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Executive Summary

This project examines the market for recycled plastic, identifies barriers to further utilisation of recycled plastics, and analyses a collection of policy tools that could be used to support and expand that market.

The project primarily focuses on post-consumer plastic waste because this is considered to be the more problematic. The market for plastic waste generated in manufacturing and production is relatively strong and well-functioning; As a consequence, the majority of plastic waste from manufacturing and production is recycled. Post-consumer waste is much less homogenous: it comes from a wide variety of sources, and contains a wide variety of plastics and tends to be difficult to collect, sort, and recycle.

Packaging waste represents by far the largest post-consumer plastic waste stream. Just over 700,000 tonnes of plastic packaging waste is generated in the Nordic region annually (Fråne et al. 2015b). Other post-consumer waste streams (MSW, agriculture, WEEE, ELVs, and C&D waste), in contrast, together contain only about 270,000 tonnes of plastics. However, some of these waste streams (agriculture, ELV and C&D) typically contain relatively few plastic types, which means they could potentially be more attractive for recycling. MSW and WEEE, on the other hand, contain a potentially large variety of plastics, making recycling potentially more troublesome.

The demand for plastic in the manufacturing and production processes in the Nordic countries are difficult to quantify for various reasons, including a lack of reliable statistics and significant import of plastic products and plastic components. However, from the available information and data, it appears that between 26% (Finland) and 83% (Norway) of plastic demand could be met if all post-consumer plastic waste generated today was recycled. It is important to note that while plastic waste generation can be disaggregated by plastic type, the demand for plastic waste in the Nordic region cannot be similarly disaggregated, so there is a high level of uncertainty about whether the plastic waste generated is suitable for the demands of Nordic manufacturing and production.

The market for recycled plastic comprises several sub-markets along the value chain. The technical requirements for the raw material are also very diverse. There are a number of different polymers with different properties. They are sometimes mixed and supplemented with additives to achieve certain properties. This means that quality specifications for a given use are not only a question of high or low quality, but also a question of using the right type of plastic for the right type of product.

This complex market landscape made a thorough analysis difficult within the framework of this project. Rather than examining the market as a whole, the market has been broken down into sub-markets between adjoining value chain actors. This allows an examination of the individual conditions and demands of each type of actor.

A lack of demand for recycled plastic waste was found to be one of the most significant problems. This can be further divided into lack of demand from producers and manufactures of products because of quality concerns and the uncompetitive price of recycled plastic compared to virgin plastic, and lack of demand by end consumers for products made with recycled material.

Limited value chain coordination was also seen as a common and significant barrier by many actors. This is a broad concern that touches on a number of different factors, including lack of communication of demands between actors, lack of value chain collaboration to identify opportunities for using recycled plastics, and lack of traceability of plastic and trust in the quality of material passing (or, more often than not, not passing) between actors. It seems that most communication along the value chain takes place between two directly linked steps, with very little communication and coordination with more distant steps. Improving communication and coordination could take place through already established channels in, for example, industry associations, or through new dedicated fora set up by industry associations or national authorities.

Design for recycling appears to be only in its infancy, and requires support along the value chain – particularly from waste collectors and sorters – to be effective in providing more and better material for recycling. This support seems to be currently lacking in all markets.

In addition to these clear barriers to better utilisation of the available plastic waste, the market suffers from significant technical and logistic barriers, as well as lack of infrastructure – for example, sorting facilities. Recycling technologies are also not yet sufficiently developed to service a market for full and high-quality utilisation of the available waste material. The fact that plastic cannot be endlessly recycled, and degrades after recycling iteration, also has to be considered.

Policy responses to these problems could take many forms, but green public procurement (GPP), taxing or banning the incineration of plastic waste, support for Ecodesign, and certification of recycled plastic were considered the most relevant in the context of this project.

GPP can be used to strengthen potential markets for environmentally or socially beneficial products and services. GPP could be used to address the lack of demand for plastics made with recycled material, both from end consumers, and subsequently demand from producers and manufacturers for recycled plastic to fulfil public demand. It could also be used to support the production of products that are easy to recycle, providing a reliable stream of high quality plastic waste for recycling. A first step would be to identify the product categories where criteria for recycled plastic would be relevant and could significantly increase demand: Only some products use plastics in large enough quantities to be influential in the market.

Implementing GPP is not always straight forward, and there can be significant administrative burdens for both public authorities and private suppliers. Perhaps in light of this, it has proved difficult to widely apply GPP, even in the Nordic countries.

Certification of recycled plastic could help support the market by increasing transparency and traceability of plastic materials, and building trust in recycled plastic

among manufacturers. This could be complemented by Ecodesign criteria to promote the use of recycled plastic in certain product groups.

A significant share of the preparatory work for GPP would be similar to that for certification and for Ecodesign. As such, many of the burdens could be shared and administrative costs reduced. In addition, the process of defining GPP criteria, certification criteria and Ecodesign criteria would necessarily involve detailed and continued consultation with industry, which in itself would help communication and coordination along the value chain.

To ban or tax plastic incineration are ways to force the plastic waste from incineration to recycling, and it is reasonable to assume that both instruments would increase the supply of plastic waste for recycling. Implementation of such a ban or tax, however, would be complicated and logistically, administrative and, perhaps most saliently, political difficult. Incineration of plastic plays an important role in waste management and energy supply in the Nordic countries. In addition, incineration is perhaps the best treatment option for plastic that is no longer fit for recycling. Both a ban or a tax on plastic incineration also risks incentivising export of plastic waste (potentially for incineration in another country) rather than recycling. This must be legislated for in any implementation. That said, it would be an incredibly potent statement to implement either of these policies, and it would certainly provide robust long-term framework conditions for a thriving market for plastic waste recycling to grow around.

Investments in waste management infrastructure and technical innovation could also help overcome some of the technical and logistical barriers currently facing the market. There are significant technological barriers to increased recycling of plastics, and there is often a chicken/egg problem related to the market and technology. Investments supporting technical innovation could be boosted by earmarking a share of existing innovation funding schemes.

1. Introduction

1.1 Background

This report outlines the findings of a project by Copenhagen Resource Institute, NIRAS, IIIIE and VTT for the Nordic Council of Ministers Waste Group. The project investigates the possibility for using policy actions to support and expand the market for waste plastics in the Nordic region. This has the objective of increasing the recycling of plastics and minimising the down-cycling and incineration of plastic waste.

Each year, 700,000 tonnes of plastic is incinerated or landfilled in the Nordic countries: a waste of valuable resources and contrary to the waste hierarchy (Fråne et al., 2015b). Separately collecting and recycling this plastic waste would have significant economic and environmental benefits. For example, recovering and recycling half of the plastic waste generated in the Nordic countries corresponds roughly to a reduction of greenhouse gas emissions equivalent to the total emissions from cars in the Nordic capitals.

A high proportion of the plastic collected in the Nordic region is currently down-cycled to a lower quality material. This is at least partly due to difficulty ensuing that the collected material is of sufficiently high quality and does not contain hazardous substances. In addition, a significant quantity of the plastic separately collected is not actually recycled: Almost half of the plastic waste collected in the EU is exported, mainly to China, and the end treatment for this plastic waste is largely unknown (Velis, C.A., 2014). Finding and promoting examples of European-based manufacturers that use recycled plastics to produce new products could inspire increased use of recycled plastics as raw materials in local markets and reduce the need to export the material for re-processing

1.2 Scope

The market for plastics and waste plastics is multifaceted and complex, has many actors and involves multiple, non-homogenous and highly differentiated waste streams, manufacturing processes, and products. A comprehensive and detailed analysis of these, let alone the analysis of the impacts of policy on these is beyond the scope of this project.

A significant portion of the plastic waste generated in the Nordic countries arises in the manufacturing industry. However, much of this plastic, being largely homogenous and clean, is already widely utilised, either directly by industry or by the existing plastics recycling market.

This report seeks to address the remaining problematic plastic waste – post-consumer waste – that has, so far, proved difficult to capture and recycle, and to explore market-oriented policy solutions to increasing its capture and recycling. This is explained further in section 2 on the findings from data and literature.

1.3 Approach

To prepare a robust basis for policy suggestions, this report briefly maps the current flows of plastics and waste plastics in the Nordic countries, and reports on consultations with actors throughout the plastics and waste plastics value chain, to better identify and understand the barriers and potential opportunities that it presents.

This process is guided by six research questions:

- What factors inhibit the market for recycled plastic materials?
- What demands do manufacturers place on recycled plastic as raw material for their production? (Can they for example, accept mixes of polymers, or mixing of hazardous substances and other pollutants).
- Why do manufacturers of plastic products not currently use recycled plastic materials?
- How could the recycling industry ensure a safe and standardized quality of recycled plastic materials that meets the demands of the manufacturer?
- What policy instruments could strengthen demand for recycled plastic material?
- What successful examples can be highlighted/showcased/presented of manufacturers who already use recycled plastics as raw material?

The Nordic Council of Ministers Waste Group was explicit in policy domains that it would ideally like to explore:

- Green Public Procurement.
- Tax or outright ban on incineration of plastics.
- Ecodesign of products.
- Certification of recycled plastics.

These research questions are answered using a four-step process that seeks to map the flows of materials, identify barriers and opportunities and provide and briefly analyse the potential impacts of possible policy suggestions.

- *Mapping* – data and literature.
- *Consulting* – interviews with value chain actors.

- *Market analysis* – identifying common barriers and hotspots, developing success cases.
- *Solutions*– policy formulation and analysis.

The four steps of the approach are described in detail below.

1.3.1 Mapping – data and literature

Mapping the current flows of plastic materials is crucial to forming a robust understanding of the market problems, and the solutions that could be employed to solve them. This was achieved by combining the data from reputable sources (Eurostat, primarily) with literature addressing the market for plastics and plastic waste. While the data provide information about the flows of plastics through the economy, the literature provide important insight into the problems encountered by actors along the value chain. These problems can act as barriers to an effective plastic waste market.

Data quality issues are discussed in more detail in section 2, together with an overall description of the flows of plastics through the Nordic economies.

Literature review findings are structured around the types of barriers uncovered:

- Technological barriers.
- Legislative barriers.
- Market barriers.
- Logistical barriers.

In addition, barriers have also been identified that affect specific actors in the value chain:

- Producer.
- Consumer.
- Waste handler.
- Recyclers.

Importantly, the current gaps in literature findings are also outlined under these headings. The findings provide, together with the stakeholder interviews, vital input to the market analysis, the findings which are in section 3 of this report.

1.3.2 Consulting – Interviews with value chain actors

In-person interviews were used to harvest supplementary data about the state of the market and, more critically, identify barriers to a stronger market for waste plastics. While this project focuses on post-consumer waste, many of the value chain actors

necessarily also deal with non-post-consumer waste plastics in their daily operations. In this way, the interview also served to substantiate the scope of the project toward post-consumer plastics.

The interviews, and the market analysis they supported, were focused on the demand side, because the motivation for and relevance of actions toward better collection of plastic waste for recycling depend on the presence of a demand for recycled plastic. This is reflected in the balance of actors interviewed:

- Plastics industry associations.
- Waste industry associations.
- Waste management company dealing with plastic waste.
- Plastic producers.
- Manufacturers/plastic consuming companies.
- National authorities.

The interviews were semi-structured based on a common but adaptable interview guide for each type of value chain actor, developed to ensure coverage of the different market aspects. The questions were formulated openly, to ensure that the interview focused on subjects that are important to the stakeholders, and to provide the opportunity to gather information that could have been overlooked using a long list of structured questions. The interview guide can be found in Appendix 1.

Eighteen interviews were conducted. The results fed directly into the market analysis and short case studies and illustrated important findings.

Table 1: List of interviewees

Abbreviation	Type of Actor
Denmark	
D-SA-1	Sector association
D-PP-1	Plastics compounder
D-WMC-1	Waste management company
D-MU-1	Municipality
D-MU-2	Municipal utility company, waste collector/sorter
Sweden	
S-PP-1	Plastics compounder
S-PCB-1	Plastic consuming business
S-WMC-1	Waste industry association
S-WMC-2	Waste collector/sorter
Finland	
F-AS-1	Sector association
F-PP-1	Plastics producer
F-WMC-1	Waste management company
F-PCB-1	Manufacturer of consumer products
F-GA-1	Government agency
Norway	
N-SA-1	Sector association
N-PP-1	Plastics compounder
N-WMC-1	Waste collector/sorter
N-WMC-2	Waste collector/sorter

1.3.3 *Market analysis – identifying common barriers and hotspots*

The market for plastic waste is highly complex: It involves a multitude of different types of actors, with widely differing and often opposing objectives and often with direct relations only to the actors one step away in the value chain. From a technical perspective, it involves a variety of sometimes interchangeable but often mutually exclusive polymers, and market conditions heavily dependent on an entirely external factor: The price of oil.

To facilitate the analysis, the market has been broken down into sub-markets: the markets between two interlinked actor types in the value chain. The aim of the market analysis is to identify the factors that hinder the market for utilisation of plastic waste in the Nordic countries. Where these barriers impact multiple actors and actor types, they can be described as hotspots. Identifying the hotspots allows the formulation and analysis of policy that could be used to tackle these hotspots, with the aim of freeing the market and the flow of recycled plastics through it.

This part of the project draws heavily on the stakeholder interviews to help pinpoint common problems and identify themes that seem to restrict the market. This is a qualitative process and therefore requires a degree of interpretation – actors tend to describe reality from their own position – and the interpretation is helped enormously by the information gathered during the literature review process.

In addition to the broader market for plastic waste, the idiosyncrasies of the national markets for plastic and plastic waste in Denmark, Sweden, Norway and Finland are explored. The market for plastic in municipal solid waste (MSW) was also investigated in isolation, to identify the specific difficulties with recycling plastics in one of the most problematic of the plastic waste streams.

1.3.4 *Solutions – policy formulation and analysis*

The Nordic Council of Ministers Waste Group was explicit about the types of policy domains they would like to investigate, and the proposals developed reflect these wishes, albeit tailored to the hotspots identified in the market analysis.

One specific policy has been developed within each of the indicated policy domains, and are based on experiences of similar types of policies already in use in the Nordic countries or in the wider world. They are not detailed policy descriptions, and focus on the nature of a potential implementation, but not the quantitative specifics of such an implementation. That is to say, for example, that where a tax is discussed, it is discussed in general terms of the likely effects of such a tax, not in terms of the effects of a specific level of tax.

Each of the policies are analysed for their potential effects in addressing the hotspots identified in the market analysis. This is done within the frame of a SWOT analysis, while also addressing the potential positive and negative effects of each policy. Each policy suggestion is analysed for its strengths, weaknesses in addressing, and the opportunities and threats it presents for, each of the identified hotspots. This is primarily to incorporate the potential side effects of a policy mainly aiming to address one hotspot, but potentially impacting another.

2. Market size and barriers: Data and literature findings

2.1 Data

Data was collected on:

- Quantities of waste plastics in the Nordic countries.
- Demand for plastics in the Nordic countries.

2.1.1 *Data on waste plastics*

Data on waste plastics is used to describe the generation of post-consumer plastic waste in each of the Nordic countries. Ideally, this data would describe waste flows by source (waste stream) and type (plastic polymer). Information and data sources for this type of national data include:

- National statistical offices and EPAs.
- International statistical offices (Eurostat).
- Producer responsibility organisations (PROs).
- Plastic associations (Plastics Europe).
- Data from literature.

