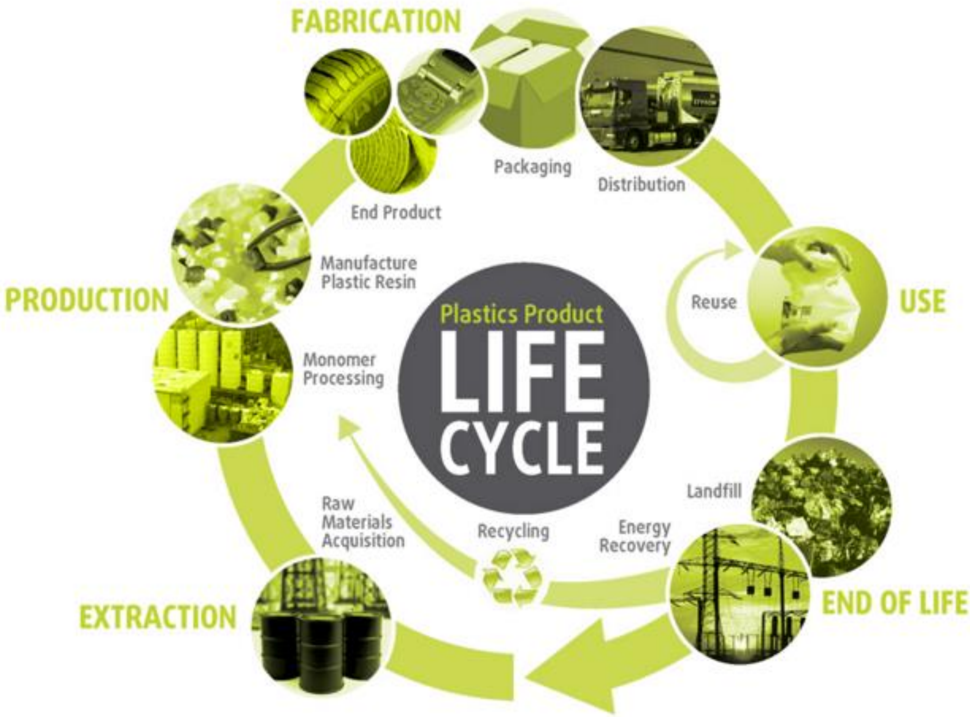


Figure 8. Life cycle of plastic products (Trinseo, 2015)

There are different variants of LCA studies that can be made depending on which part of the lice-cycle it is desired to concentrate on. Cradle-to-Grave represents the full life cycle assessment, which starts at the resource extraction (cradle) stage and stops only at the disposal stage (grave). The other variants concentrate on limited parts of the complete life cycle. The following are the most commonly used types of LCA studies:

- Cradle-to-Grave
- Cradle-to-Gate
- Cradle-to-Cradle (Closed loop production)
- Gate-to-Gate
- Well-to-Well
- Economic Input-Output Life Cycle Assessment
- Ecologically based LCA

To find out the true difference in environmental impact between e.g. a product made from virgin fossil fuel-based raw material, and product made by using recycled material or bio-based material, LCA studies need to be done for all of the products separately. This allows a comparison of the total impacts. The LCA would take into account such questions as; where the materials come from, which methods have been used to produce or collect them, how far have the materials been transported, how will the waste be treated and sorted, etc. This means following the material from the start of its life and throughout all the processes until the end of its life-cycle. It is not correct to assume that by using less material in some single process, or that by using a material such as recycled plastic instead of virgin material, the overall environmental impact would be smaller. This is because there are so many factors that play their role in the life cycle of a product.

Nowadays there are many good computer programs for conducting LCA studies. Amongst the most popular are SimaPro and GaBi. These programs significantly speed up the process of conducting an LCA due to their massive available databases with information about processes and materials.

Guidelines for how to conduct an LCA are described in the ISO 14040-14044 series standards. The ISO standards define four main phases for performing an LCA, these are:

- Goal and scope
- Life cycle inventory (LCI)
- Life cycle impact assessment (LCIA)
- Life cycle interpretation

6. Legal frameworks controlling plastics recycling

There are a number of laws both on international and national levels that control the operations of any company.
The Finnish national laws that control the operations of Rani are largely based on the EU regulatory frameworks. In Finland, the regulations that control the operations at Rani can be seen in whole from table 3 in appendices.

