Resource efficient recycling of plastic and textile waste

Preliminary report prepared for the Nordic Council of Ministers
Project number: 2012.05.21, Date 7 February 2013
1 Plastic waste survey

1.1 A quantitative survey on plastic waste

1.1.1 Available studies on plastic waste

The EU member states (together with the EEA members) are obliged to report waste statistics to Eurostat according to the waste statistic regulation (EC No 2150/2002). The obligation includes specified figures of generation and treatment of waste. Despite this European statistics on plastic waste is inadequate.

However each EU member state and every EEA member has a special duty to report their results on plastic packaging waste based on the Packaging and packaging waste directive. Based on this national reporting, European statistics are compiled. According to Eurostat this is done without any in depth check of the quality of the figures. See chapter 3.1.3.

Different national studies available are analyzing plastic mass flows in general or just for some defined waste streams. A recent example is a Swedish SMED-report, published in 2012 assessing plastic waste streams in Sweden, including production waste. In Norway, Mepex has assessed the amount of plastic waste and also estimated the potential for increased recycling in a report for the Norwegian Climate and Pollution Agency in 2012.

Several recent European reports for EU Commission have chosen to base their assessment on the yearly study “Plastics- the Facts” developed by PlasticsEurope in cooperation with other European organizations within the plastic value chain. This survey has been made for several years and the model is well established and recognized. As the same chosen model is used for each country within EU27+2, inclusive four Nordic countries, we have chosen to use this survey as a basis for the Nordic quantitative analysis. This gives the analysis a joint basis.

As different studies on generated amounts of plastic waste are based on different methods with a different scope, results thus vary also a lot. One main difference is based on the fact that Plastics- the Facts defines generated waste as the amount of plastics collected separately or as a part of mixed waste, while other studies often calculate the amount of generated waste based on key figures on defined average life span of applications. Another difference is that Plastics-the Facts focuses on post- consumer plastic waste while other studies, like SMED, includes production waste.

In the following chapter 3.1.2.1 the Nordic plastic waste will be analyzed based on data from Plastics- the Facts for 2010. In the subsequent chapters these results will be commented and discussed by presenting official EU figures and relevant Nordic studies.

1 Kartlägging av plastavfallsströmmar i Sverige, SMED Rapport på uppdrag av Naturvårdsverket, Nr 108, 2012
2 Økt utnyttelse av ressursene i plastavfall, Mepex rapport utført for KLIF, 2012
3 PlasticsEurope, EuPC, EuPR, EPRO and Consultic, Plastics-the Facts 2011- An analysis of European plastics production, demand and recovery for 2010
1.1.2 A European survey as basis for a quantitative assessment

1.1.2.1 Plastic waste generated and plastic recycling in 2010

The plastic mass flow in Plastics-the Facts is based on the model illustrated below.

- The plastic stream starts to the left with the converter demand for raw materials.
- The converting industry produces different kinds of plastic applications, of which only 40\% have a short service life (mostly packaging).
- The products are consumed and at the end collected as waste for treatment; recycling, energy recovery or landfill. 24.1\% of the waste was recycled in 2010.

It is important to stress the importance of import and export streams along the whole value chain; these streams are difficult to estimate and further information about these flows is not available in this study. Other studies illustrate the globalization of recycling; China imports 9Mt of plastic waste, Europe, USA and Japan are the main exporters. BIR (Bureau of International Recycling) estimates the global recycling market to 50Mt (Million tons).

It is also important to note that the report does only focus on postconsumer (PC-) waste, e.g. excluding production waste.

The amount of post-consumer waste, 24.7 Mt is much lower than the converters demand of 46.4 Mt. This is due to the fact that 60 \% of the plastic applications have a long life; plastics are thus accumulating in society, e.g. in buildings, pipes etc. Old pipes in the ground, not in use any more are in this European survey not regarded as waste before they are removed and collected as waste.

*Figure 1 Plastic flows, EU 27+2 (2010)*

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4 Identifying opportunities across the PE and PP value chains, presentation by Surendra Borad, BIR, 15.05.12, Brussels
5 PlasticsEurope, EuPC, EuPR, EPRO and Consultic, Plastics-the Facts 2011- An analysis of European plastics production, demand and recovery for 2010
The products made of plastics in Europe consist of different types of polymers. As can be seen in the figure below, "The Big Five" contribute as much as 74% of plastics consumption in Europe (PE, PP, PVC, PS / EPS and PET). This distribution has been relatively stable over the past five years. More information about the polymers can be found in chapter 5.1.