The waste streams containing significant quantities of plastic are packaging, non-packaging municipal solid waste (MSW), waste from electronic and electrical equipment (WEEE), construction and demolition waste (C&DW), end-of-life vehicles (ELV) and agricultural waste.

After reviewing the potential sources mentioned above, it was clear that Eurostat provides the best usable data. The Nordic countries' national statistics provide the same data as Eurostat, while reports from producer responsibility organisations aggregated data per waste stream, making it impossible to isolate data for individual plastic fractions.

Eurostat hosts the most complete datasets, arranged per waste stream. Eurostat in general collects data in a biannual basis, and the latest available data refer to 2012. However, for specific waste streams (packaging waste, WEEE and ELV) Eurostat host annual datasets, and the latest dataset for these streams refers to 2013. Therefore, the collected data refer to different years.

Figure 1 shows the amount of plastic waste generated per waste stream. It is evident from the data in the Figure that packaging waste is the dominant waste stream, followed at a distance by WEEE and ELV.¹ Figure 2 shows the same information as Figure 1, but broken down to country level.

Figure 1: Plastic waste generated by waste stream in the Nordic region

Source: Eurostat, 2016.

Figure 2: Plastic waste generated by waste stream in each Nordic country

Note: The Eurostat data for Finnish agricultural plastic waste varies significantly from year to year. The figure from 10,000 tonnes to nearly 0.

Source: Eurostat, 2016

It is also important to look at what plastic types each waste stream contains. For example, C&DW should contain harder plastic types such as PVC used in piping, while agricultural waste normally consists of greenhouse plastics made of PE or foils used for silage wrapping. Figure 3 uses data from Hestin et al. (2015)² combined with the data from Eurostat, and shows the distribution of the plastics from each waste stream into

¹ MSW has been assumed to contain 70% packaging waste, so only 30% is taken into account (NCM, 2014). WEEE is assumed to contain 20% plastics (UNU, 2007). ELVs are assumed to contain 11% plastics (GHK, 2006).

² http://www.plasticsrecyclers.eu/sites/default/files/BIO_Deloitte_PRE_Plastics%20Recycling%20Impact_Assessment_Final%20Report.pdf

specific plastic types. While packaging waste covers a large variety of plastic polymers, other waste streams are represented by some dominant polymer types.

Figure 3: Plastic types in each plastic waste stream in the Nordic countries

Source: Eurostat, Hestin et al. 2015.

The split between polymer types in post-consumer plastic waste across the whole Nordic area is illustrated in Figure 3. The influence of packaging fractions is clear.

Figure 4: Polymers in plastic waste in the Nordic region

Source: Eurostat, Hestin et al. 2015.

2.1.2 Data on plastics market

The second part of data collection refers to demand data for plastics in the Nordic region. This allows a comparison between the waste arisings in the Nordic region with the demand for plastic (defined as domestic production demand and imports) from the local industries in each country.

Sources for demand data include international and national trade statistical databases. These databases include trade data per product codes and refer to imports, exports and domestic production. The data are measured both in economic and mass terms. However, data in these databases (Eurostat's Prodcum and Comext, UN's Comtrade, as well as national offices) is incomplete for most countries, with the possible exception of Denmark. For some product codes, domestic production data is missing, while for others import data is not available. Therefore, the statistical databases do not offer a comprehensive image of plastic demand in each country.

The last source of data examined is Plastics Europe, which published a report on EU plastic demand, covering also Denmark, Finland, Norway and Sweden (no data for Iceland). This data is also problematic, as it is not clear how demand is defined in the report. Using this source, it is possible, however, to correlate demand with waste generation data (from the six waste streams investigated) and draw some rough conclusions on how much of the demand, plastic waste recycling could potentially cover. This comparison refers to total plastic waste generation and total plastic demand, as it is not possible to find data supporting a more detailed comparison per plastic type.

Figure 5: Potential coverage of demand for plastics by waste plastics

Source: Eurostat, Plastics Europe (2015).

Figure 5 shows that the potential coverage of demand for plastics in the various countries is between 26% (Finland) and 83% (Norway). Despite the data uncertainty analysed previously, the data shows that:

- There is a significant difference between waste arisings and demand (also consumption), which indicates some part of plastic is stockpiled or exported. Interview with The Danish Plastics Federation [Plastindustrien] indicates that 70% of Danish production is exported.
- Even if all plastic is recycled, it would not cover the demand for plastics in the countries.
- If the market for secondary plastics is improved, local industries can absorb potentially all recycled plastic wastes, when calculated as aggregate plastic, although this may not be true for individual types of plastic.

2.2 Literature

The literature review investigated the technological barriers and the legislative/market-based/logistics barriers limiting demand for recycled plastics.

The information presented in the following sections is a synthesis of a review of multiple literature sources, as many identified barriers were included in more than one source. The reviewed sources are presented in the Reference list at the end of this report.

2.2.1 Technical barriers

Difficulty in achieving a recycled polymer of high quality seems to be the most important technical barrier. The following issues affect the quality of recycle:

- Feedstock material.
 - Material diversity.
 - Contamination/impurities of feedstock (including additives).
- Recycling technologies.
- Design for recycling.

In addition to the issues of quality, there appears to be two additional indirect technological barriers related to:

- The low volumes and fluctuating supply of waste plastics.
- Lack of treating and sorting capacity.

The next section examines each of these barriers in detail.

Feedstock material

The quality of the feedstock material is decisive for a high-quality recycling. The closer the quality of recycled plastic is to virgin material, the more options for recycling exist.

Feedstock material needs to be free of contaminants and not contain other polymer types. Usually, the chemical properties and composition of the feedstock material, as well as the additives included, are not known, so it is difficult to assess its potential for recycling. Barriers related to the feedstock material quality are in general:

- Quality of feedstock material: mixed plastics and presence of contaminants (e.g. OECD 2005, Hopewell et al. 2009, Fråne et al. 2014, Villanueva & Eder 2014).
- Lack of transparency and traceability (e.g. KEMI 2012, Fråne et al. 2014, 2015c, Baxter et al. 2015b, WEF 2016).
- Standards for feedstock characterisation as well as quality demands for recycled plastics are generic or absent (e.g. KEMI 2012, Villanueva & Eder 2014, Baxter et al. 2014).

Diversity of feedstock material: Usually mechanical recycling processes are designed for single polymer types. Besides mixed plastic waste, some plastic materials are composed of more than one polymer type, making it difficult to separate when it becomes waste. Also, plastics continuously undergo changes in chemical and mechanical properties, leading to degradation of the materials (COWI 2013, Andersen 2015).

Impurities and additives: There are various types of impurities or contaminants in waste plastics that require different removal techniques. In addition, additives might be considered as hazardous materials and extra effort is required to remove them.

Recycling technologies

Recycling technologies mainly target plastic packaging waste. Diversification of technologies will be needed to address other plastic waste material. Developing more efficient sorting technologies should be emphasised to address the array of possible contaminants in the feedstock material. More specifically:

- Compaction/shredding technologies: Focus should be on avoiding excessive mixing of polymer types. Also, some polymers do not respond well to compaction (e.g. EPS) (Andersen 2015).
- Sorting: Sorting processes are key in ensuring purity of the final recyclate. Problems associated with sorting include the presence of items composed of more than one plastic type, presence of black carbon colorant, and difficulty in separation of additives (e.g. Franckx et al. 2008, Baxter et al. 2014, Fråne et al. 2014, Villanueva & Eder 2014, Andersen 2015, WEF 2016).
- Cleaning: The removal of certain glues and inks on waste materials is difficult (WEF 2016).

Design for recycling

Design for recycling is largely absent in plastic products. There is little incentive for product designers to consider recycling activities, leading to bad labelling of plastic

products, increase of cost for sorting and recycling, and absence of homogeneity in recycled plastic materials.

Other issues identified through the literature review involve the low volumes of plastic waste collected, along with the fluctuating supply of waste plastics and the absence of adequate sorting and treatment capacity in the Nordic region.

Data gaps: The literature is rich in information but there are still knowledge/information gaps:

- Quality issues.
 - Are there any general specifications (i.e. boundary conditions) for feedstock quality that recyclers commonly follow?
 - Quality control of recyclates: Purity demands, are there any common procedures for characterization?
 - Is the long-term durability of recycled plastics different to that of virgin plastics?
- Recycling technologies.
 - How efficient are current separation technologies in separating different polymer types?
 - How much plastics/other materials is discarded after separation?
 - How much of the feedstock material is actually recycled to new products? What happens to the rest? (further processing, incineration, landfilling).
 - Which types of polymers are currently recycled in the Nordic countries?
- Impurities and additives.
 - What are the cross-effects of additives in recycled plastics?
 - Has a comprehensive risk assessment been undertaken?

2.2.2 *Legislative/market-based/logistics barriers*

The barriers identified are presented below for each of the areas investigated:

Legislation

- Plastic recycling is an international market. Legislation on import and export may challenge this trade.
- Recycling policies and targets focus on overall recycling levels and may have the side effect that, due to its lighter weight, plastic is not prioritized in national policies, which again can mean relatively weak incentives for companies to work towards higher recycling rates for plastics.
- Differences in national implementations of EU-legislation.
- The difficulties of avoiding the creation of an illegal waste market when introducing fees or charges.

- Lack of criteria for characterization of waste plastics and different recycled polymers (e.g. KEMI 2012, Baxter et al. 2014, Villanueva & Eder 2014).
- BS EN 15343 is the European standard that specifies the procedures needed for the traceability of recycled plastics. This gives the basis for the calculation procedure for the recycled content of a product.
- Some standards/legislation prevent the use of recycled materials (e.g. Franckx et al. 2008, Baxter et al. 2014).

The literature review did not find adequate information on the size of the illegal market for waste plastics and the experience of legislative barriers by relevant stakeholders. These issues were addressed instead in the interviews.

Market/Logistics

- The price of virgin plastic is linked to the price of oil, which is itself highly volatile. This fundamentally influences the price that manufacturers are willing to pay for recycled plastics.
- Overall the market is fragmented without overarching value chain coordination.
- China is a key player in the plastic recycling market, although it's importance to each of the individual Nordic markets varies. Risk of dependence on a single importing country.
- Inconsistent supply load is a logistical challenge.
- Current practices for managing plastic waste (i.e. energy recovery by incineration or export/illegal markets).
- Limited data availability.
- Uncertainty over costs: It has been estimated to cost around 1 billion EUR/year to achieve the targets in 2020 – corresponds to roughly 40 EUR/tonne of plastic waste generated. The EPR annual participation fees for the recycling of plastic packaging (e.g. green dot, etc.) are much higher than 40 EUR/tonne (Hestin et al. 2015).
- Uncertainty over which actors can reap economic benefits of increasing plastic recycling, including:
 - Capturing plastic packaging material value,
 - Reducing the potential negative externalities for companies,
 - Reducing dependence on oil prices.
- The international trade in used plastic is complex and can be threatened by many factors.

Gaps in the literature

- How integrated is the Nordic plastic industry in the global market? (to what extent can parameters/markets outside the Nordic region be neglected).

- Missing overall description of the existing infrastructure between the different links in the value chain.
- Lack of detailed knowledge of specific barriers and possibilities connected to concrete sources and recycling opportunities.
- No reliable overview of number and size of market actors.
- No reliable break-even point for prices on recycling versus production.
- Barriers experienced by the stakeholders.

2.2.3 *Specific barriers for value chain actors*

The literature review identified barriers to recycling plastics experienced by producers and consumers, waste handling and recycling units. Under each barrier category, gaps in literature/existing knowledge have been identified.

Producers

- Company disclosure on plastic is poor.
- Inconsistency in supply load of recycled plastics.
- Material quality not good enough.
- Development of plastic products happen faster and is disconnected from the development of an after-use system.

Gaps:

- Plastic costs: Virgin versus secondary materials?
- What types/purity of plastic are demanded?

Consumers

Although no distinct barriers were uncovered for consumers in the literature study, there are some areas that it would be useful to have further information about (see gaps, below).

Gaps:

- The significance of consumer demand and CSR.
- Willingness of consumer to sort plastic.
- How powerful is consumer demand for recycled plastic – and in what sectors?

Waste handling:

- The effectiveness of the collection and treatment systems strongly influences the ability to produce and offer secondary raw materials to client industries at competitive prices.

- High costs of separate waste collection.

Gaps

- What are alternative waste handling methods and the success rate of these?

Recycling unit

- Products that use plastics, including packaging, develop much more rapidly than the waste management and recycling systems that are to process them.
- High implementation costs of technologies in plastic reuse.
- Current lack of capacity in recycling units.
- Pre-treatment process efficiency is relatively high: About 75% for waste from households and about 95% for waste from commercial/ industrial post-consumer packaging is 95% (Hestin et al. 2015).
- For sorting, the investment cost varies from about 500 EUR/t to 800 EUR/t (Hestin et al. 2015).
- For recycling, the investment cost varies from 275 EUR/tonne (e.g. PET recycling facility with treatment capacity of 36,500 tonnes/y) to 750 EUR/tonne (e.g. specialised facility of high quality PP and PE recycling) (Hestin et al. 2015).

Gaps:

- What is the capacity load of Nordic recycling units? And are they overloaded?
- To what extent is the recycling unit aware of what is needed by the producer? (e.g. what types/purity of plastic is needed? How much does it need to be processed?).
- Recycled vs. reused; How does the recycling unit determine whether plastic should be reused directly or go through recycling process?

2.3 Summary of data and literature review

Regarding data on waste flows, information has been collected for the plastics contained in the most important waste streams, namely packaging, non-packaging MSW, WEEE, C&DW, ELV and agricultural waste. The confidence around this data is relatively high as it has been collected through a single homogenous source (Eurostat) and for similar years. The waste generation data show that packaging waste contains by far the most plastic, followed by WEEE and ELV.

Another set of data refers to the demand for plastics in the Nordic region. This data should be used to assess the room for absorption of recycled plastic in the domestic production of the Nordic region. National and European statistics do not register this

type of data, but data from Plastics Europe show that the available plastic waste quantities lag much behind the demand for plastics by the local industries.

Barriers that limit the uptake of plastic wastes into manufacturing of new plastic products were identified in literature sources.

The *technological barriers* identified are mainly related to the quality of the feedstock material, including the presence of mixed plastic types and other contaminants in the waste collected. Indirect technological barriers include the lack of design for recycling from plastic items and a lack of diversification of existing recycling technologies that currently mainly target packaging waste.

Legislative barriers are influenced by the fact that plastic waste is subject to international trade. Non-harmonised systems across geographical areas and the presence of an illegal waste market are the main barriers that legislation needs to address.

Barriers have also been identified with respect to *market/value chain/logistics* aspects. The market for recycled plastics is fragmented and is dependent largely on exports to China. Another issue that might deter investments is the price volatility of plastic wastes compared with virgin plastics.

Identified gaps in existing knowledge are addressed in the interviews with relevant stakeholders where possible and relevant.

3. Market analysis

This section of the report describes the current market for plastic recyclables from (primarily post-consumer) waste to new plastic products. Quantitative data from Eurostat, qualitative data from literature studies and interviews with relevant players on the market have been incorporated.