6.1. Packaging Producer Responsibility

Companies who operate in Finland as packagers of goods or importers of packaged goods to Finland, and have a turnover of EUR 1 Million or more, are by law assigned a producer responsibility to take care of their packaging materials. A company that belongs to this group is obliged to organize the collection and recycling of its packaging waste as well as cover the related economic expenses.
The Finnish national targets and requirements for recycling and reuse have been defined by law and the producers are responsible for fulfilling them.
Producer responsibility is part of both the EU and Finnish national packaging and packaging waste directives. This means that producers are responsible for taking care of collection, recycling and other treatment of packaging waste products.
On the EU level these targets are set by the European parliament and council directive 94/62/EC and the amending directive 2004/12/EC.

In Finland the packaging directive is being implemented through the Waste act 1072/1993, the government decision “Pakkauksista ja pakkausjätteistä 962/1997” and government decrees 987/2004 and 817/2005. Through the act 452/2004, the chapter 3a regarding producer responsibility was added, on which packaging producer responsibility has been based since 01.09.2004. The more specific details regarding reuse and recovery of waste are based on the government decision 962/1997 and decree 817/2005.

The new Waste act 646/2011 came into force on 01.05.2012. This act was amended in January 2014, when the implementation of the “extended producer responsibility” was given additional transition time. The extended producer responsibility came into legal power 01.05.2015. On 03.07.2015 the government council accepted the decree 518/2014 on packaging and packaging waste, which is based on the waste act. In this new decree the packaging reuse and recycle targets were set and the consumer packaging collection responsibility were more clearly defined (Rinki Oy, 2015).

The main goals with the implementation of the producer responsibility are:

- To minimize packaging material waste
- To maximize the use of packaging waste as raw material for new products
- To prevent environmental damage and to remove obstacles for trading
- To prevent skewed competition through an equal treatment of packaging materials

The implementation of this law is a direct result of the EU “zero plastic to landfill by 2020” target for the reduction of waste in Europe and development of the recycling industry.

7. Standards for quality, sustainable development and product declaration

International standards are used to ensure quality, safety and efficiency of products, services and systems. They are very important in facilitating international trade. There are a number of international standards used today, the most famous being ISO, IEC and ITU. These are all based in Geneva, Switzerland. These three together form the Worlds Standards Cooperation (WSC) alliance. In additional to these, there are a large number of regional standard organizations, such as the North-American ANSI, the German DIN and the Finnish SFS. In Europe another very important organization is the CEN, European Committee for Standardization.

Controlling the sustainable development and product declaration are the ISO 14000-series and EU standard CEN/SS S26 which is based on the ISO-standard but includes some additional requirements.

7.1. ISO

Rani is certified according to ISO 9001 and 14001 systems. ISO stands for International Organization for Standardization. It is an independent, non-governmental membership organization and the world's largest developer of voluntary international standards. The ISO has a large number of standards for all kinds of applications, but most relevant to this thesis is the 14000-series which is the series of standards for environmental management. The following are the most important standards when using life cycle thinking in decision-making processes. (PlasticsEurope, 2015)

- ISO 14040: Environmental management – Life cycle assessment – Principles and Framework
- ISO 14044: Environmental management – Life cycle assessment – Requirements and Guidelines

- ISO 14021: Self-declared environmental claims - Type II Environmental Labelling
- ISO 14025: Environmental labels and declarations – Type III Environmental Declarations
- ISO 14067: Carbon Footprint of Products (under development)

The ISO 14000-series standards aim to secure that the environmental work in an operational activity is done in a systematic and effective manner. It also aims to minimize the operational environmental footprint through constant improvement. The standard is designed to ensure that the operations management has good control over the process development both regarding results and expenses. The standard also aims to allow for communication both internally and externally to follow up the progress of the environmental work in a concrete and verifiable way. The ISO 14000-series standard is a requirement standard, which means that it consists of requirements that than be verified objectively. The standard can be used to certify the EMS of an operation, but can also be used by a company to leave their own statement of their operations being in line with the requirements of the ISO 14000 standards.

The ISO 14000 standard builds on five base pillars. (Wickenberg, et al., 2008):

- The set-up of an environmental policy
- Operational planning
- The introduction of an EMS
- Follow-up and control of the progress
- Measures and continuous improvement