Figure 2 Plastic types in new production, EU 27+2 (2010)

The figure below combines the two cake diagrams above:
- Converter demand related to applications/product groups
- European plastic demand by resin type (polymer)

The big balls below indicate the largest product groups by type of resin, referring to the use of plastics in new applications. As can be seen below, Packaging made by PE, PP and PET are key areas. Within building/construction PVC products are dominant.

Figure 3 Plastic types in different application, EU 27+2 (2010)

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6 PlasticsEurope, EuPC, EuPR, EPRO and Consultic, Plastics-the Facts 2011- An analysis of European plastics production, demand and recovery for 2010
While packaging contributes by 39% of the production of plastic products, packaging represents 62% of the plastics waste, far more than any other application. This dominant role is due to the fact that packaging has a short life while other products, like pipes and cables have a very long life.

The post-consumer plastics waste consists of the same different polymers. “The big five”; PE, PP, PET, PS and PVC are also here dominant and contributes with 78.9% of all plastic waste in EU27+2.

![Figure 4 Post-consumer plastic waste by application and polymer, EU (27+2) 2010](image)

The distribution of different polymers in the Nordic plastic waste is, according to the study similar to the European distribution. However, as can be seen from Table 2 below, there are some differences:

- In Norway the share of PE-LD in the waste streams is much higher than elsewhere, may be due to higher consumption of plastic carrier bags and other film products
- In Norway the share of PET in the waste streams is much lower than elsewhere, may be due to reuse systems for PET based on taxes on disposable beverage containers. As of 2012 and 2013, however, the PET stream is expected to increase due to the fact that key brewers convert to disposable PET bottles.

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7 PlasticsEurope, EuPC, EuPR, EPRO and Consultic, Plastics-the Facts 2011- An analysis of European plastics production, demand and recovery for 2010

8 PlasticsEurope, EuPC, EuPR, EPRO and Consultic, Plastics-the Facts 2011- An analysis of European plastics production, demand and recovery for 2010
Below the plastic waste in the four Nordic countries is compared according to seven different applications. According to the table plastic packaging is by far the biggest plastic waste fraction in the four Nordic countries, e.g. 61% of all plastic waste. The rest is spread on different applications. The share of plastic WEEE waste/capita is somewhat higher in the Nordic countries as in EU.

The table shows that the four nations generate in total 1.121 Kt (1000 tons) of plastic waste. The Danes contribute by 56 kg/capita, Sweden and Finland by just 39 kg/capita and Norway by 48 kg/capita. The average amount of post-consumer plastic waste in Europe is

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9 PlasticsEurope, EuPC, EuPR, EPRO and Consultic, Plastics-the Facts 2011- An analysis of European plastics production, demand and recovery for 2010
10 PlasticsEurope, EuPC, EuPR, EPRO and Consultic, Plastics-the Facts 2011- An analysis of European plastics production, demand and recovery for 2010
also estimated to 48 kg/capita. According to this study the Danes generates 43% more plastic waste/capita than the Finns and the Swedes!

In the following table the same total plastic waste amounts are split by waste streams.

Table 3 Plastics post-consumer waste per waste stream, Nordic countries (kt)

<table>
<thead>
<tr>
<th>Waste Stream</th>
<th>DK</th>
<th>N</th>
<th>S</th>
<th>SF</th>
<th>Total</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residual household waste</td>
<td>158</td>
<td>69</td>
<td>124</td>
<td>89</td>
<td>440</td>
<td>39</td>
</tr>
<tr>
<td>Bulky hh waste</td>
<td>16</td>
<td>11</td>
<td>23</td>
<td>15</td>
<td>65</td>
<td>6</td>
</tr>
<tr>
<td>Separate collection from hh</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>by municipalities (non-packaging)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sales packaging waste collected</td>
<td>13</td>
<td>22</td>
<td>61</td>
<td>15</td>
<td>111</td>
<td>10</td>
</tr>
<tr>
<td>WEEE waste collection</td>
<td>15</td>
<td>17</td>
<td>29</td>
<td>11</td>
<td>72</td>
<td>6</td>
</tr>
<tr>
<td>Municipal waste generated by</td>
<td>31</td>
<td>40</td>
<td>40</td>
<td>36</td>
<td>147</td>
<td>13</td>
</tr>
<tr>
<td>commercial activities</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commercial &amp; Industrial waste</td>
<td>13</td>
<td>21</td>
<td>13</td>
<td>15</td>
<td>62</td>
<td>6</td>
</tr>
<tr>
<td>Commercial packaging waste collected</td>
<td>41</td>
<td>32</td>
<td>40</td>
<td>14</td>
<td>127</td>
<td>11</td>
</tr>
<tr>
<td>ELV, incl auto-shredded residue</td>
<td>10</td>
<td>9</td>
<td>15</td>
<td>8</td>
<td>42</td>
<td>4</td>
</tr>
<tr>
<td>Other recycling systems</td>
<td>11</td>
<td>19</td>
<td>17</td>
<td>5</td>
<td>52</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>310</td>
<td>240</td>
<td>363</td>
<td>208</td>
<td>1.121</td>
<td>100</td>
</tr>
</tbody>
</table>