3.1 Introduction to the plastic market

During the interviews, carried out as part of this project, key players stated that recycling of plastics has great potential and that recycling is on the agenda in the industry. However, the market for recycled plastic faces several technical and socio-economic challenges that hinder increased recycling.

One key challenge is the fragmentation of the market and the lack of communication between parties. The plastic market is very complex and cannot be described as “one market”. Plastic waste derives from several very diverse waste producers (e.g. municipal, industry, agriculture etc.), and “plastic” is the umbrella term for many chemical polymers (e.g. PP, PE, PET etc.) which should preferably not be mixed in the recycling-process. The usage of composites composed of several polymer types and the usage of additives further complicates the recycling process.

The value chain for recycled plastic is illustrated in Figure 6.

Figure 6: Value chain for the recycling of plastic waste

Each arrow in the value chain represents the relation between two parties and thus represents a sub-market. The supply and demand related issues of these sub-markets are influenced by the number of players, the substitution possibilities, and the legal requirements.

In Figure 6 the plastic waste life-cycle starts when plastic is classified as waste by the consumer, and ends when the waste has been formed into a new plastic product. However, from a circular economy perspective, defining a start and end point is perhaps futile. For instance, it can be argued that the value chain should begin at the plastic producer, since the recyclability of the plastic is, to a large extent, decided at this stage.

The quality of the initial plastic, the addition of additives and usage of composites influences the potential for high quality recycling.

3.1.1 *The key actors in the value chain are*

Consumer

- Consumers produce the plastic waste, some of which is collected for recycling and some of which ends mixed with residual waste.
- Very diverse group, including households, industries, agriculture etc.

Waste handling

- Waste handlers collect and transport the plastic waste.
- Handling can be carried out by municipalities, municipality owned companies or privately owned companies. Very diverse size of waste handling companies.
- Often not specialized in plastic waste handling.

Sorting

- At the sorting facility plastic is sorted between polymers and colour, and “dirty” plastic is discarded.
- The sorting can take place at a dedicated sorting facility, but can also be integrated in the activities of the waste handler or the recycler.

Recycling/compounder

- The compounder turns the sorted plastic into granulates, which is readily usable for the plastic producer.
- Mostly there is one dominant compounder on each national market.
- Tend to prefer “clean” industrial waste, but are beginning to experiment with the usability of plastic sorted from the municipal solid waste (MSW) stream.

Plastic producer

- Produces the final plastic product.
- Large variety of small and large companies and different quality demands.
- Products are very diverse, and may be either standard or tailor made.

Consumer goods company

- Purchases plastic products from producer either for packaging – as product parts – or finished products for the consumer.

As indicated by the arrows in the value chain, excess plastic is lost to incineration, landfills and to the environment at different stages of the chain. Furthermore, a large quantity leaves the Nordic value chain to export. When exported, the plastic of course

may still be recycled, but it will no longer be under Nordic regulation. When plastic is rejected from sorting/recycling, it will be compiled with regular waste and most often incinerated.

3.2 Overall recycling plastics value chain

The following section describes each sub-market of the plastic recycling value chain and identifies barriers and potential solutions.

Increasing the quantity and quality of plastic recycling requires action in all value chain sub-markets. To create incentives for increased recycling, it is important to recognize what motivates each sub-market to recycle.

3.2.1 From consumer to waste handling

The first sub-market is the market between the consumer that produces plastic waste and the waste handling organisation.

Figure 7: The first two sub-markets for recycling of plastic waste

The supply of plastic waste for recycling comes from households, agriculture, industry etc. The share of the plastic sent directly to recycling largely depends on consumers making their plastic waste available for recycling. The availability and price of waste handling influence this decision. Providing a clean plastic waste fraction for waste handlers to collect often (but not always) demands an extra effort for the consumer. This inevitably leads to some plastic waste being treated as residual waste for incineration or landfill. The waste handler may do a brief initial rough sorting, by which a commodity value increase occurs.

This sub-market is influenced by the goals set in the EU's Waste Framework Directive³ and the efforts of the authorities to achieve these goals through legislation and incentives. For businesses, it can be less costly to deliver a waste fraction for recycling than for incineration, so there is an economic incentive to send plastic waste for recycling.

³ Directive 2008/98/EC.

The table below presents the barriers towards, and opportunities for increasing supply and demand in this sub-market.

Table 2: Barriers and opportunities for increasing supply and demand in the first sub-market

	Supply (consumer)	Demand (waste handling organisation)
Barriers	Separation of plastic waste will often demand an effort from the consumer.	Separate collection of several fractions will be more expensive. Knowledge of plastic and the plastic market is necessary.
Opportunities	Increase communication and awareness, so that consumers supply more plastic waste. Improved incentives would increase the willingness to sort and supply plastic waste.	Waste handler can strengthen connection between consumer and sorting or compounder.

Practical experiences of barriers and opportunities

- The agricultural industry produces a relatively large quantity of plastic waste in the form of plastic film from protective covering. However, this film, otherwise ideal for recycling, is often contaminated with gravel and sand. This increases the weight of the film and thus increases the cost of transporting the film to the recycling facility, and must be removed before the film can be recycled anyway. Removing the sand and gravel as early in the value chain as possible would increase the efficiency and likelihood of recycling. Practical issues similar to this example must be identified for all waste streams (waste producers) (D-SA-1 – for reference see table 1).
- The waste producers' attitude towards recycling can be a barrier. For example, construction and demolition (C&D) waste contains a high quantity of reasonably "clean" plastic waste. Some of this is recycled, but far more could be achieved with the right incentives (economic) and information for C&D companies. Practical issues must also be addressed, including practical separate collection solutions (D-SA-1).

3.2.2 From waste handling to sorting

The second sub-market is the market between the waste handling organisation and the sorting organisation.

Figure 8: The second sub-market for recycling of plastic waste

The waste handler generally carries out an initial sorting – for instance, sorting bales according to their quality – before shipping the plastic to a sorting company. Their focus

will often be to achieve the best price (or lowest cost), which is not necessarily the same as achieving the highest recycling rate.

At the sorting facility the plastic is sorted into different polymers. Several technologies exist to assist this stage, often supplemented by manual sorting, and the sorting may vary from rough to very fine depending on the required end-quality of the recycled product. Sorting is especially important for very mixed waste streams like MSW, while clean plastic fractions from industry can often bypass this process, as they can be provided in large quantities and uniform quality directly to the compounder.

At the sorting plant, some of the plastic is discarded. The main reasons for discarding plastics are if the plastic item consists of more than one type of plastic (laminates and composites), if it is black and therefore not detectable by automatic Near infrared (NIR) sorting systems, if the plastic is too dirty, and if polymers are either not in demand or the quantity is too small to make a feasible business case.

Norway and Sweden have sorting facilities that automatically separate mixed plastic waste into different polymers and colours, but Denmark and Finland do not have such sorting facilities. Sufficient supply of waste is required to make such sorting plants economically feasible. Ensuring sufficient waste is, to some degree, a barrier for establishing the necessary capacity, while the literature study indicates that insufficient sorting capacity is a barrier for increased plastic recycling.

Due to the limited sorting facilities at the Nordic market, many waste handlers export plastic waste, primarily to Germany and China. Export of plastic leads to both a lack of control of the environmental aspects of recycling of the plastic, and a loss of the potential value increase when the plastic is refined.

The table below presents the barriers towards, and opportunities for increasing supply and demand in this sub-market.

Table 3: Barriers and opportunities for increasing supply and demand in the second sub-market

	Supply (waste handling)	Demand (sorting facility)
Barriers	The waste handler sells the plastic through existing channels and to highest price/lowest cost.	Current lack of capacity to handle the amount of waste generated. Security of supply necessary to invest in increased capacity.
Possibilities	Tenders from publicly owned entities with incentives for documented recycling.	Development of low-tech sorting for plastic products which do not have high quality requirements.

Practical experiences of barriers and opportunities:

The waste handling and sorting sector points at the lack of “product design for recycling” as an important barrier. One domestic appliances manufacturer makes products that are, to a large extent, easy to disassemble and recycle, as they consist of separate well-defined parts. However, this process demands extra manpower in sorting and recycling centres. Currently, recyclers tend to shred incoming waste then mechanically sort it into different fractions. Unfortunately, manual dismantling, that could result in very clean plastic fractions from this type of product, is likely to be more expensive than shredding, particularly in mixed wastes. This emphasizes the fragmentation of the market, where a

positive initiative in one part of the value chain does not have the desired effect because of lack of communication with parties later in the value chain (in this example the sorting facility) (N-WMC-2; S-SA-1; F-WMC-1).

3.2.3 From sorting to recycling facility or compounder

The third sub-market is the market between the sorting organisation and compounder/recycling facility.

Figure 9: The third sub-market for recycling of plastic waste

After sorting, plastic is often sent to a compounder. The compounder transforms the recycled plastic into granulates, which are then readily workable for the plastic producer. As can be seen from the value chain illustration, some production waste is also sent directly from the plastic producer to the compounder. When the waste material is sorted, the compounders can use both MSW and industrial waste. According to a Swedish compounder, their input plastic material is approximately 75% industrial waste and 25% post-consumer waste.

The sorting company will choose the polymers to be isolated in the sorting process based on which polymers are present in large amounts and on the prices which can be achieved by the compounders. The compounder will often have quality demands concerning cleanness and a maximum content of other polymers.

The compounders may purchase sorted plastic waste from all over the world, though they often prefer to buy from local suppliers to be better able to control the quality of their input material and consult with suppliers at short notice. Geographically close suppliers also mean lower transportation costs. Due to the large diversity and number of suppliers, and the fact that the market is international, a “trader” often acts as connection between sorting facilities and compounders:

“There is also quite a lot of dependency on traders. The market is quite complex and with the involvement of traders it’s not always easy to know the origin of the material and its quality. Of course, we always check the quality internally [chemical testing at own facilities] but it would be better to know the source and trust the source, rather than rely on traders with unknown material. Using traders and dealers requires extra testing in the laboratory to check quality and this raises the costs and operations”.

(Interview with compounder (S-PP-1))

Compounders are not able to recover all plastic types to virgin plastic quality due to polymer mixing or multilayer plastics in the original plastic product. This leads back to the design phase, where some interviewees state that habit rather than necessity drives the use of polymer mixes and multilayer plastics (e.g. N-WMC-2).

The table below presents the barriers towards, and opportunities for increasing supply and demand in this sub-market.

Table 4: Barriers and opportunities for increasing supply and demand in the third sub-market

	Supply (sorting)	Demand (compounder)
Barriers	Lack of capacity – large investments required to establish capacity. Technological barriers. Insecurity on whether the compounders will buy MSW.	Cannot get sufficient amounts of industrial waste. New investments may be needed to take in MSW. Technological barriers. Security of supply.
Possibilities	Incentives for establishing sufficient capacity. Technology development.	Developing expertise in handling plastic from MSW. Technology development.

Practical experiences of barriers and opportunities

- Vehicles that enter recycling centres are approx. 20 years old and contain relatively little plastic (compared to current situation). However, when modern cars reach end of life, the quantity of plastics will make their recycling more profitable. Further, initiatives taken today to increase the amount of recyclable plastic in cars will not have an effect on increased re-cycling of ELV plastic in the near to medium term (F-PP-1).
- Studies have revealed great economic and technical challenges in the mechanical recycling of plastics in WEEE. This is mainly because of the large number of different types of plastics and the significant use of black plastics in electronic and electrical equipment. Research is ongoing to find solutions for these types of plastic (F-WMC-1).

3.2.4 From recycling /compounder to plastic producer

The fourth sub-market is the market between the compounder/recycling facility and the plastic producer.

Figure 10: The fourth sub-market for recycling of plastic waste

The compounder sells the produced granulate to the plastic producer. The compounder plays an important role in setting the specifications for the products which are relevant for the producer.

As mentioned, there is a large variety in the demands for plastics for different types of products, and a close dialogue between compounders and producers is necessary to achieve high recycling rates. There are products where it is possible to use less pure fractions, and that can help to increase the overall recycling rate to the economic benefit of the whole value chain.

The relation between supply and demand in this part of the plastic value chain is complex. Some compounders mention a lack of demand for recycled plastics, at least for some polymers, whereas others say they can sell more recycled plastic than they can get from the present sources. Plastic producers argue that the accessibility to the material is a barrier in increasing the use of recycled plastics. This shows the importance of close communication between the stakeholders, in order to help supply and demand to meet:

“Working with recycled plastics and developing the right material to use for production requires a great effort from both sides [supplier and consumer of recycled plastics] in order to secure a proper sourcing of the material in quality and quantity”.

(Interview with plastic producer (S-PCB-1).)

Some fractions of the waste are very difficult to find a market for:

“The plastic industry communicates the opinion that it is preferable to incinerate plastics that do not meet certain criteria of purity for recyclability and re-use, rather than recycling it, especially if the process for recycling such difficult plastic waste is too complicated and costly, while at the same time the end-product is of substandard quality and cannot match the virgin material which is becoming cheaper and cheaper”.

(Interview with sector association (S-SA-1).)

The price difference between recycled plastic and virgin plastic is argued to play a key role in the plastic producers' demand for recycled plastics. Many inputs on the price difference has been given. Overall, it's found that recycled plastic is generally cheaper than virgin plastic. One estimate is that recycled plastic is 15–30% cheaper than virgin plastic (D-PP-1). However, the price of virgin plastic is volatile due to the volatility of oil prices and at the moment oil prices are so low that the prices of virgin plastics and of recycled plastics are almost the same. Changes in the price of recycled plastics usually follow later than the changes of virgin plastics, and the prices are rather dependent on the availability of recycled plastics in the market and the demand for recycled plastics.

Further, despite the price of recycled plastics being lower than virgin plastic, scepticism towards the quality prevails (e.g. S-PCB-1). It is easier to have a defined quality of virgin plastic. As such it is argued that the lower price is currently the main

asset of recycled plastics. Compounders find, however, that the attitude towards recycled plastic has become more positive.

“Hopefully this situation will change in the future, and other drivers [such as the importance of recycling in itself] become more important”.

(Interview with waste management company (F-WMC -1))

“Number one barrier is the price of oil which makes recycling not a preferable option from an economic perspective. No municipality is willing to take the extra cost of increasing collection for recycling. The goal of municipalities is to keep the charges as low as possible and if not reduce costs – ideally to keep costs at a stable level.”

(Interview with sector association (S-SA-1))

However, for some products, at least a part of virgin plastic will be needed:

“Further, some technological barriers exist. The technologies to separate and clear impurities from plastics are not yet sufficiently advanced, so in compounding, and especially for technical plastics, there will always be a need to add a fraction of virgin material in order to keep the quality at an acceptable level.”

(Interview with plastic producer (S-PP-1))

This sub-market is increasingly international, as the production of plastic products is generally shifting to Asia.

The table below presents the barriers towards, and opportunities for increasing supply and demand in this sub-market.

Table 5: Barriers and opportunities for increasing supply and demand in the fourth sub-market

	Supply (compounder)	Demand (plastic producer)
Barriers	Recycled plastic is expected to be cheaper than virgin. Identifying customers for all the produced products.	Desire for traceability. Need security of supply. Development cost for new formulations including recycled plastics.
Opportunities	Continued product development to meet demand. Close dialogue with demand side.	Product development to meet supply (possible to change between virgin and recycled in the production). Close dialogue with supply side.