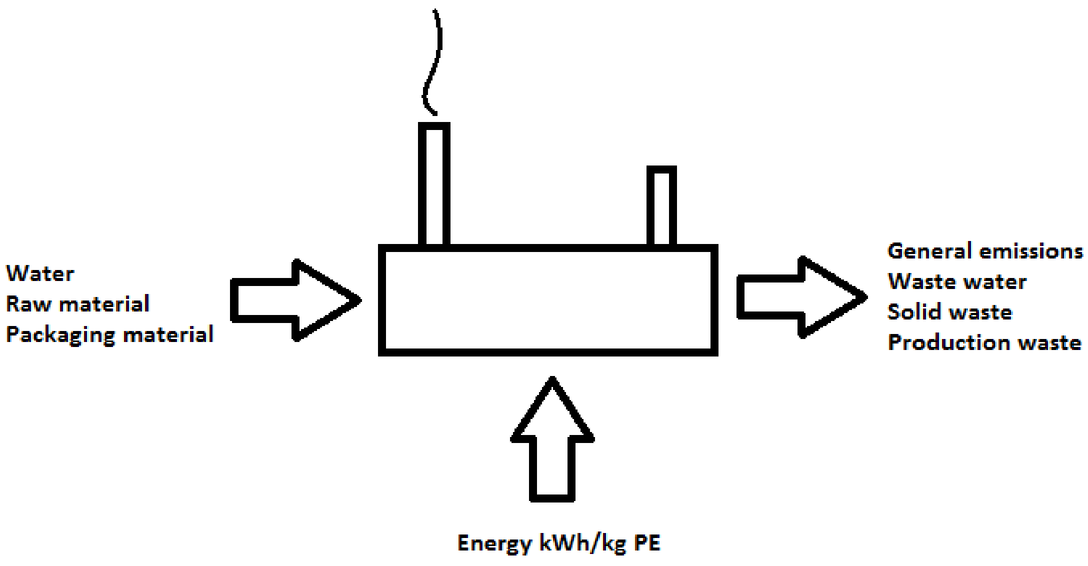
Rani relies on their Rani Management System which is based on the requirements and structure of both ISO 9001 and 14001. The RMS includes all the policies, meters, instructions, and analyses that are required by the ISO standards and used by the company for follow-up purposes. RMS is the go-to place for finding all documents relevant to the company operations.

8. Focus areas and methods for reducing environmental impacts and their current status at Rani Plast

This chapter mentions some areas that are worth focusing on for Rani and which are reasonably easy to measure. It is however hard to know the total impact of changes made to any process or product without doing conducting a LCA to cover the whole process. Rani is concentrating on the most effective use of raw material and energy. This has a direct effect on operational costs but also on the environmental performance. The company spends around 3 million EUR annually on electricity alone so cost is the biggest driver for these changes.
The info presented here is what was seen as the most important by the author, with regards to environmental performance. The info has been collected through literature studies and interviews with selected people from across from the company.

The largest direct environmental impact from Rani comes from logistics and transport, but they are not included in the scope of this thesis. This is something that should preferably be examined in the future. Developing more efficient logistics management systems could bring both economic and ecologic benefit.

At Rani there are a few environmental aspects that are constantly measured in accordance to ISO standards.



IN: Water, energy, raw materials, packaging materials

OUT: General emissions, waste water, solid waste, production waste

The energy use is reported in the form of kWh electricity per kg of produced PE.

Rani does have a way of measuring its carbon footprint, but it is rarely requested and has not been updated in several years. With regards to the environmental footprint there are no tools currently used at Rani for this purpose. It has also not been requested by customers and is therefore not a priority in the company.

Eco-efficiency is however a high priority at Rani, since the effective use of raw material and energy directly affects the company profitability. Therefore Rani is investing in making all processes as resource-efficient as they can be, and this naturally leads to a better environmental performance. One of the projects for improving these is the implementation of more clearly defined product hierarchies. Rani has a vast amount of different products, and by organizing them better, the production are able to better plan the production runs which would result in higher yield and less waste. This has a direct impact on the eco efficiency as a whole. Rani has also taken measures to minimize the energy use. Recently an audit was done for the energy efficiency of the Bjölas factory, and a report of this audit has been made. There were a few areas where efficiency could be improved, mainly related to the heating and cooling of the buildings, machine settings and identifying compressed air leaks. These are being taken into account for future development plans.

8.1. Recycling

Using recycled material is at the moment one of the more interesting areas for Rani, but the whole concept still needs much development. It is hard to get hold of recycled plastic of a good, clean and consistent quality. This is largely a result from the collection of waste being very fragmented and a lack of regulations controlling plastics recycling. Additionally there are the problems of logistics, cleaning and processing of the waste. The most interesting recycled materials for Rani would be the PE waste from industry and agriculture, where the volumes are big and the materials are cleaner and easier to separate from one another. Household waste is not particularly interesting because of the contamination of the plastics and because the materials are very scattered which makes collecting them inefficient. There is ongoing discussion between a few companies and Rani regarding the supply of regranulated raw material. At the moment Rani purchases around 2400 tons annually of reg. material from external sources. This material however consists mainly of damaged or defective products which are sent from Rani to a subcontractor for processing, as the capacity of the regranulation mill at Rani is not sufficient to process all the waste material.