Plastics waste are to a certain extend collected separately, often as part of recycling systems like WEEE stream. In total we find 405 Kt plastic wastes in these streams, e.g. 36% of all plastic waste collected. This includes;

- Packaging
  - Sales packaging waste collected, 111 Kt
  - Commercial packaging waste collected, 127 Kt
- Non packaging
  - Separate collection from households by municipalities (non-packaging), 1 Kt
  - Other recycling systems, 52 Kt
- Integrated in other systems
  - WEEE waste collection, 72 Kt
  - ELV, incl. auto-shredded residue, 42 Kt

However, according to the table above, most of the plastic waste can be found in the residual household waste, 440 Kt, e.g. 39 % of all plastic waste collected. In Denmark this share amounts to about 50 %, in Norway the figure is only 28 %.

Furthermore 65 Kt of plastic waste (6%) can be found in bulky household waste.
From commercial and industrial sources a large amount of plastic waste is collected as part of general waste streams, in total 209 Kt, or 18 % of collected plastic waste:

- Municipal waste generated by commercial activities, 147 Kt
- Commercial & Industrial waste, 62 Kt

The table below shows the amounts of mechanical recycling of plastic waste by application in four Nordic countries 2010 (Kt). As can be seen packaging stands for 73% in the Nordic countries, compared to 84% for EU27+2. WEEE and agriculture contribute with 10% each. The rest is split on different applications.

Table 4 Mechanical recycling results (Kt) in the Nordic countries, structure of recycling results (%) compared with the rest of EU (27+2) 2010

<table>
<thead>
<tr>
<th>Applications</th>
<th>DK</th>
<th>N</th>
<th>S</th>
<th>SF</th>
<th>Total</th>
<th>%Nordic</th>
<th>% Europe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Packaging</td>
<td>54</td>
<td>53,3</td>
<td>100,8</td>
<td>28,5</td>
<td>236,6</td>
<td>73 %</td>
<td>84 %</td>
</tr>
<tr>
<td>Building/Construction</td>
<td>2,8</td>
<td>2,5</td>
<td>2,0</td>
<td>2,0</td>
<td>9,3</td>
<td>3 %</td>
<td>4 %</td>
</tr>
<tr>
<td>Automotive</td>
<td>2,5</td>
<td>0,4</td>
<td>3,0</td>
<td>0,8</td>
<td>6,7</td>
<td>2 %</td>
<td>2 %</td>
</tr>
<tr>
<td>WEEE</td>
<td>7,0</td>
<td>7,0</td>
<td>13,0</td>
<td>3,0</td>
<td>30,0</td>
<td>10 %</td>
<td>2 %</td>
</tr>
<tr>
<td>Housewares, leisure, sports</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0 %</td>
<td>0 %</td>
</tr>
<tr>
<td>Agriculture</td>
<td>8,0</td>
<td>9,5</td>
<td>10,0</td>
<td>2,5</td>
<td>30,0</td>
<td>10 %</td>
<td>4 %</td>
</tr>
<tr>
<td>Other (Furniture etc.)</td>
<td>1,0</td>
<td>7,0</td>
<td>1</td>
<td>0</td>
<td>8,0</td>
<td>2 %</td>
<td>2 %</td>
</tr>
<tr>
<td>Total</td>
<td>75</td>
<td>80</td>
<td>129</td>
<td>37</td>
<td>321,6</td>
<td>100 %</td>
<td>100%</td>
</tr>
<tr>
<td>Recycling rate</td>
<td>24%</td>
<td>33%</td>
<td>35%</td>
<td>18%</td>
<td>28%</td>
<td>-</td>
<td>24%</td>
</tr>
<tr>
<td>Kg recycled capita</td>
<td>13,6 Kg</td>
<td>16,0 Kg</td>
<td>14,0 Kg</td>
<td>7,0 Kg</td>
<td>12,9 kg</td>
<td>14,0 Kg</td>
<td>13,6 Kg</td>
</tr>
<tr>
<td>Increase of recycling vs 2009</td>
<td>5,5 %</td>
<td>35,5%</td>
<td>17%</td>
<td>18%</td>
<td>-</td>
<td>18,4 %</td>
<td>8,7 %</td>
</tr>
</tbody>
</table>