Practical experiences of barriers and opportunities

- Færch Plast is a producer of plastic packaging. Their goal is to replace as much virgin PET with recycled PET as possible. They are successful in their operation, which may be due to the focus on the recycling of just one plastic polymer, PET, and the fact that this polymer is easily obtainable

in large quantities from recycled bottles. PET is also the only plastic polymer which can be recycled continuously without a drop in quality occurring (D-SA-1).

- ABK Plast produce plastic waste containers from recycled plastic, which may present an interesting business case for municipalities, where they can supplement with plastic from old waste containers turned into granulates. Unfortunately, they ABK Plast meet barriers in the municipal tenders, which solely focus on price instead of incorporating an environmental aspect (D-SA-1).
- One home appliances manufacturer mentions the cost of product design to be a barrier when changing from virgin to recycled plastics. Additional costs are associated ensuring the quality of the recycled plastic complies with product design and manufacturing standards. The cost is mostly related to R&D and human resources and not so much to production itself. These costs are allocated to the development of the specifications of the new products (which incorporate the recycled plastics), but also to suppliers that must produce the specific quality recycled plastics (S-PCB-1).

3.2.5 From plastic producer to consumer goods company

The fifth and final sub-market is the market between the plastic producer and the consumer goods company

Figure 11: The fifth sub-market for recycling of plastic waste

Contradicting statements are given on the effect of the demand from consumer companies for recycled plastics. Some mention that there is very little demand from consumer companies to include recycled plastics in products, because knowledge about how to secure the right quality for the right application is not there (S-PP-1). However, some consumer companies argue that the demand for recycled plastics is there, but that the material must be of a sufficient and consistent quality (S-PCB-1).

The motivation for using recycled plastics in products is noted to be primarily economic, as recycled plastic should be cheaper than virgin plastic. Corporate social responsibility (CSR) can also be a factor leading to an increased demand (F-SA-1). The results of this study illustrate that the motivation differs significantly between consumer companies.

"There is of course the idea in the automotive industry of promoting sustainability and showing to the customer that they care about the environment, but the more obvious reason is cost savings. [...] although the automotive industry uses a lot of recycled plastics, they don't communicate this

fact to their customers out of risk that recycled components in a car might give a lower quality or performance impression.”

(Interview with plastic producer (S-SA-1))

“In contrast plastic furniture manufacturers demand more and more recycled plastics in their products in order to get environmental labelling and certification [...] in order to boost sales in government organisations and institutions and others, that seeks such certifications in their purchases. [...] The demand of recycled plastics comes from obtaining eco-labelling and higher share on the market, rather than the costs or quality of the recycled plastics.”

(Interview with plastic producer (S-PP-1))

The table below presents the barriers towards, and opportunities for increasing supply and demand in this sub-market.

Table 6: Barriers and opportunities for increasing supply and demand in the fifth sub-market

	Supply (plastic producer)	Demand (consumer goods company)
Barriers	Lack of design for recycling. Easier to meet customer specifications with virgin plastic. Price of recycled plastic not always sufficiently low.	Lack of demand for design for recycling. Lack of demand for recycled products.
Possibilities	Co-operation with demand on design for recycling.	Increasing focus on CSR can increase demand for both recycled plastic and design for recycling. Increased public procurement of products with recycled plastic can be strongly motivating for increased sorting.

Practical experiences of barriers and opportunities

In the automotive industry, the use of recycled plastics is equal to the use of virgin plastic. Their motivation for using recycling plastic mainly lies on the prices of the product. They want to use plastics of high quality but at low prices, so recycled plastics that fulfil certain quality requirements are preferred over virgin plastics on cost basis. However, the high amount of recycled plastic is often concealed, due to the impression that costumers prefer that everything in the car is “new”.

3.3 Municipal and solid waste value chain

Recycling plastic waste in MSW is challenging, particularly compared to recycling plastic waste coming from industry. The MSW waste is often dirty and contains mixed and many different polymers. Increasing sorting and washing through the value chain in order to meet required plastic quality at the end of the chain is a challenge.

Waste is either collected by the municipality or handed in at recycling stations. Waste from Norway and Denmark is mainly transported to plants in Sweden and Germany for sorting and further utilisation. A part of the plastic exported to Germany

will be exported further to China. According to interviewees from Norway, approximately 80% of the collected plastic remains after labels and non-recyclable plastics have been removed. This amounts to approximately 25% of all packaging on the market (N-WMC-1). Insufficient separate collection of plastic waste is often argued to be a main barrier, with some plastic producers claiming that the supply of waste plastics is too small.

Other actors, however, question whether an increasing collection of plastic waste will lead to an increase in recycling. They argue that if collection increases but the quality of the collected waste remains very low (dirty), then the recycling will not increase, since the dirty fraction will be rejected altogether by the recycler (S-SA-1). Therefore, any increase in the amount of plastic waste separately collected should also be accompanied by an increase in quality of separation and collection methods, otherwise the anticipated gains in recycling will not be realised in practice.

According to compounders, there's a need for more sorting and washing prior to the recycling. Labelling and ink print is often mentioned as a significant barrier in the sorting of plastics.

It is suggested that the final sorting should be left to the compounder, as they have the appropriate knowledge and expertise on the different plastics and purities, which they need to perform high quality recycling.

Plastic waste deriving from households is of non-uniform type and quality, and often collected in combination with non-plastic materials (food products, cosmetics, labels etc.). In order to recycle this plastic and make an economic gain for the waste handler, it is necessary to know the quality of the plastic and to be able to sort it into uniform polymers.

Different types of plastic have different value and some can be recycled to the same quality as virgin plastic (e.g. PET without additives), whereas the quality of other types decreases when recycled (mixed polymers, polymers with additives and thermosetting polymers). Therefore, the composition of plastic in MSW is important when looking into the technical and economic potential of increased recycling.

Safety aspects need also be considered: Contaminants and additives should be registered, and their effects understood, particularly as concentration or cross-effects may occur when plastics are recycled. Due to these potential problems, recycled plastic in Finland⁴ may currently not be used in food contact uses or for medical application. Again, it is argued that product design is a critical leverage point because by the time it becomes waste there are not many options to change its consistency.

⁴ This was specifically mentioned in an interview with Finnish plastic producer (F-PP-1).

Experience from the FORS A/S (DK) sorting facility

FORS A/S state that it is currently more expensive for waste management companies to recycle plastic than it is to send it to incineration, giving little economic incentive to initiate sorting of plastics. Lack of separate collection and lack of automated sorting facilities in Denmark mean that the market for plastics is challenging, as compounders demand plastic sorted between polymers. Sorting methods should be developed in collaboration with all stakeholders (sorting, compounder and plastic producer).

3.4 Plastic market features specific to national markets

The following section briefly describes some of the issues with recycling of plastics and the initiatives taken to increase the recycling in the Nordic countries. All information is drawn from the inter-views of key market players, and the discussed issues are therefore not a fulfilling list, but rather a summary of the most vital issues according to the interviewees.

3.4.1 Denmark

In Denmark, almost 70% of the collected plastic waste is exported after waste handling (D-SA-1). If plastic is not exported, it is incinerated to generate energy. Recycling of MSW is considerably lower in Denmark than in other comparable countries with a recycle rate of approx. 10% compared to Germany at 50%.⁵ Simultaneously, Danish plastic producers can only fulfil their demand for recycled plastics by importing them from countries like Germany, the Netherlands or Belgium. Neither the demanded quality nor quantity of recycled plastic is available on the domestic market (D-SA-1).

The Danish government has set a goal that 50% of seven focus materials, including plastic, must be recycled by 2022.⁶ The municipality of Copenhagen targets to increase the current 1% recycling of hard plastic to 23% in 2018, by collecting plastic both at recycling stations and at multi-family houses (including apartments). By the end of 2016 all single-family houses should also have two-part containers for metal and plastic. As mentioned by other actors, the municipality of Copenhagen finds a main barrier in sorting the plastic in fractions and between colours. The municipality is therefore working on establishing a sorting facility for plastics. Further they experience barriers in relation to quality (when marketing), sorting (at waste producer) and technology (sorting facility).

⁵ Comparison between countries may be challenged by different registration methods.

⁶ Danmark uden affald – ressourceplan for affaldshåndtering 2013–2018.

3.4.2 Finland

In Finland, legislation is the main/only driver to increase the demand for recycled plastics. There are no large players on the Finnish market to raise the demand for recycled plastics, and currently the share of recycled plastic in the Finnish market products is below 5% (F-SA-1). Plastic producers express that recycled plastic plays no role in the production of products for the domestic market, although smaller business activities in Europe do take recycled plastic into consideration.

Finland has a producer responsibility scheme for packaging, with 500 take-back points for packaging throughout the country (F-SA-1).

The legislation that prohibits the use of recycled waste for food contact is mentioned as a barrier, particularly as Finland has few manufacturers that can utilise lower quality plastics such as recycled plastic (F-SA-1).

The market for recycled plastic in Finland appears to be rather immature, and one interviewee mentioned, that the recycling rate is only half of that in Sweden.

3.4.3 Norway

In Norway mixed plastic is collected by municipalities. The member organisation Grønt Punkt, of which nearly all municipals are members, organizes for the collection and transport of the plastic waste to Sweden and Germany, where the plastic is sorted and recycled. Grønt Punkt is a member organisation for companies importing products in plastic packaging, companies producing plastic packaging, and companies selling products in plastic packaging. The organisation works nationally and has nationwide agreements with the industry. Through this, they have a good overview of the market enabling them to drive forward methods and systems to increase the collection and recycling of plastic products.

In Norway the main challenge is still, however, the collection of the plastic waste. In areas where a large effort has been made to provide good collection schemes for the consumers, 10–13 kg/citizen/year is collected, compared to 4–5 kg/citizen/year on average (N-WMC-1). According to one interviewee, to increase collection and recycling of plastic, focus should be placed on industrial waste, as 70–80% of collected plastic waste in Norway is commercial waste.⁷

A main barrier to increasing recycling of plastics in Norway is the lack of meaningful targets. Many initiatives have been taken in the last decade, primarily voluntary, and the targets are no longer up to date. Targets are necessary in order to motivate and to set a direction towards the best way to increase recycling.

⁷ Statistics Norway (2015), table 10514: 86% of collected plastic waste comes from commercial sources, 14% from households.

3.4.4 Sweden

In Sweden, the collected plastic is either recycled by Swerec (largest recycler in the Nordics), or exported, mostly to Germany. Currently most MSW is incinerated (S-SA-1).

Collection of MSW was the main issue brought up in interviews. The Swedish population is used to transporting paper and glass to recycling stations but are less inclined to do so for plastics due to it being more dirty and more voluminous. Recycling centres are currently working at increasing the recycling of rigid plastics. Challenges include encouraging the collection of separate fractions, but also how to make the waste producers understand what types of plastics qualify as rigid plastics (S-WMC-1).

At all 14 recycling centres under the SYSAV (Sydskånes avfallsaktiebolag), plastic bags are collected separately. Plastic bags represent a good fraction of plastic, because they are usually very clean and homogenous. Currently, plastic bags are the only plastic fraction collected by SYSAV that holds good market price. However, the collected bags are not sorted by colour. This will be another initiative to take if the market for waste plastics improves and there is a demand for single type-single colour waste.

The price for the separately collected plastic waste from households is around 0 SEK/tonne – of no value. On top of that, the waste collector has to pay transportation costs and acceptance fees to the recycler (S-WMC-1).

About 20% of municipalities in Sweden have “near collection” (door-to-door collection), but the 20% includes only small and medium sized municipalities. The larger municipalities still use bring-sites for plastic packaging (S-SA-1). Swedish municipalities that have applied “near collection” of plastic packaging see an increase in collection of plastics from households. Higher purity may be achieved this way as sorting is done at source and the voluminous fraction of plastic waste doesn’t have to travel long distances to the recycling stations or bring sites.

3.5 Barriers to the recycling of plastics: Hotspots

The analysis and interviews with key stakeholders, identified several barriers hindering the development of recycled plastic. These barriers can be split in four categories or hotspots:

- Low demand for recycled plastic.
 - Low demand from producers because of price and quality issues.
 - Low consumer demand for products made with recycled plastic.
- Limited market communication and lack of value chain coordination.
 - Lack of traceability.
- Technical barriers to better recycling.
- Legislative barriers to the market.

Some barriers are only evident for a specific link in the value chain or only influence a certain group of stakeholders, whereas others are characteristic for most of the sector. Whenever it has been possible to identify the barrier to a specific link in the value chain, the barrier has been described in the relevant section of this analysis. In this section the more overall barriers are described.

3.5.1 Low demand for recycled plastic

Lack of demand due to price and quality.

The relatively high price of recycled plastic compared to the price of virgin plastic was a common theme mentioned in many interviews:

“At the moment, that the oil prices are so low, the prices of virgin plastics and of recycled plastics are almost the same. There is only a very little [insignificant] difference in the price levels.”

(Interview with plastic producer (S-PP-1))

The price of virgin plastic is to a certain extent dependent on the oil price, and with the current low oil price the comparative price of recycled plastic is relatively higher.

Low quality or uncertainties and variations in the quality of recycled plastic is another key reason mentioned to describe the relatively low demand for recycled plastic. This is particularly observed in manufacturing processes that currently use virgin plastic, and a change to recycled plastic will mean that the buyer must invest in research and development:

“ There are extra costs to be covered for the production of recycled plastics. It is also definitely easier to have a defined quality in plastics from virgin raw materials. It is a lot harder when you handle recycled plastic because there is no prior knowledge of what kind of additives or other chemicals are present in the waste plastic the recycler receives.”

(Interview with Waste Management and Compound stakeholder (S-WMC-1))

Lack of demand from end-consumer

A lack of demand for products containing recycled plastic or products that can relatively easily be recycled at the end of their life from end-customers has also been highlighted as a barrier hindering a more rapid change to the use of recycled plastic. This lack of demand, combined with a relatively low price difference between recycled and virgin plastic, means that the incentives to change production to use recycled plastic in place of virgin plastic is low.

3.5.2 *Limited market communication and lack of coordination*

As described in the previous section, the plastic value chain is very fragmented. There are examples of very well-functioning links between actors in the value chain, but a lack of coordination and communication between suppliers and those demanding plastics is a noticeable tendency:

“There is a severe lack of communication between the actors in the value chain. The producers almost never take into account the recycling of their products [design for recycling] and do not consult with waste managers what is possible to treat effectively and what is not. There is no communication beyond two directly linked steps in the value chain. Sometimes there is a lack of communication even with the next step, e.g. what quality the recyclers demand from the waste managers. They just accept or reject the containers with plastic waste, while rarely paying for them.”

(Interview with Waste Management and Compound stakeholder (S-WMC-1))

An example mentioned by several plastic producers is that, in their experience, recyclers don't know what polymers the producers would be willing to buy, and therefore plastic is shredded, and low quality granulate is produced. This can only be sold at a very low price, whereas a more comprehensive sorting could lead to more differentiated products that the plastic producers would be interested in buying.