The definition of recycling is the *"process of collecting and processing materials that would otherwise be thrown away as trash and turning them into new products"* (US EPA , 2015). The benefits of recycling are many; they include the reduction of waste sent to landfills, the conservation of natural resources, the reduction in pollution due to a lower need of virgin raw materials, and the possibility of creating new jobs within the recycling industry.

Plastic is a valuable raw material that, in theory, can be recycled over and over again. When recycling plastics, the process can be divided into steps. These are collection, sorting, and reuse or recovery. Most of the different plastics have their own material classification for recycling as shown in table 1 in appendices. This is the reference to be used when sorting plastics for recycling in Finland. It is important to notice that different types of plastics are not usually suitable to be mixed with each other. This is one of the main causes for the slow progress in the implementation of plastics recycling. The other reason is that much of the plastic becomes contaminated with different substances during use, and is as such not suitable for recycling without prior cleaning.

In general plastic is a material that is very suitable for recycling due to its characteristics. Therefore it is important that the recycling industry is being developed to become comprehensive and cost-efficient. In many European countries already more than half of the plastic waste is recycled. (Suomen Uusiomuovi Oy, 2015)

There are several techniques for handling plastic waste. These include mechanical, mixed plastic and feedstock recycling, along with energy recovery. Mechanical recycling means that the plastics are processed mechanically, while feedstock recycling means that the plastic waste is broken down to its fundamental chemical elements which are then reprocessed for use where suitable.

8.1.1. Mechanical recycling

Mechanical recycling refers to methods that aim to recover plastic waste through mechanical processes such as grinding, washing, separating, regranulating and compounding. Mechanical recycling thus produces recyclates that are suitable to be converted into new plastic products. These can sometimes be used to replace virgin plastics. One drawback of mechanical recycling is that it is in practice only suitable for thermoplastic materials.
Mechanical recycling often results in so called “downcycling”. This is a result from the fact that after use, plastics become contaminated and mixed with other materials. It is therefore more feasible to use the recycled plastic for lower quality products, rather than to process it extensively to gain sufficient quality for the original product.

For instance: **PET → Fleece → Plastic carpets → Energy recovery**

Rani uses mechanical recycling at the Bjölas plant in Teerijärvi. There is a so called "eko" department where two mills are located. Here the PE waste from production is shredded, melted and regranulated. This site produces around 4500 tons of reg. material every year which is then reused in film extrusion.

8.1.2. Feedstock recycling

Feedstock recycling is the term used when plastic waste is broken down into its chemical elements which may then be used for different applications. Feedstock recycling is not very common due to the massive structures needed, and is only feasible when connected to an already running petrochemical plant where the waste plastic can be utilized in continuous processes. Feedstock recycling is still very much a technology under development but there will be progress within the near future, once the technology matures and costs decrease. Today there are new technologies under development which theoretically allow a production of virgin plastics from plastic waste through depolymerization processes.

As of today, techniques such as pyrolysis and gasification are used to break down the plastics. These processes produce synthesis gas (syngas) and other liquid and semi-liquid products that are utilized in the process industry.

8.1.3. *Energy recovery*

When plastic reach the end of its life-cycle, meaning that it is no longer viable to reuse it, it may be incinerated to produce heat and electricity for people to use. Plastics have a very high heating value, and 1kg plastic contains roughly the same amount of energy as 1kg of oil.

8.1.4. *Use of recycled plastic at Rani Plast*

Today Rani uses about 6500 tons of reg. plastic annually. Of this amount, 4500 tons is processed on site at the regranulation plant in Teerijärvi, while about 2500 tons of plastic waste is sent to external companies for regranulation and is then bought back. Most of this reg. material is used in the production of agricultural products such as silage films, or e.g. in the mid layers in other films where applicable. In the summer of 2016 a new production line for agricultural films is set to open at Rani Plast Bjölas production plant in Teerijärvi. Upon completion it will be among the most modern and largest production lines of this type in the world. This means that there will be a large additional need of regranulated plastic raw material, but it will also result in more scrap produced. It is estimated that an additional 2000-3000 tons annually are needed, on top of the 6500 tons already used each year. This poses certain challenges for Rani. At this moment Rani has neither the capacity to process the additional scrap on site, nor suppliers who can supply the ideal amount of high quality reg. material. Therefore there have been some talk about whether it would be feasible to open up a new re-granulation plant at the Rani factory. This would allow the company to produce their own reg. material through collecting and processing plastic waste. The problem here is to get hold of plastic waste which holds a certain quality, along with the high investment and running costs of such a plant. It is therefore not seen as an optimal solution for the moment being.

Table 2 below provides a short analysis of the positive and negative aspects in the use of recycled plastics and can be seen in larger format from appendices.

RECYCLED PLASTIC AS RAW MATERIAL	
Strengths	Weaknesses
Allows production waste to be used within the company	Availability of good quality recyclates
Has a positive impact on environmental performance	Plastics are often contaminated after use
Cost efficient	Different types of plastics do not function together
Lower waste handling costs since waste is used on site	Is not fit for every product type
Less waste ending up in the nature	
Opportunities	Threats
New legislation - Better availability of recyclates?	Cost of waste processing
New investment at Ekokem - Availability?	Quality may be bad
Feedstock recycling - Virgin quality material from waste?	Contamination
Waste processing on site - Better availability?	
Products from recycled raw material sold as "eco-friendly"?	

Table 2. Use of recycled plastic

8.2. Down-gauging

Down-gauging is the term used to describe the reduction of the amount of raw material in a product, while still maintaining or improving the material properties. The environmental impact of down-gauging is tremendous. A reduction in weight of a PET bottle from 68 grams in 1977, to 47 grams in 2006 saves an estimated 82 million kilograms of PET annually, in 2-liter soft drink bottles alone.

Compared to the plastic packages of the 1970’s, todays packaging materials are lighter by almost 70%, with a 28% weight reduction in the last 10 years alone. This is due to quickly developing raw materials from which ever thinner films can be made. One of the drivers allowing this down-gauging was the introduction of metallocene compound polymers, specifically mPE in the early 1990’s. The metallocene technology allows for greater control over the molecular structure of the polymer, and subsequently greater control over the behavior of polymer melt flows. (PlasticPackaging, 2015)

Down-gauging is also economically smart, as the amount, and therefore cost, for the raw material needed is reduced. In today's market the price is one of the single most decisive factors, so producing more by using less is really the only way to remain cost-competitive. Down-gauging is constantly being developed at Rani and there has been much progress. The thinnest film Rani made in the 1970's was 0.2 mm while today the thinnest film consists of 3 layers and is only 0.01 mm thick. Borealis which is one of the largest raw material suppliers for Rani is about to launch their 3rd generation Borstar PE within the near future. This new material will allow ever further possibilities for down-gauging and other innovative uses through its flexible design. Rani has been using the Borstar polymers since they were launched.

8.3. Waste streams from Rani Plast

Rani re-uses almost all of the plastic waste that stems from its production processes. The waste that cannot be reused in production is collected for recycling. Annually around 4.5% of the production is scrap material of which most is recycled and re-used on location at Rani.

In addition to the production waste also other waste streams are monitored. These are general emissions such as gas emissions, waste water, and several different solid waste streams. There are collection points for all kinds of waste, which are then handled by a contractor in a proper manner. VOC emissions are one of the areas which has been concentrated most on at Rani. There is still some unused potential regarding these, as the heat from burning them off could be utilized for instance in heating. These VOC emissions derive from the printing machines, the colors and solvents which are used for them.

8.4. The use of bio-based Plastics

Rani has a rather neutral view on the use of bio-based plastics. It is fully possible to operate the current machinery at Rani using bio-based raw materials. The main challenge is the use of another material in the re-granulation process of the set-up rolls at the start of the process, but this can be overcome quite easily. As for the moment bio-based plastics are of interest to many customers, but due to the still high cost of the raw materials there is no extensive use of them at Rani.

The environmental impact from using bio-based plastics versus fossil-based are subject of much discussion, but here maybe the bigger issue here is the ethical aspect, e.g. is it acceptable that land which could be used for food production is used for producing industrial crops? And then there is of course the price. If the bio-based PE is 2-3 times as expensive as fossil based PE, there is naturally only limited interest for the material in an industry with constant price pressure. Borealis has stated that it does not intend to produce bio-based plastics based on food stock such as e.g. corn principally because of ethical reasons.

There is however interesting development in the use of forest industry residue to produce plastics based on ethane derived from forest bio mass. Here there are many possibilities, but also challenges. The biggest challenge is perhaps the question whether it would be economically or ecologically feasible to produce plastics from ethanol, which instead could be used directly in transport fuels. That is perhaps more a political than business-oriented question but is something worth noting. For instance Borealis is participating in a project in Sweden called "Närproducerad Plast" (locally produced plastic) coordinated by SEKAB. This project aims to investigate the possible uses of forest bio material in plastic production. At the moment one of the challenges for setting up operations are the EU import tariffs for bioethanol. Imported bioethanol would be needed at the start-up stage of the forest-to-plastic production cycle as the surrounding operations are being built up. Another even bigger challenge is to be able to foresee how the markets will develop in order to be able to set up economically profitable operations.