Some stakeholders highlight the lack of supply of the needed type of plastic as a key barrier against an increased use of recycled plastic, whereas others mention that access is not a problem. This again illustrates the fragmented market, where the suppliers might not be aware of the actual market demand, or where possible suppliers do not come into contact with possible buyers.

It has been mentioned that the establishment of an organised cooperation or forum where actors from the entire value chain participate could increase the recycling.

Lack of traceability

With little value chain cooperation, and divided responsibilities between actors, it is very difficult to track and trace the material through the value chain and assure its quality.

“Once the product leaves the company, it is very difficult to follow it through the stages of use and end-of-life in order to make sure that the product is indeed dismantled and the components are recycled properly (...) then what is the point of designing the product for easier recycling – what is the gain for the producer in doing so?”

(Interview with plastic consuming business (S-PCB-1))

3.5.3 *Technical barriers*

The technical barriers are primarily described in section 3.2, yet some overall tendencies are evident from almost all links in the value chain.

Firstly, the quality of recycled plastic is, for most polymers, lower than the quality of virgin plastic, and the more times the plastic is recycled the lower becomes the

quality of the plastic. This is different from other waste types such as glass and metal. The gradual degradation is exasperated by the mix of different polymers and additives, labels, and other non-plastic elements in the waste stream and the inability to reliably sort and remove these.

For some products not containing food or medicine the quality of the plastic does not need to be the best possible quality, and one way to increase the demand of recycled plastic for such products, could be to include an external demand when procuring plastic products:

“The degradation of plastic quality should be added to the service requirements. The highest quality virgin polymers should be used only by the industries having the highest quality demands [e.g. food contact uses]. Operators having lower quality requirements for their products could also use recycled plastics. This would decrease the amount of virgin plastics used.”

(Interview with plastic consuming business (F-PCB-1))

Lack of design for recycling

Another key aspect in this regard is the design of the products, where it is highlighted that if the producers included the end-of life recycling of the products in their design, the recycling could be increased in the long term.

3.5.4 Legislation

Analysing the national regulations regarding plastic recycling is outside the scope of this project. However, barriers deriving from regulation have been mentioned by several stakeholders during the interviews.

An overall barrier that stakeholders mention is that the legislative definition of plastic as waste and plastic as a resource/product in some circumstances are unclear. This is specifically mentioned in relation with the EoW regulation (333/2011). Similarly, it has been mentioned that the regulation regarding the use of recycled plastic is somehow unclear. If the economic incentive for increased sorting or utilisation of secondary raw materials is not very large or uncertain, unclear regulation can prevent companies from pursuing these possibilities, because the effort to understand the regulation, and the risk of not complying is perceived as larger as the possible gain.⁸

The scope of the plastic market is international, and this also leads to some regulative challenges, as described by one plastic producer:

“Legislation and instructions should be harmonized [currently there are different kinds of guidance and practices between different countries, and even between different municipalities].”

(Interview with plastic producer (F-PP-1))

⁸ Reguleringsmæssige barrierer for danske virksomheders energieffektivitet, Miljøstyrelsen 2015.

Having different regulations across regions makes recycling more complex, and in a worst-case scenario, can prevent recycling from taking place. Not all stakeholders agree on the need for more homogenous and clear legislation, as some argue that an adequate framework is already in place, and that suppliers and buyers will find each other if they try:

“No new regulations are required, as the companies can find meaning in increasing the use of recycled plastics based on business models cases. If it makes sense as a business model, then the company will act towards increasing the use of recycled plastics before [and/or without] any regulatory measure comes into place.”

Interview with plastic consuming business (S-PCB-1)

3.6 Conclusions of market analysis

The market for recycled plastic comprises several sub-markets along the value chain. Plastic products and the requirements of the raw material are also very diverse. There are a number of different polymers with different properties, which are sometimes mixed, and supplied with additives to achieve certain properties. This means that quality specifications are not only a question of high or low quality, but also a question of using the right type of plastic for the right type of product.

There are many challenges connected to recycling mixed plastic waste from households and recycling centres, but this fraction can also be a large potential for increased recycling. It can however be connected with higher cost than incineration, because separate transportation of the light and bulky waste is expensive, and technology for automatic sorting requires substantial investments. Currently large amounts of this waste are exported to Germany and China, although the recently opened SWEREC plant in Sweden has absorbed a large fraction of the plastics collected in the region. Several stakeholders and the literature, however, point at insufficient sorting capacity within the Nordic countries as an important barrier to this market.

Several stakeholders mention that an increased awareness of which products have relatively low requirements to polymer purity etc. can help developing the market for the mixed plastic waste. Public procurement of waste containers produced from less pure recycled plastic, for example, could further help the market.

However, some parts of the market for recycled plastic work quite well. A very substantial part of production/manufacturing waste is reported to be recycled, and there are also functioning markets for other types of industrial waste, where large quantities of relatively pure and uniform plastics are available.

It is still possible to increase the recycling of some industrial fractions, but this will usually demand an increased effort to locate the specific sources, identify the barriers for that specific source and finding a way to overcome it.

Throughout the value chain, the lack of both supply and demand of recycled plastic has been highlighted. This is probably due to the very fragmented nature of the market.

Many stakeholders indicate that increasing value chain cooperation is key to increasing the recycling of plastic.

Developing the right specifications for recycled plastic for a specific product can be expensive. In order to make that investment, the producer needs to have security over supply of the specified plastic. This is an ongoing challenge.

Many stakeholders point at design of plastic products for recycling as an important possibility to increase recycling of plastic. Products composed of several plastic polymers are particularly problematic.

The diverse nature of the market means that the measures for increasing recycling of plastic must also be diverse.

4. Policy options

This section explores and briefly analyses the potential effects of policies that could be used to overcome the barriers identified in the previous section. A previous project for the Nordic Council, *Economic Policy Instruments for Plastic Waste– A review with Nordic perspectives, 2014*, extensively mapped the existing policy in the Nordic countries that directly or indirectly addressed plastic waste.

The Nordic Council expressly wished to include the following specific policy tools in this analysis:

- Green Public Procurement.
- Tax on incineration of recyclable materials.
- Ban on incineration of recyclable materials.
- Ecodesign.
- Certification schemes.

Based on the findings from the stakeholder interviews, data analysis and literature review, we have added to the list of potentially useful policy options:

- Value chain networking/communication.
- Innovation investments.

Key problems identified in the preceding section:

- Lack of demand by producers due to price considerations.
- Lack of demand by consumers for products made with recycled plastic.
- Lack of design for recycling.
- Lack of traceability through the value chain.

It must be underlined that there are additional technical problems that relate to the quality of the material for recycling, the quality of the material after recycling, and the quantities of material entering and exiting the recycling system. Much of this is dependent on the development of technologies for more effective sorting and recycling of plastics, but also on the provision of necessary logistics to collect the material from source. These problems are chicken/egg in nature: The market needs the technology innovation but the technology innovation needs the market.

4.1 Specific policies

The policy domains indicated by the Nordic Council of Ministers, together with those suggested by the market analysis, have been elaborated into more specific policy initiatives. These are based on existing experience within the policy domains for addressing similar problems within plastics recycling in other countries (or a single Nordic country), or within recycling of other materials in the Nordic countries and abroad.

These policies have only been formulated at the conceptual level to enable scoping of possible effects and side effects. They are not sufficiently specific to enable a quantitative analysis of outcomes.

4.1.1 *The specific policies within the policy domains are*

Green Public Procurement

Using public procurement to increase the market for products made from recycled plastic. This could be achieved by including demands for a certain percentage of recycled plastic content in product category rules for product categories where plastic is or could be present.

Tax on incineration

Imposing a tax on the incineration of recyclable plastic to make alternative disposal/treatment routes (e.g. recycling) more attractive. This could be levied at the point of delivery to the incineration plant per tonne of delivered plastic. Where the waste is mixed waste, it could be based on ongoing composition tests from waste collectors.

Ban on incineration

An outright (phased in) ban on incineration of plastic waste. This would force collectors to collect plastic separately from other wastes or otherwise sort plastic waste from other wastes and divert it to alternative treatment facilities (ideally recycling) instead.

Ecodesign

Promoting the market for recycled materials through setting Ecodesign criteria for certain product categories or product types. At the Nordic level, this would have to be voluntary. At the EU level it could be mandatory (as in the Ecodesign Directive). Ecodesign criteria could be used to describe products or product categories that are particularly suitable for the application of recycled plastics. In this way they could function as design guidelines.

Certification

Certification of recycled plastic materials to provide a level of certainty about the quality of recycled plastics. This would of course be differentiated by plastic/polymer type and perhaps application. The aim is to assure producers and manufacturers that they can safely use recycled plastics in their production processes. This would necessarily be undertaken in coordination and cooperation with the Nordic industries.

Value chain coordination

A networking facility to bring the disparate parts of the plastic value chain together. This would allow manufacturers, plastics producers, recyclers, sorters and collectors to be more explicit about their demands of one another and facilitate a better understanding of the potential solutions that can only be implemented if actors along the value chain work in concert.

Funding for innovation

A funding stream specifically for the development of technologies for better exploitation of the plastic waste stream. This could be part of an existing innovation fund or a specific fund established for the purpose. There are significant technological barriers to increased recycling of plastics, and there is often a chicken/egg problem related to the market and technology.

The first five policies have been analysed for their potential impacts on the hotspots and barriers identified in the market analysis. The last two were deemed unsuitable for this type of analysis, and instead are addressed discursively.

4.2 Addressing hotspots: Analysis

Each of these policies has been analysed for their potential impacts on the hotspots identified in the market analysis. This qualitative analysis focuses on the positive and negative effects (if any) that the policy has on each of the hotspots and barriers, and the strengths, weaknesses, opportunities and threats of using such an approach for addressing each of the barriers. The multi-faceted nature of the market for plastic and waste plastic means that this is a rather generalised picture of these issues. However, where possible, distinctions have been made where effects vary by, for example, plastic type, country or waste stream.

4.2.1 Green public procurement

Using public procurement to increase the market for products made from recycled plastic. This could be achieved by including demands for a certain% of recycled plastic content in product category rules for product categories where plastic is or could be present. Alternatively, or simultaneously, it could be used to demand plastic products that are easily recycled, through having less complex polymer composites, or strictly controlled additives.

Lessons from similar policies

GPP has been successfully used to support the market for other recyclable waste fractions, most notably recycled paper for use as office paper. This is typically implemented through product category reference documents, which lay out procurement criteria for green public procurement within a given product category.

Office paper⁹ is a particularly simple example of a product that can support the market for recycled material: There is a clear need for office paper in the public sector and the product “office paper” is made entirely of the material in question. This is dissimilar to plastics, which are typically not used directly, but often as one component of a product or as packaging. A recent report on GPP by the Plastic Zero programme (Plastic Zero, 2014) uses Copenhagen as a case city, but focuses on waste prevention rather than recycling.

Table 7: Positive and negative effects of GPP

Positive effect(s)	Negative effect(s)
<p>Increased demand for recycled plastics from manufacturers and producers to fulfil demand from public sector.</p> <p>Increased demand stability in the market is more conducive to long term investments in improved technology and infrastructure for recycling plastics.</p> <p>Increased market size could provide economies of scale for plastic recycling.</p> <p>People working within the public sector exposed to products/packaging made with recycled material. This could help normalise and increase acceptance of recycled plastics in products.</p> <p>Where <i>recyclable</i> products are emphasised, it could produce a large, clean stream of easily recycled plastic waste.</p> <p>Increased demand for recycled plastic would theoretically lead to higher prices and therefore to an increased incentive for collecting more plastic. In the long run this can lead to investments in technology that makes recycling cheaper.</p>	<p>Demand is specific to those products for which criteria can be developed; these are not necessarily the same products that private consumers would be interested in.</p> <p>Increased administration for public procurement, both for procurers and private firms.</p>

Table 8: SWOT analysis of effects of Green Public Procurement

	Strengths	Weaknesses	Opportunities	Threats
Lack of demand – producer (price Lack of demand – producer (price and quality) and quality)	<p>Demanding products that are made from recycled plastics would send a clear signal to producers that there is a market that can be exploited by integrating recycled plastic into manufacturing processes.</p> <p>Demanding products that are easily recyclable could provide cleaner plastic waste for recycling and increase quality of recycled plastics.</p>	<p>GPP does not directly address other issues limiting the ability of manufacturers to use recycled plastics - not least the quality of the available recycled plastics and its suitability to be used in a given manufacturing process. It may only increase the demand for certain types of plastic, or certain grades of recycled plastic - not necessarily high-quality recycling.</p> <p>Products can be more expensive than “conventional” products or technical properties can be less certain.</p>	<p>Provide producers with the economic rationale to invest in or change manufacturing processes to incorporate recycled plastics. Increasing the demand for recycled plastics from recyclers.</p> <p>Prompt producers to redesign products to make better use of recycled plastics (changing design parameters to allow incorporation of different types of plastics).</p>	<p>That the market is not currently equipped to fulfil GPP criteria on products or packaging using recycled plastics. This could be for both technical or market reasons.</p> <p>Market could be met by recycled plastics from other countries or regions, with less control over environmental conditions. Can require complicated documentation requirements.</p>

⁹ http://ec.europa.eu/environment/gpp/pdf/toolkit/paper_GPP_product_sheet_da.pdf

	Strengths	Weaknesses	Opportunities	Threats
Lack of demand - consumer	Demanding products that are easily recyclable or made of recycled plastics could further normalise the practice.	A relatively small quantity of products that fall within the auspices of “public procurement” involve a significant quantity of plastic.	Demands could instead be placed on packaging of the products for public tender. This could be a potentially higher volume, and could also be allied across multiple product groups. This could drive a market for packaging made from recycled plastics. Could be coupled to a certification system that would also be public facing.	Low uptake of GPP in the Nordic countries. Forcing the market in a specific direction (toward the products groups or packaging types demanded by the public sector) may divert efforts away from other, potentially more promising areas.
Lack of design for recycling	Could be used to demand products that are design for disassembly/easy recycling.	Could be difficult to implement (GPP of products designed for easy recycling) in practice - both in terms of initial specification and in verification of the products meeting the criteria.	Mixed polymer, low quality plastic could be suitable for certain types of packaging. So GPP in this way could drive a market for this type of packaging.	Lack of desire to design for recycling. Lack of collection infrastructure for collecting for dismantling complex products.
Lack of communication along value chain actors	Clear demand specifications could prompt better communication and coordination between manufacturers and plastics suppliers/recyclers to try to find solutions that fit the specifics of the market.	Does not specifically drive communication between actors.	Support programmes for public procurement could include sector guidelines and/or workshops covering the new criteria. A market pull on products can be an incentive to increased value chain communication.	-
Lack of traceability	Public procurement demands (including verification that a product meets the specification) could drive better traceability of plastics along the recycling value chain.	Nothing specifically that helps to overcome the complexity of the plastics value chain and difficulties inherent in tracing volumes.	Nothing specifically that helps to overcome the complexity of the plastics value chain and difficulties inherent in tracing volumes.	-

4.2.2 Tax on incineration of plastic waste

Imposing a tax on the incineration of recyclable plastic to make alternative disposal/treatment routes (e.g. recycling) more financially attractive. This could be levied at the point of delivery to the incineration plant. Levied per tonne of delivered plastic. Where the waste is mixed waste, it could be based on ongoing composition tests from waste collectors.