8.5. Collaborations in the value-stream

To be able to utilize the large amounts of plastic waste, there has to be good collaboration between the various actors in the field. This is not something that can, or will, be done by Rani alone, but is rather something that has to be decided politically. The new regulations that ban plastic landfill are a step in this direction. However there are still problems, such as who should collect the waste, sort it, clean it, and process it etc. The figure below illustrates how the actors in the value-stream are connected to each other.

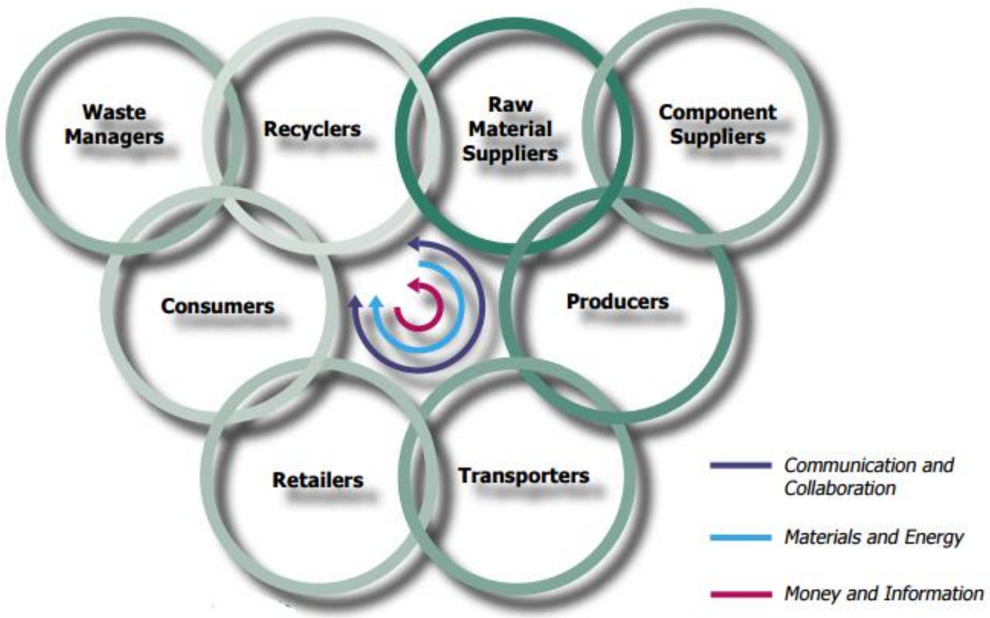


Figure 9. Collaborations (United Nations Environment Programme, 2007)

8. Development suggestions

After having talked to a number of people in different positions at Rani, a few development suggestions could be made. The general consensus at the company seems to be that environmental performance does play a big role in business performance. The problem however, is that environmental performance is hard to define. Also, the customer and producer seem to have a differing view on the topic on top of a general confusion about the whole concept.

For the plastics industry as a whole, one of the biggest problems is a negative image. Many people portray plastics as something bad and which pollutes the nature. This is largely the result of poor waste handling which has resulted in plastics polluting the environment. It should be remembered that this is the fault of people and not of plastics. For the plastics industry it would therefore be important to highlight the actions taken to prevent the pollution. Additionally, to bring into knowledge the huge benefits of using plastic as a packaging material would be beneficial. Other benefits of plastics in the form of reduced use of fossil fuels and food waste should also be highlighted. These are issues that are rather actively worked on, but which take time. These issues are talked about mainly at industry meeting events where actively involved people meet. However to get the information flowing from here down to the average consumer is the hard part.

There are a few development ideas which could be implemented with relative ease, which may have a positive impact for the business and environmental performance of Rani.

Development areas				
	Available at Rani	Status	Future potential	Potential type
Regranulate market	Yes	Active	High	Cost savings
				Company image
				Environmental performance
Regranulate allocation	Yes	Active	High	Cost savings
				Company image
Eco efficiency	Yes	Active	High	Cost savings
				Environmental performance
				Better know-how
				Business opportunities
Marketing	Yes	Semi-active	High	Company image
				Business opportunities
LCA	No	Planned	High	Environmental performance
				Cost savings
				Company image
CO2 Footprint	Yes	Not active	Medium	Company image
				Environmental performance
Environmental footprint	No	No action	Low	Company image
				Environmental performance

Figure 10. Development areas

In the figure 10 above, the development suggestions are summarized. A more detailed table can be found in appendix 3.

8.1. ***Highlighting the actions*** done in Rani which have a direct impact on environmental performance.

This could work for marketing purposes and would not be a huge cost for the company. This means highlighting normal operational actions such as maximizing efficiency, energy use auditing and minimizing, minimizing waste streams, a minimized raw-material use and added use of reg. material. All the information is available through the RMS and/or personnel and would be quite easy to highlight.

The main problem here is to recognize in which circumstances, to whom, and through which channels these actions should be marketed in order to gain any advantage. It is most probably of no use to simply mention it at every possible opportunity unless it is of special interest to a business partner.

8.2. ***Closely monitor the situation*** on the reg. market to be able to take advantage of possibilities coming from legislation changes and investments coming online.

This is something that is already taken into account at Rani, but which could be mentioned again. There will probably be some kind of boom in the plastic recycling industry within the coming years, and keeping up to date on who does what and realizing the potential possibilities could prove to be very beneficial.

8.3. ***Map out the markets*** it would be most feasible to sell products using reg. material on. This would include researching which geographical areas have the most interesting markets for products benefitting from a positive environmental image. This may allow for higher margins, even though they may be offset by high transport costs for the more far away markets.

Point 8.3 is closely linked to number 8.4 following in this list.

8.4. ***Allocation of reg. material*** for products which would benefit from a more environmentally friendly image for added value. This is already done in Rani, but if there are upcoming changes in the availability of reg. material in the near future, perhaps a larger focus in this area could yield positive results.

This is due to the fact that some industries and products are more sensitive to their environmental image than others. Added value to the products could be had e.g. by using reg. material. Acknowledging and marketing the fact that recycled plastics were used to produce a certain material would raise its environmental performance, and could perhaps help business. This of course requires the availability of reg. material of sufficient quality and a clear vision of what is wanted and how such a resource should be used.

8.5. ***Carry out LCA studies*** to find out which processes and stages of the product life cycle are the causes of the largest impacts, and then find methods to minimizing these. This would allow the company to see not only where the largest environmental footprint comes from, but it would also help to clearly define the process steps of each type of product. This could also help in synchronizing the processes, so that the operations would become as efficient as possible. This would of course have a direct impact on the economy.

The problem with LCA studies are that they are rather complex and time consuming to carry out. And even when they are carried out the results should be carefully examined to be able to gain any benefits. An LCA does not contain any value in itself, except perhaps for marketing purposes. It is the actions taken based on the LCA that carry the value, and therefore careful examination of results is extremely important.

9. Summary and conclusions

Having talked to several people within the company, many acknowledge that there are significant business possibilities in the concept of environmentally friendly plastics for Rani. It is something that is discussed with customers, and is often requested. However there is a problem with the concept of environmentally friendly plastics. It is that nobody seems to know exactly what they are. Customers are used to thinking about environmental performance, and it has almost become a norm, but in fact there is rather little knowledge about what it really means. In the end, the way the plastic is being disposed of has a larger impact on the environment than the way in which it has been made.

There are common misconceptions about bio-plastics. Even products made of bio-based and biodegradable plastics are not necessarily environmentally friendly unless they are handled properly throughout their life cycle. There is a moral dilemma in that by offering “environmentally friendly” products, a company can wash its hands clean and say that it did its part to protect the environment, even though their actions have zero impact on the total environmental performance. This holds especially true with the use of bio-based plastics. Rani has all the possibilities to use them in production, but it is at the moment not considered feasible from almost any point of view. It is seen as questionable whether these bring any other benefits except possibly a slightly better environmental image. It should also be remembered that fossil-based virgin polymers are often made from oil refinery byproducts that would otherwise possibly be flared off e.g. burned on site.

To really be able to fully utilize any ideas and concepts of environmental friendly plastics, there must first be a well working waste handling industry. It is of little value to produce or buy expensive bio-based and biodegradable plastics, if in the end the material is still thrown away to a landfill or left somewhere to rot by itself. There is development in this area and the new legislation that comes into force in 2016 will most probably be the single most efficient driver for the upcoming change. It should be noted that with every change there will also be business opportunities, and these may be opportunities which Rani could benefit from. Without legislative action, plastic waste handling and utilization would very much remain a chicken vs. the egg- situation.

At the moment, the increased use of recycled material could be seen as the most interesting area for development at Rani. There will be large changes in how plastic waste material is handled in Finland. Hopefully these changes could be utilized by realizing their potential in time. It should be noted that Finland at the moment is a developing country in respect to waste handling. Therefore also Rani could take the use of good practices learned by companies abroad. To see the most likely future scenarios, eyes could be turned to countries such as Germany and the Netherlands. In these countries, the evolution of waste handling is much more advanced than it is in Finland, and these will probably serve as models for how waste will be handled in Finland in the near future.