Lessons from similar policies

Waste incineration taxes are reasonably common throughout Europe as a means to ensure avoiding landfill does not lead directly to incineration, although they apply to mixed waste rather than specific fractions. Specifically taxing post-consumer plastic waste could be difficult, given that it tends to be mixed with residual waste. A tax could be applied to the incineration of separately collected mixed plastic waste to better effect.

Table 9: Positive and negative effects of a tax on incineration of plastic waste

Positive effect(s)	Negative effect(s)
<p>Increases the price at which recycling becomes the cheapest option for waste management companies.</p> <p>If incineration is taxed, a larger share of the plastic will most likely go to recycling, leading to a larger supply of recycled plastic (other things being equal leading to a lower price of recycled plastic, making the price more competitive to virgin plastic).</p> <p>Provide an income/impetus to invest in ways to remove plastic waste from the incinerated waste stream.</p> <p>In the long term, the tax on incineration could lead to better design for recycling, making the waste handling easier.</p>	<p>Likely to lead to higher waste costs for citizens.</p> <p>Possibly drive incineration off-shore, which is less environmentally and socio-economically desirable than incinerating it in the Nordic countries.</p>

Table 10: SWOT analysis of the effects of a tax on incineration of plastic waste

	Strengths	Weaknesses	Opportunities	Threats
Lack of demand – producer (price and quality)	<p>Economic drivers tend to be very efficient to drive technology development and change the demand situation.</p> <p>Driving plastics away from incineration should increase the amount of plastics available for recycling, ultimately decreasing unit costs for recycled plastics, making the use of recycled plastics more attractive for producers and manufacturers.</p>	<p>Plastic is a low weight material - tax must be high per tonne to have economic impact.</p> <p>To avoid increased handling costs for waste, infrastructure need to be in place to collect and sort materials.</p> <p>Does not directly influence demand from producers/manufacturers</p> <p>Incineration is the preferred treatment for mixed contaminated plastic waste.</p>	<p>Provides the opportunity to tailor the tax level to suite demand and market conditions.</p> <p>Predictable tax increases help drive investment infrastructure along the value chain - particularly in collectors and sorters, which would provide long-term supply of recycled plastics to producers and manufacturers.</p> <p>Plastics in some waste streams that are relatively homogenous (e.g. agricultural plastic sheets) could be made available for high quality recycling with relatively simple technology.</p>	<p>Driving plastics away from incineration could lead to a higher quantity of mixed plastics that end in down-cycling applications if sufficient sorting capacity is not in place.</p> <p>Export of plastic for incineration or alternative treatment.</p>
Lack of demand - consumer		<p>Still lacking standards for recyclable plastics.</p> <p>Would need to address exempt certain unrecoverable fractions of plastic waste - home medical and sanitary waste plastics for example.</p>	<p>Communicating the tax on incineration (though information on utility bills) could raise awareness of plastic recycling and, by association, products made by recycled plastics.</p>	<p>Long-term properties of materials not known.</p>
Lack of design for recycling	No direct effects on design for recycling.	No direct effects on design for recycling.	No direct effects on design for recycling.	No direct effects on design for recycling.
Lack of communication along value chain actors	Could strengthen communication between waste collectors, sorters, and compounders/producers	-	-	-
Lack of traceability	-	High tax per tonne may encourage non-legal disposal	-	-

4.2.3 Ban of incineration of plastic waste

An outright (phased in) ban on incineration of plastic waste. This would force collectors to collect plastic separately from other wastes or otherwise sort plastic waste from other wastes and route it to alternative treatment facilities (ideally recycling) instead.

Lessons from similar policies

Bans on treatment options for waste fractions, of waste with specific properties are common. Denmark, Norway, Sweden and Finland (from 2016) have statutory bans or limitations on the landfilling of organic or combustible waste. This is likely to be one of the factors driving relatively high levels of incineration and low landfill levels in the Nordic countries.

Bans on incineration designed to drive recycling, however, are rare although they are being increasingly called for at the European level to avoid incineration being the preferred alternative to landfilling. However, certain specific types of waste *are not* allowed to be incinerated – including heavy metal contaminated waste, and waste that, with incineration, can lead to environmental problems.¹⁰ Further there are stricter demands for incineration plants burning some fractions, for instance impregnated wood and PVC (DK) and other types of hazardous waste. This indicates that the principle of incineration bans is in place already, albeit for grounds other than increasing recycling, and for relatively easily identifiable and sortable waste types.

Table 11: Positive and negative effects of a ban of incineration of plastic waste

Positive effect(s)	Negative effect(s)
<p>Provide a significant extra quantity of plastic for recycling.</p> <p>A stable and predictable framework for innovation.</p> <p>Could force slow moving, traditional industries (agriculture and construction/demolition for example) to pluck the low hanging fruit, providing a high quantity of clean, mono-polymer plastic waste.</p> <p>A larger share of the plastic will most likely go to recycling, leading to a larger supply of recycled plastic (other things being equal leading to a lower price of recycled plastic, making the price more competitive to virgin plastic).</p>	<p>Possible drive incineration of plastic waste (and, depending on implementation, mixed waste!) abroad, which is less environmentally and socio-economically desirable than just incinerating it in the Nordic countries.</p> <p>Entirely removes a waste fraction that has a very high calorific value for incineration.</p> <p>Nordic countries have invested heavily in incineration capacity, and as such it may be politically difficult to ban the incineration of plastic waste.</p> <p>The producer will not automatically get more aware of recycling issues, as the ban on incineration will affect waste handlers.</p> <p>Recycling not always possible and is not always the soundest environmental solution.</p>

¹⁰ Affaldsbekendtgørelsen: BEK nr. 1309 af 18/12/2012: <https://www.retsinformation.dk/forms/r0710.aspx?id=144826>

Table 12: SWOT analysis of the effects of a ban on the incineration of plastic waste

	Strengths	Weaknesses	Opportunities	Threats
Lack of demand – producer (price and quality)	Removing plastics from incineration should increase the amount of plastics available for recycling, ultimately decreasing unit costs for recycled plastics, making them more cost competitive. Provides clear framework conditions for a future market to develop around.	The pervasive nature of plastic waste - in all streams and all types, would make implementation complicated and difficult, and result in dirty plastic streams. Much plastic waste cannot be recycled indefinitely. At some point incineration becomes the preferred option. Some materials (mixed plastics, multi-material products) cannot always be recycled mechanically. Not possible to find new products of all plastic materials.	Much more plastic waste should in principle be available for recycling. Plastics in some waste streams that are relatively homogenous (e.g. agricultural plastic sheets) could be made available for high quality recycling with relatively simple technology. Potentially large socio-economic benefits: 481,000 tonnes of waste PVC was recycled across Europe in 2014, which contributed to the creation of around 1,000 direct jobs in recycling plants.	Banning plastics from incineration could lead to a higher quantity of mixed plastics that end in down-cycling applications, especially if sufficient sorting capacity is not in place. Export for incineration or alternative treatment.
Lack of demand - consumer	Awareness raising of the quality of products and of recycled materials. Positive statement.	Does not specifically promote demand for recycled products	Knowledge that plastic waste may not be incinerated could increase consumer demand for products or packaging with recycled plastic.	consumers may avoid plastics altogether in favour of relatively more (net) harmful materials (for example, paper bags/packaging).
Lack of design for recycling	In some waste streams, a ban could prompt better design for recycling: particularly plastic packaging.	Does not specifically promote design for recycling.	Combined with increased value chain coordination could prompt collaboration on methods and guidelines for designing products for easier collection, disassembly and sorting.	-
Lack of communication along value chain actors	-	Does not specifically promote communication along the value chain.	Could promote better communication between producers and collectors and sorters.	-
Lack of traceability	No specific strength of this approach for increasing traceability along the value chain.	No specific weaknesses of this approach for increasing traceability along the value chain.	The quantity of material entering the recycling loop could drive cooperation between value chain actors to trace specific streams and polymers.	The quantity of material entering the recycling loop could make tracing specific waste streams and polymer types more difficult, decreasing traceability.

4.2.4 Ecodesign

Promoting the market for recycled materials through setting Ecodesign criteria for certain product categories or product types. At the Nordic level, this would have to be voluntary - at the EU level it could be mandatory (as in the Ecodesign Directive). Ecodesign criteria could be used to describe products or product categories that are particularly suitable for the application of recycled plastics. In this way they could function as design guidelines.

Lessons from similar policies

Ecodesign criteria have been implemented very successfully for energy using and (to a lesser extent) energy related products through the Ecodesign Directive. There could be valuable synergies between Ecodesign criteria, certification of recycled plastic, and GPP criteria for products made with recycled plastics and/or products that are easy to recycle.

Table 13: Positive and negative effects of Ecodesign

Positive effect(s)	Negative effect(s)
<p>Sets clear priority areas for development of products that use recycled materials.</p> <p>Facilitates easier GPP of products and packaging that use recycled plastics.</p> <p>Brings together value chain actors in consultation.</p> <p>Increases knowledge along the value chain, but specifically within producers/manufacturers, about the potentials for using recycled plastics in chosen product areas.</p> <p>Increased information and knowledge on the design of products would likely change the demand of some consumers towards the eco-friendlier alternatives.</p> <p>Increased communication in the value chain will be necessary - especially compounder - producer - consumer goods company.</p>	<p>Fixed criteria can be a barrier to further development within chosen applications.</p> <p>Limited to specific products or product categories.</p> <p>Could potentially limit search for new designs and possibilities for using recycled material outside of the chosen products/product categories.</p> <p>Can be administratively burdensome and complex.</p>

Table 14: SWOT analysis of the effect of Ecodesign

	Strengths	Weaknesses	Opportunities	Threats
Lack of demand – producer (price and quality)	<p>Would clearly communicate to producers what types of products could safely use recycled plastics (focusing on current qualities of recycled plastics and realistic applications) and how they could be applied in practice.</p> <p>Would support producers in utilising recycled plastics.</p>	<p>Cannot be mandatory (but the technology and market level is perhaps not large and robust enough to support mandatory demands) and without consumer demand for ecoproducts - or other financial incentives to use recycled materials - there is little incentive to utilise design guidelines.</p> <p>Can be cumbersome to maintain updated product category guidelines with latest technology developments.</p>	<p>Ripe for integration with GPP criteria - product categories criteria could be developed in tandem for both GPP and Ecodesign guidelines promoting manufacturers and producers to increase demand for recycled plastic.</p> <p>Could help push product development toward recycled materials, increasing demand from producers.</p> <p>Could support stubborn producers to develop new products or adapt product design that they would otherwise not have considered.</p>	<p>Increased demand from producers/ manufacturers could lead to price increases which would rise the base price of virgin plastics at which recyclables become competitive (but probably not a significant threat, as price is only one consideration).</p>
Lack of demand - consumer	<p>Ties in very well with GPP initiatives for products and packaging made with recycled plastic, creating the potential for GPP demands for recycled plastic content in products and packaging.</p>	<p>Other than GPP interlinkages, does not directly drive consumer demand.</p>	<p>Ripe for integration with GPP criteria - product categories criteria could be developed in tandem for both GPP and Ecodesign guidelines.</p>	<p>No direct threats to consumer demand from e Ecodesign guidelines.</p>

	Strengths	Weaknesses	Opportunities	Threats
Lack of design for recycling	Design for recycling could be integrated as a core concept in the Ecodesign guidelines for product categories.	Setting relevant criteria in a fragmented market is difficult.	Design for recycling could be integrated into the Ecodesign criteria. This would at least make the issue visible among producers and manufacturers. Could focus on important product groups (e.g. packaging).	Criteria are not operable and therefore not used. It must be reactive to changes in waste management practices that may impact the treatment of products designed for recycling.
Lack of communication along value chain actors	Would necessarily bring value chain actors together in consultation on design guidelines.	Stronger focus on producers/manufacturers than on the other end of the value chain.	Potential to establish value chain working groups for each product category.	Competing demands of actors may not be compatible.
Lack of traceability	Products designed according to guidelines – and therefore their material content – could potentially be more easily traced.	Ecodesign does not specifically increase traceability through the value chain.	Increased coordination could be used to foster better tracking and handling routes for specific product groups and eventual waste streams.	Complex value chains and uncertain disposal route could still limit traceability of materials.

4.2.5 Certification schemes

Certification of recycled plastics materials to provide a level of certainty about the quality of recycled plastics. This would of course be differentiated by plastic/polymer type and perhaps application. The aim is to assure producers that they can safely use recycled plastics in their production processes. This would necessarily be undertaken in coordination and cooperation with Nordic industries.

Examples of instruments in other contexts (countries or materials)

The European Commission's *Circular Economy Package*¹¹ aims to set work in motion to develop quality standards for secondary raw materials, particularly plastics, with the specific aim of supporting and formalising the market for plastic recycling at an EU level. It started in 2016.

Looking toward other waste fractions, the European Compost Association's Quality Assurance Scheme seeks to harmonise the European market for compost around a quality standard and certification scheme.¹²

¹¹ Closing the loop - An EU action plan for the Circular Economy, COM(2015) 614 final.

¹² European Compost Network: <http://www.compostnetwork.info/about-the-ecm-qas-2.htm>

Table 15: Positive and negative effects of Certification schemes

Positive effect(s)	Negative effect(s)
<p>Provides guarantees of quality to producers/ manufacturers.</p> <p>Provides a robust market framework for waste sorters, compounders/recyclers and manufacturers/producers to work within and toward.</p> <p>Supports communication and trust among actors.</p> <p>Guarantees traceability of plastics.</p>	<p>Potential administrative costs and burdens could increase the price of recycled plastic.</p> <p>If the scheme does not reflect the multi-faceted nature of the plastic market (and the large variety of plastics on the market) it could limit the market for recycling of these plastics.</p>

Table 16: SWOT analysis of the effects of certification of recycled plastic

	Strengths	Weaknesses	Opportunities	Threats
Lack of demand – producer (price and quality)	Will provide quality guarantees for producers, alleviating one of the main complaints against the use of recycled plastics: Uncertainty about quality and content of recycled plastic.	Potentially difficult to control for plastics coming from mixed or dirty waste streams (particularly for the presence of contaminants/ additives). Plastics coming from dirty waste streams are the ones that need certification, but are likely the ones that will not be able to receive it. Could drive up costs of high quality recycled plastic.	Could be used on a wide variety of plastic types, polymers and mixes. These could be adapted or added to as waste management/recycling processes improve technically. Certification criterion could be integrated into Ecodesign guidelines. Promotes development of new technologies e.g. for monitoring of quality, better understanding of plastic waste generation.	Too little recycled plastics will be suitable to be certified. High certification and monitoring costs, no consensus on aspects/criteria to be included in schemes.
Lack of demand - consumer	No specific impact on consumer demand.	No specific impact on consumer demand.	Could be used in marketing of products produced with certified recycled plastics. The criterion for certification could be used for GPP purposes.	-
Lack of design for recycling	-	-	Could lead to products with fewer polymer and additive mixes.	Differences between Nordic/European schemes.
Lack of communication along value chain actors	Certification would require some level of coordination. Certification is, in itself, a reliable communication tool for the quality of a given unit of recycled plastic.	-	Open a dialog with manufacturers/ producers on required input quality, polymer types and where lower quality recycled plastic can be used. Certification would improve communication between virgin plastic producers and recyclers.	-
Lack of traceability	Certification demands could filter down the value chain to sorters and waste collectors, prompting the collection and sorting of better fractions at an earlier stage.	Does not help in tracing plastics entering household waste systems.	In some clean waste streams (C&D waste or agriculture for example) certified plastics could be followed through the value chain.	Control and monitoring of certification is vital. Lack of the above would actively work against traceability, giving a “free pass” to unsuitable materials.

4.2.6 Value chain coordination

Fostering coordination and cooperation along the value chain is essential to explore and exploit opportunities for increasing the recycling of plastic waste. The above policy initiatives would drive some level of cooperation, but explicit facilitation along the value chain could multiply the benefits. An independent networking platform could be used to bring the disparate parts of the plastic value chain together. This would allow manufacturers, plastics producers, recyclers, sorters and collectors to be more explicit about their requirements and facilitate a better understanding of the potential solutions, many of which are only attainable if actors along the value chain work in concert.

The benefits gained from establishing a value chain coordination include:

- A better understanding by all actors of the needs of others.
- An opportunity for coordination of market development and value chain responses to other policy initiatives in the domain.
- By increased information on the whole value chain, consumers might start to see their waste as a product, which can lead to increased recycling and sorting at the beginning of the value chain.
- Can lead to better understanding among plastic producers on the optimal design of the produced products, to ensure increased recycling.

4.2.7 Funding for innovation

A funding stream specifically for the development of technologies for better exploitation of the plastic waste stream. This could be part of an existing innovation fund or a specific fund established for the purpose. There are significant technological barriers to increased recycling of plastics, and there is often a chicken/egg problem related to the market and technology.

The benefits of specifically targeting the plastic waste market for funding include:

- Innovation can solve several barriers throughout the value chain.
- Funding possibilities can be a driver for cooperation between actors along the value chain.
- Innovative solutions and technologies can be developed, some of which may be suitable for commercial operation in the future.
- Currently a limited “design for recycling” takes place. If a fund can attract producers to focus on this aspect an increased focus on recycling at the end of the product life might be more achievable

However, there are some inherent problems with innovation funding, including:

- Non-commercial viable project might be initiated, depending on the type and quality of pre-approval screening.

- Funding to innovation projects can lead to competition amongst the actors, but is can also lead to market distortions.
- Funding can divert innovation from what is actually needed towards whatever is funded.
- It is dependent on available funds and political will.

4.3 Policy conclusions

All the policies analysed above would provide some benefits to the market for recycled plastics. The exact nature and extent of those benefits would largely be defined by the specific details of their implementation. This has not been addressed in this project.

All the policies analysed above would also have significant effects though most if not all on the value chain for recycled plastics. However, it is very important to remember that the market is so diverse and complex, and is in reality a large number of sub-markets addressing specific relationships and materials, that some would be strongly affected while other similar actors could be largely unaffected by these policies.

Using public procurement to drive a market for products made from recycled plastics – and hence recycled plastics themselves – or alternatively, to drive a market for easily recyclable plastic product – and providing a reliable and sizable stream of clean plastic for recycling – seems a useful place to begin. Designing and implementing GPP can be a difficult process in practice, and the uptake tends to be much lower than initial hopes. Synergies between GPP, certification of recycled plastics and particularly Ecodesign initiatives indicate that such a system could become operational and support a robust market.

Taxing or prohibiting the incineration of plastic waste could provide a very large quantity of waste, of both high and low cleanliness, for recycling. Additional measures may be required to ensure that making incineration in the Nordic region less attractive (or not possible) does not lead to the export of plastic waste for incineration to countries without such policies in place. It would also be remiss not to mention that incineration is still a central component not only of waste management, but of energy policy, and there could be strong resistance to removing such a high calorific value waste type from the waste going to incineration. It must also be noted that in some cases, and after a certain number of recycling iterations, incineration could be the best (least environmentally damaging) treatment route: this is an aspect that would have to be addressed to provide a solid economic, social and environmental rationale for prohibiting the incineration of plastic waste.

Once put in place, all of these policies will require a reasonable level of industry involvement to ensure that they function as planned. Support should be built in to the policies, but a broader cooperation and communication along the value chain of plastics could help foster solutions to the complex problems that influence the market for plastic and plastic waste. A formal or informal networking platform has the potential to foster this cooperation, but only if actors actively engage with it. The policies above would certainly push value chain actors towards recognising the benefits of cooperation.

5. Inspiration and illustration

This section presents a selection of case studies drawn from the interviews conducted in support of the market analysis and from literature. They illustrate some of the opportunities and barriers that affect the market for the recycled plastic waste, as well as provide inspiration about potential solutions and point to opportunities that are yet to be exploited.

The following experiences are included:

- Design for recycling: Home appliances manufacturer.
- Sorting and utilising plastic in household waste: Fors S/A and ROAF.
- Supply and demand of plastic waste: Aage Vestergaard Larsen.
- Using recycled plastics for simple product: Arla.

5.1 CASE: Design for recycling (home appliances manufacturer)

It is likely that the plastic sector can obtain a higher share of recycling if the products disposed as waste consists of more uniform types of plastic, or if the sorting of the waste makes it easier to dismantle the products into uniform types of plastic.

Considering recycling into the product design already when developing products is one way to make better recycling easier at the end of the products life. However, a number of barriers can hinder this development.

A key component of the company's strategy is a focus on environmental sustainability, including a focus on recycled materials in their production, especially in their green product line. In 2015 recycled thermoplastics constituted 7–8% of the total use of thermoplastic, and according to the 2020 strategy the share of recycled plastic must increase in the coming years.

The company sources the recycled plastic through established partnerships with a limited number of suppliers from across Europe. A key component in the sourcing is traceability and a secured quality, and it is the company's experience that many compounders are not able to track their input, or they cannot guarantee a steady supply of plastic in an ensured quality. The company also stresses that their green products to a large extent are easy to disassemble and recycle, as they consist of separate well-defined parts.

However, dismantling of the products require specific product knowledge as well as time, and might not be possible at the level of the individual waste handler. A general practice when recycling plastic is that recyclers shred the incoming waste into small pieces, and then mechanically sort the material into fractions. By manually sorting the

materials before shredding it would be possible to obtain a more uniform recycled material, however the cost of manual sorting would likely not be justified fully by a higher price for the recycled material.

Therefore, more uniform products would ease the mechanical sorting and increase the quality of the recycled plastic. To achieve this the producers must consider design for recycling when developing new products.

Still, the incentives for thinking recycling into the design is low for many producers. The life-time of the household appliances designed and sold by the company is usually 10–20 years. The company cannot track the product post sale, or require the consumers to return the products to specific recyclers when they are to be disposed.

Even though a key pillar of the company's strategy is sustainability, the uncertainty of future recycling- and waste collection methods at the time are not foreseeable. Unless most producers focus on design for recycling, it is likely that the products, even though they are designed for recycling, will be mixed with products of different polymers and other material. This feature of the waste management system significantly decreases the incentive to design for recycling.

Taken together, there is a value chain paradox when looking at opportunities for increasing "design for recycling" In order to obtain more products designed for recycling, the producers will have to develop and pay for the design, whereas the possible economic benefit will accrue to the waste handlers and compounders.

5.2 CASE: Sorting plastic waste from households (FORS A/S & ROAF)

FORS A/S and ROAF have engaged in innovative projects to attempt to overcome the difficulties inherent in collecting, sorting and recycling plastic waste from households.

ROAF is an inter-municipality utility company in Norway that services approximately 190,000 inhabitants. They run a modern sorting facility that sorts and recover PET, PP, PE, plastic foils and mixed plastic (as well as ferrous and non-ferrous metals and residual paper, and bagged food waste). Approximately 2,500 tonnes of plastic are recovered each year for material recycling. They acknowledge that it has been challenging to sell the recovered materials, although some fractions (e.g. plastic foil) have been easier to sell on.

In 2014 the following amounts of plastic waste from MSW went through the sorting facility:

Table 17: Treatment of MSW at ROAF facility (2014)

Plastic fraction	Tonnes	% of total
Plastic film	596	73
Polypropylene (PP)	77	9
Polyethylen (PE)	40	5
Polyester (PET)	41	5

ROAF is working together with plastic producers to influence them to produce as much packaging as possible of only one plastic polymer. This would make sorting into pure plastic types much simpler. To support this process, ROAF also suggests increased focus from legislators; including a strengthening of producer responsibility to oblige producers to produce plastic products (including packaging) that is easily recycled.

FORS A/S is a Danish inter-municipality utility company. It collaborated with the plastics compounder Aage Vestergaard Larsen and the plastic producer Schoeller Plast in a pilot project to increase collection and recycling of plastics in their municipalities. During the project, Aage Vestergaard Larsen successfully developed a method for washing the collected plastic, such that the dirty fraction was also useable in the recycling.

In the FORS project, sorting is currently done by hand, and they also stress the need for an automatic facility for sorting. Currently, the following plastic fractions are collected:

Table 18: Plastic fractions handled at FORS facility (2015)

Plastic fraction	Tonnes	% of total
Plastic containers	20	7
Plastic film	17	6
Hard polyvinylchloride (PVC hard)	68	24
Styrofoam	35	12
Plastic garden furniture	33	11
Hard plastic	115	40

Another issue pointed towards by FORS A/S is that it is more expensive for waste management companies to recycle plastic than sending it to incineration, which reduces the economic incentive to initiate sorting of plastics. Due to the low degree of sorting caused by the lack of an automatic sorting facility, the marketing of plastics in Denmark is challenging, as compounders demand plastic sorted between polymers. When developing sorting methods this should be done in collaboration with all stakeholders (sorting, compounder and plastic producer).

5.3 CASE: Plastic recycler (Aage Vestergaard Larsen A/S)

Aage Vestergaard Larsen A/S (AVL) is one of the largest plastic recycling companies in Scandinavia. In 2015 AVL produced approximately 12,000 tonnes of plastic raw materials, primarily granulates. The company was established by Aage Vestergaard Larsen in Mariager (Northern Jutland, Denmark) in 1972, and was from the beginning converting plastic production waste into new plastic raw materials. AVL has 52 employees, and is certified ISO9001 (Quality management), ISO14001 (Environmental management system) and ISO50001 (Energy management).

AVL manufactures the most common thermos plastic types PP, PE, PS and ABS, but also manufactures smaller amounts of the more technical types of plastics like PA,

POM, PET and PBT. AVL receives the plastic production waste from the following sources located in Europe:

- Plastic product industry and other industrial companies.
- The retail sector and other businesses.
- Waste collection companies and environmental companies.
- Municipal recycling stations as well as energy and water supply companies.
- Building and construction sites.

The following categories of production waste are received:

- Production cut off waste and residuals.
- Items from production errors.
- Plastic waste from building and construction sites as well as recycling stations.
- Production waste from plastic manufacturing companies.
- Plastic waste from household, but only for testing (Fors A/S og RenoNord).

The company aims to increase the recycling of plastic waste. The company has recently invested in new washing and sorting equipment and a new production line, which should increase the capacity by 5,000 tonnes.¹³

The company's director, Franz Cuculiza, points out that there are unused potential sources of plastic waste, which today is either incinerated or exported. In particular, there seems to be a large potential in the building and construction sector.¹⁴ The company is not so interested in sorted plastic waste from households, as it is usually a mixture of different types of plastic. There is still a need for further development of sorting technology before plastic waste from household can be as attractive as the plastic waste from the business sector.

AVL has been involved in a number development projects; among others, to develop a crate for milk products based on 100% recycled plastic waste. This is done in cooperation with Arla Packaging, Force Technology and Ikadan.

5.4 CASE: Closed loop recycling (Arla)

Arla is the biggest manufacturer of dairy products in the Nordic countries. Much of its product is distributed to the retail sector in reusable plastic milk crates. Originally there

¹³ Danish magazine "ingeniøren", 15th April, 2016.

¹⁴ Ibid.

was a total stock of 1.2 million crates. However, as 340-400,000 crates disappear every year, Arla needs to supplement with new crates.

To strengthen its green profile, Arla investigated the possibilities to include recycled plastic in new milk crates. There might also be the possibility to reduce costs as recycled plastic cost around 1000 EURO per tonnes, while virgin plastics cost around 1500 EURO per tonnes.¹⁵

In cooperation with Ikadan Plast A/S, the manufacturer of the milk crates, Aage Vestergaard Larsen A/S, the manufacturer of plastic granulates based on recycled plastic, and the consultants Force Technology, as well as support from the project “Production in Denmark”, they initiated a project to develop new milk crates.

The starting point was to produce milk crates with a content of 25% recycled plastic. However, test showed that it would be possible to include a much higher percentage of recycled plastics in the crates, even if they had to fulfil rather strict demands concerning mechanical strength. In the end the test shows that 100% recycled plastics could be used.

A first batch with 16,000 crates have been produced and put into circulation in Arla’s milk distribution system. After a couple of years Arla will know whether the new crates can fulfil the tough demands to strength. If this is the case Arla will have established an almost closed loop for recycled plastics (Force Technology, 2015).

5.5 CASE: Waste containers from plastic waste (Fors, Aage Vestergaard Larsen, Schoeller Plast)

Source separated plastic from households (both recycling centres and “near” collection) were manually separated (originally automated separation was planned, but the company was not able to participate) into PP and PE and a residual fraction at Fors’ recycling facility in Holbæk. After sorting, it was sent to further treatment by Aage Vestergaard Larsen, who found that the product could meet the desired specifications. Schoeller is responsible for designing sorting equipment for the households for which the recycled plastic will be used. They used the specifications similar to those for modular box systems, and found that the recycled plastics could meet the specifications.

AVL also carried out tests on “dirty” plastic, which would normally be discarded, and found that the dirty plastic could also be processed to achieve an acceptable quality.

Manual sorting can provide very pure fractions for recycling, provided the sorters are trained by plastic specialists. Work environment issues were addressed by using full-face breathing masks, and by limiting the time each person spends by sorting. This is possible since there are other activities at the recycling centre.

¹⁵ Ibid.

One of the main ideas in this project is that the citizens experience that their plastic waste is actually used for something productive. This is done by using the plastic for sorting equipment for the households.

This approach also has the benefit that the whole value chain is involved.

5.6 CASE: Fortum Finland (formerly Ekokem)

Fortum Waste Solutions Oy (until August 2016 Ekokem Corporation) was originally established for the management of hazardous wastes. Today Fortum employs nearly 700 people in Finland, Sweden and Denmark, and has widened its business areas also to cover waste management solutions, such as waste recycling, recovery and final disposal, as well as soil remediation and environmental construction services. Altogether, in 2015 Fortum received about 1.7 million tonnes of different types of wastes of which 40% are hazardous wastes. Over 20% of the received waste is utilised as material.

Fortum currently recycles clean post-industrial and post-commercial plastics and separately collected plastic consumer packaging. Fortum also recycles waste plastics from agriculture. Collected plastics are refined into CIRCO® recycled plastics for use as raw materials and granulates for the plastics industry, as well as ready-for-use CIRCO® plastic profiles. The profiles can be used as a replacement for wood and concrete in many applications, such as public construction, posts and fences, traffic barriers and agricultural structures.