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11. Appendices

Table 1. Plastics recycling and the plastic types

MUOVITYYPPI OMINAISUUDET		YLEISET OMINAISUUDET	ESIMERKKEJÄ KÄYTTÖKOHTEISTA JA HYÖTYKÄYTÖSTÄ
Polyeteeni-tereftalaatti PET	01 PET	Kirkas, kova, kemikaaleja kestävä	Virvoitusjuoma- ym. pullot, tekstiilit. Pullot voi palauttaa kauppojen automaatteihin.
Polyeteeni high-density PE-HD	02 PE-HD	Samea tai värillinen, joustava, vahamainen pinta	Mehupullot, ämpärit, virvoitusjuomakorit. Soveltuvat energiajätteen keräykseen. Eräillä paikkakunnilla on PE-HD-muovi-pakkausten kierrätyspisteitä, katso www. uusiomuovi.fi.
Polyvinyyli-kloridi PVC	03 PVC	Erittäin moni-muotoinen ja -piirteinen	Putket, letkut, rakennusmateriaalit. PVC-muovia ei saa polttaa eikä laittaa energiajätteen keräykseen, katso www.uusiomuovi.fi.
Polyeteeni low-density PE-LD	04 PE-LD	Pehmeä, joustava, vahamainen pinta	Muovikassit, pussit, kalvot. Soveltuvat energiajätteen keräykseen. Pieniä määriä voi polttaa puun seassa. Pussit voi palauttaa kauppojen palautus-automaattien yhteydessä oleviin muovi-jätteen keräysastioihin.
Polypropeeni PP	05 PP	Jäykkä, sitkeä, hyvin moni-käyttöinen	Narut, rasiat, tekniset osat, kalvot. Soveltuvat energiajätteen keräykseen.
Polystyreeni PS	06 PS	Lasinkirkas tai värjätty, hauras	Rasiat, purkit. Soveltuvat energiajätteen keräykseen.
Muut	07 O	Kaikkien ylläolevien yhdistelmät ja muut materiaalit	Soveltuvat vain laitosmaiseen polttoon, joten tämän merkin sisältävien tuotteiden soveltuminen muualle kuin sekajätteeseen pitää tarkistaa paikalliselta jätehuollolta.

Table 2. Recycling SWOT

RECYCLED PLASTIC AS RAW MATERIAL	
Strengths	Weaknesses
Allows production waste to be used within the company	Availability of good quality recyclates
Has a positive impact on environmental performance	Plastics are often contaminated after use
Cost efficient	Different types of plastics do not function together
Lower waste handling costs since waste is used on site	Is not fit for every product type
Less waste ending up in the nature	
Opportunities	Threats
New legislation - Better availability of recyclates?	Cost of waste processing
New investment at Ekokem - Availability?	Quality may be bad
Feedstock recycling - Virgin quality material from waste?	Contamination
Waste processing on site - Better availability?	
Products from recycled raw material sold as "eco-friendly"?	

Table 3. Development areas

Development areas					
	Available at Rani	Status	Future potential	Potential type	Author's comments
Regranulate market	Yes	Active	High	Cost savings	Find sufficient quality and supply of reg. material
				Company image	Monitor the developing reg. market
				Environmental performance	Market the use of reg. Material - Environmentally friendly
Regranulate allocation	Yes	Active	High	Cost savings	Find out which product type is it most feasible to use reg in
				Company image	Which products are the most image-sensitive?
					Analyze cost vs. benefit and future potential
Eco efficiency	Yes	Active	High	Cost savings	Better raw materials on the market
				Environmental performance	Product hierarchy optimzation
				Better know-how	More cooperation and better internal communication
				Business opportunities	New applications for e.g. MDO and pre-stretched products?
Marketing	Yes	Semi-active	High	Company image	Highlight actions done to minimize environmental impact
				Business opportunities	Company image, as what kind of a company should Rani be marketed?
					Where can the biggest impact be made with the least effort?
LCA	No	Planned	High	Environmental performance	Study material flows, energy use and process efficiency
				Cost savings	Carefully analyze the results, what could be improved?
				Company image	Show that responsibility is taken for the environment
CO2 Footprint	Yes	Not active	Medium	Company image	Could be used in marketing
				Environmental performance	Could be updated
Environmental footprint	No	No action	Low	Company image	Could be used in marketing
				Environmental performance	Could be updated

Table 4. List of laws applicable to Rani Plast operations (Confidential)

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