In summer 2016 Fortum opened a Plastics Refinery that handles different types of plastics collected in Finland. Fortum is currently the only company receiving plastics packaging collected under the producer responsibility scheme in Finland. Plastic films from different sources and as well as agricultural plastics are also recycled in the refinery. In addition, Fortum recycles plastics that are separated from MSW in their own Ecorefinery, being the only actor handling these types of plastic wastes in Finland. The new refinery of Fortum presents a clear opportunity to increase the availability and use of recycled plastics in Finland. The Circular Economy Village, including the Plastics Refinery, Eco-refinery and Biorefinery (operated and owned by Gasum) became fully operational by the end of 2016.

The estimated yearly amount of plastics to be processed in the refinery is around 20,000 tonnes. Finnish Packaging Recycling RINKI Ltd arranges the collection and delivery of consumer plastics packaging that are under the producer responsibility scheme in Finland. In addition, Fortum also collects plastic films straight from the waste customers, and some actors deliver their plastics wastes to Fortum themselves. In brief, the processing of plastics in the new plastics refinery comprises the following steps: sorting, washing, and production of recycled plastic granulates by extrusion and granulation. The refinery will produce the best possible quality CIRCO® recyclates (LDPE, HDPE, and PP) from mixed feedstock material, which are sold mainly to domestic plastics industry customers. The share of plastics that cannot be processed is expected to be small, as Fortum is also able to handle dirty plastic materials. The

plastics that cannot be recycled (containing mainly different kinds of rejects) are utilized as part of solid recovered fuel and, as last possible alternative, diverted to grate incineration.

Fortum invests in certified production and traceability, as well as constant product development. The quality of recycled plastics is uniform and their characteristics can be tailored according to the customer needs. Customer-specific planning and solutions in environmental management bring efficiency into the plastics industry processes. Fortum wants to act as a forerunner and develop a circular economy society in which valuable materials can be circulated as much as possible. In addition, they offer a route for the recycling of clean plastics: rejects from production are crushed, granulated, and can be then returned back to the customer. Fortum sees also potential in expanding their plastic recycling activities in the future. According to them, their new plastics refinery is just the first step, and the experiences gained from it will have an influence on the investments that will be made in the future.

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Sammenfatning

Dette projekt undersøger markedet for genanvendt plast, identificerer barrierer for en yderligere udnyttelse af genanvendt plast samt analyserer en række politiske instrumenter, der kan bruges til at støtte og videreudvikle dette marked.

Projektet fokuserer primært på post-consumer plastmarkedet, da det anses for at udgøre det største problem. Markedet for plastaffald fra fremstilling og produktion synes at være relativt stærkt og velfungerende. Derfor genanvendes allerede i dag størstedelen af plastaffald fra fremstillings- og produktionsvirksomheder. Post-consumer affald er meget mindre homogent. Det kommer fra en lang række kilder, indeholder mange forskellige typer plast og er ofte svært at indsamle, sortere og genanvende.

Emballageaffald udgør langt den største post-consumer plastaffaldsstrøm. Der genereres årligt mere end 700.000 tons plastemballageaffald alene i Norden (Fråne et al. 2015b). I stærk kontrast hertil udgør mængden af plast fra andre post-consumer affaldsstrømme (husholdnings-, landbrugs- og bygge- & anlægsaffald, WEEE samt ELV) kun ca. 270.000 tons. Imidlertid indeholder nogle af disse affaldsstrømme (landbrugsaffald, ELV og bygge- & anlægsaffald) kun relativt få typer plast, hvilket potentielt gør strømmene mere attraktive for genanvendelse. I modsætning hertil indeholder husholdningsaffald og WEEE mange forskellige plasttyper, hvilket gør genanvendelse mere besværligt.

Efterspørgslen efter plast fra fremstillings- og produktions-virksomheder i de nordiske lande er svær at kvantificere. Det skyldes blandt andet mangel på pålidelige data samt en stor import af plastprodukter og plastkomponenter. Ifølge tilgængelig information og data ser det ud til at mellem 26 % (Finland) og 83 % (Norge) af plastefterspørgslen vil kunne dækkes, hvis al den nuværende mængde post-consumer plastaffald blev genanvendt. Det er vigtigt at understrege, at selvom plastaffaldet kan opdeles i forskellige plasttyper, så er det meget usikkert, hvorvidt den nordiske produktion af plastaffald matcher efterspørgslen efter specifikke typer.

Markedet for genanvendt plast består af adskillige del-markeder i værdikæden. De tekniske krav til råmaterialet varierer også meget. Der findes en lang række polymer med forskellige egenskaber. De blandes nogle gange og tilsættes tilsætningsstoffer. Det betyder, at kravspecifikationer for et givent produkt ikke kun er et spørgsmål om høj eller lav kvalitet, men også om den specifikke type plast kan anvendes til det konkrete produkt.

Disse komplekse markedsforhold har gjort det vanskeligt at gennemføre en grundig analyse inden for rammerne af dette projekt. Så i stedet for at undersøge markedet som helhed, er det blevet opdelt i de del-markeder, der eksisterer mellem enkelte aktører i værdikæden. Dette gør det muligt at gennemføre en analyse af de specifikke forhold og krav, der gør sig gældende for hver type aktør.

Ét af de største identificerede problemer er manglen på efterspørgsel efter genanvendt plastaffald. Der er dels en manglende efterspørgsel grundet industriens skepsis over for kvaliteten samt prisen på genanvendt plast set i forhold til virgine råvarer; dels en manglende efterspørgsel fra forbrugerne efter produkter lavet af genanvendt plast.

Flere aktører ser også den begrænsede koordinering gennem værdikæden som en væsentlig barriere. Denne manglende koordinering påvirker en lang række forhold: Kommunikationen mellem aktører om deres behov; samarbejdet i værdikæden om identifikation af mulighederne for at genanvende plast; samt vanskeligheder med at spore hvorfra affaldet stammer og dermed manglende tillid til kvaliteten, når plasten går (eller rettere ikke går) fra ét led i værdikæden til næste. Det ser ud til, at kommunikationen og koordineringen i værdikæden kun eksisterer mellem to direkte forbundne led og ikke over flere led. En forbedring af kommunikationen og koordinering kunne formidles af en brancheorganisation eller ved etablering af nye fora bestående af brancheorganisationer eller nationale myndigheder.

Design til genanvendelse er endnu i sin vorden og kræver opbakning gennem hele værdikæden, specielt fra dem, der indsamler og sorterer affaldet, hvis det skal lykkes at levere mere og bedre plast til genanvendelse. Opbakningen mangler lige nu i alle markeder.

Udover disse udtalte barrierer for en bedre udnyttelse af plastaffaldet, er markedet også karakteriseret ved væsentlige tekniske og logistiske barrierer samt manglende infrastruktur til for eksempel sortering. Genanvendelsesteknologierne understøtter endnu ikke til fulde et marked med fuld og højkvalitativ udnyttelse af det plastaffald der produceres. Det skal også tages i betragtning, at plast ikke bare kan genanvendes et utalligt antal gange, men at det degraderer efter hver behandling.

Der findes en lang række politiske værktøjer, der kan bidrage til en løsning. De mest relevante i forhold til dette projekt er: Offentlige grønne indkøb (GPP), afgifter ved eller et decideret forbud mod forbrænding af plastaffald, støtte til Ecodesign, og certificering af genanvendt plast.

GPP kan styrke potentielle markeder gennem minimering af miljøbelastningen og fremme af bæredygtige produkter og serviceydelser. GPP kan bruges til at stimulere den manglende efterspørgsel efter materialer af genanvendt plast, både fra slutbrugernes side og fra industrien. GPP kan også bruges til at støtte produktionen af produkter, der nemt kan genanvendes. Dermed kan man sikre en stabil forsyning af plastaffald til genanvendelse af høj kvalitet. Et første skridt kunne være at identificere de produktkategorier, hvor det vil være relevant at formulere krav til genanvendt plast og dermed føre til en øget efterspørgsel, idet det kun er visse produkter, der bruger plast i så store mængder, at de kan påvirke markedet.

Det er ikke altid let at implementere GPP, idet det er forbundet med store administrative udfordringer for både den offentlige myndighed og den private leverandør. Det er måske årsagen til, at det har vist sig svært at udbrede GPP, selv i de nordiske lande.

Certificering af genanvendt plast kan ligeledes understøtte markedet ved at øge gennemsigtigheden og sporbarheden af plastmaterialerne, og ved at skabe tillid til

genanvendt plast blandt fabrikkerne. Dette kunne suppleres med kriterier for Ecodesign for at fremme brugen af genanvendt plast i de enkelte produktgrupper.

Det forberedende arbejde til GPP er for en stor dels vedkommende det samme som for certificering og Ecodesign. Mange af byrderne kunne derfor deles og de administrative omkostninger holdes nede. Processen med at definere kriterierne for GPP, certificering og Ecodesign vil nødvendigvis kræve detaljeret og fortsat deltagelse af industrien, hvilket i sig selv vil forbedre kommunikationen og koordineringen i hele værdikæden.

Et forbud mod eller indførelsen af afgift på forbrænding af plast vil tvinge plastaffald videre i affaldshierarkiet, fra forbrænding til genanvendelse, og det er rimeligt at antage, at begge instrumenter vil øge forsyningen af plastaffald til genanvendelse. Implementeringen af et forbud eller en afgift er imidlertid forbundet med komplikationer og er logistisk, administrativt og – måske vigtigst – politisk udfordrende. Forbrænding af plast spiller en væsentlig rolle i affaldshåndteringen og energiforsyningen i de nordiske lande. Ydermere er forbrænding muligvis den bedste behandling af plast, der ikke længere kan genanvendes. Både et forbud mod og en afgift på forbrænding af plast risikerer at tilskynde til eksport af plastaffald (muligvis til forbrænding i et andet land) frem for genanvendelse. Der skal derfor lovgives imod dette i enhver implementering. Når det så er sagt, så vil det have en meget stor effekt såfremt et af disse instrumenter tages i anvendelse. Det vil i hvert fald sikre pålidelige, langsigtede rammebetingelser for et robust marked for genanvendelse af plastaffald.

Investeringer i behandlingsanlæg og teknologisk innovation kan være medvirkende til at overkomme nogle af de tekniske og logistiske barrierer, som markedet lige nu står over for. Der er væsentlige teknologiske barrierer for en øget genanvendelse af plast, som kunne afhjælpes ved øgede investeringer. Omvendt sker disse investeringer ikke, fordi der ikke er et marked. Én måde at booste investeringer der fremmer den teknologiske innovation kunne være gennem øremærkning af en del af de eksisterende finansieringsordninger til dette formål.

Appendix 1 – Sample interview guide

Waste management and compounders

Instructions for the interviewer

Below some of the questions in the guide, you'll find "support questions". These are to be used as you find fit and if they seem useful, but you need not go through them in all details.

During the interview you can put your interview notes directly into the document. After the interview, please make a short resumé on the central findings. You'll find bullet points for the resumé at the bottom of the document.

Notes and resume are to be send to Lena Holm, from NIRAS DK (lhc@niras.dk) in either Swedish, Norwegian, Danish or English.

Figure 13: Interview facts

Date	
Company /organisation	
Number of employee	
Name and position of the informant	
Interviewer	
Other comments	

Introduction to the informant

Background and purpose

- Study conducted for the Nordic Council of Ministers focusing on the plastic market and recycled plastics (market share, demand, barriers and opportunities).
- We are glad that you'll share your knowledge and experience on this topic.

Treatment of data

- Quotes from the interview will be used for analysis and when reporting the results.
- If we touch upon information or subjects that require confidentiality or that you do not wish to be quoted on, please inform us.

Time frame

- The interview will take appr. 45 minutes. [can be adjusted]

Do you have any questions before we begin?

The company

- What are you working on at the time being? Are there any challenges or opportunities you are especially occupied by (in relation to plastics)?
- Can you make a short description of your business model, collection and reprocessing methods?
 - Primary products?
- What are your special market strength (in relation to plastics)?

The plastic

- What plastic do you primarily collect/reprocesses?
 - Plastics types
 - Quantities?
 - Prices? Volatile or stabile?
- How do you collect the plastic?
 - Mixed, pure, compounded, readymade?
- Which demand do you place on the plastic?
 - Are certain qualities, quantities or other demand required?

The Market

- Who are your primary customers?
 - Many small/few large? Domestic/Nordic/foreign?
- Who are your primary competitors?
 - Domestic/Nordic/foreign?
- How is the collecting of plastics carried out in practice?

Recycled plastic

- How big a share of the materials you collect are (recycled) plastics?
 - Quantity/economy?
- What are your motivation for collecting and reprocessing plastics?
 - Economy, CSR, other concerns?

- What is the price difference between recycled and virgin plastics for your products?
- How do you handle the plastics that cannot be reprocessed?
 - What do you do with it, who collects it, how much does it cost?
- Do you see a potential for expanding your collecting and reprocessing of recycled plastics in the future?
 - Do you have objectives/initiatives/development projects concerning recycled plastics on the drawing board?
- Is recycling of plastics on the agenda in the industry in general?

The barriers

- What hinders you from collecting (more) plastic for recycling today?
 - Do you experience barriers in e.g.: regulation, market infrastructure, supply, quality, price, other?
- Are the barriers related to certain actors, agents or parts of the value chain?
- Are there any other conditions, that hinders an increased use of recycled plastics?
 - In you company and on the market in general?

The opportunities

- Do you see any opportunities to increase the share of recycled plastics?
 - In you company and on the market in general?
- Are there any “easy pickings”?
 - How about WEEE, end of life vehicles, other?
- Who needs to make an extra effort in order to increase the collecting and recycling of plastics?
 - Consumers (in relation to waste sorting), waste managers or reprocessors, commodity suppliers, plastic producers, customers, other?
- Which initiatives do you think is required, in order to increase plastic recycling?
 - Is it value chain cooperations (industrial symbiosis), new regulations, tender requirements, new technologies, other?

Rounding off

- Are there others, whom you’ll suggest that we talk to about plastic recycling?
 - Customers, partners, other?
 - Are you in contact with any of the big suppliers of plastic commodities?
- Are there anything further we need to know on the topic?
- Thank you so much for your time. May we get back to you, if we need further information?

Interview resumé

Interview notes and answers can be typed directly into the document below the individual questions. Key findings can be summarized below:

- Price levels – recycled vs. virgin plastics:
- primary BARRIERS to expanding the demand of recycled plastics:
- Opportunities and potentials for expanding the demand of recycled plastics:
- Central actors, agents and parts of the value chain:
- Questions that need further investigation:
- Contacts to persons/organisations we could include in the study:

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Nordens Hus
Ved Stranden 18
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Plastic Waste Markets

This project examines the market for recycled plastic, with a primary focus on post-consumer plastic waste because this is considered to be the more problematic. The market for plastic waste generated in manufacturing and production is relatively strong and well-functioning; As a consequence, the majority of plastic waste from manufacturing and production is recycled. Post-consumer waste is much less homogenous: it comes from a wide variety of sources, and contains a wide variety of plastics and tends to be difficult to collect, sort, and recycle. This project identifies barriers to further utilisation of recycled plastics, and analyses a collection of policy tools that could be used to support and expand that market.

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