1) Partly recycling of cables outside WEEE directive

As can be seen from the table the recycling results/ capita in the Nordic region equals the EU27+2 level, e.g. about 14 kg/capita. Norway is on top, Finland much behind. The Nordic countries have a lead within WEEE and agriculture film recycling. Iceland, not part of the European survey, also obtains good results on agri-film recycling.

1.1.2.2 Plastic waste recycling in the Nordic region compared to rest of Europe

The chart below compares the plastic recycling and recovery results for EU27+2. As can be seen the recovery rates differs from almost 100 % to 10% only. Three Nordic countries are

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11 PlasticsEurope, EuPC, EuPR, EPRO and Consultic, Plastics-the Facts 2011- An analysis of European plastics production, demand and recovery for 2010
among the top 10 countries in Europe and recover more than 90% of their post-consumer plastic waste while Finland recovers 45%.

Figure 5 Total recovery rates by country of post-consumer plastic waste in EU (27+2) 2010

In the following chart the recovery figures for 2010 are compared with the results in 2006. Finland has shown a growth of more than 25% on its recovery rates during this five year period, while Norway achieved about 15% increase. Both Denmark and Sweden also increased their recycling rates. On the other hand this growth in recycling reduced the already high energy recovery results.

Figure 6 Change in total recovery rate by country, post-consumer plastic waste, EU 27+2 (2006-2010)

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12 PlasticsEurope, EuPC, EuPR, EPRO and Consultic, Plastics-the Facts 2011- An analysis of European plastics production, demand and recovery for 2010
As mentioned packaging waste contribute by 62% to all plastics waste. In Europe packaging stands for as much as 83% of all plastic waste recycled. The results for plastic packaging are shown below. Sweden is among the top three with high recycling rates for both households and the trade and industry segments. Denmark is ranked 5th. Denmark is ranked on the top for recycling of packaging waste from trade and industry, but is among the poorest countries regarding recycling of household packaging waste.

![Figure 7 Total recovery rate by country for post-consumer plastic packaging waste, EU 27+2 (2010)](image)

1.1.2.3 Updated results for 2011
End of October the report "Plastics - The Facts 2012" with results for 2011 was published. In brief the report shows the following key figures for the demand, waste and disposal of waste in EU27+2:

- Converter demand 47 Mt
- Post-consumer waste 25,1Mt
- Recycling 6,1Mt (25,1%)
- Energy recovery 8,6Mt (34,1%)
- Landfill 10.2Mt (40,9%)

Recycling rate for plastic waste reached 25,1% compared to 24,1% in 2010, while energy recovery reached 34,1% compared with 33, the year before. Slowly plastic waste is diverted from European landfills, but still 40,9% was landfilled in 2011. This report has not updated detailed 2011 results for the Nordic countries.

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13 PlasticsEurope, EuPC, EuPR, EPRO and Consultic, Plastics-the Facts 2011- An analysis of European plastics production, demand and recovery for 2010
14 PlasticsEurope, EuPC, EuPR, EPRO and Consultic, Plastics-the Facts 2011- An analysis of European plastics production, demand and recovery for 2010
1.1.3 European official statistics for plastic packaging

Eurostat has recently published plastic packaging recycling results for 2010. The results are shown and compared with PlasticsEurope results in the table below.

Table 5 Plastic packaging recycling by country (2010)

<table>
<thead>
<tr>
<th>Country</th>
<th>EUROSTAT Recycling % 2010</th>
<th>PlasticsEurope Recycling % 2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Denmark</td>
<td>26,4%</td>
<td>26%</td>
</tr>
<tr>
<td>Norway</td>
<td>36,4 %</td>
<td>35%</td>
</tr>
<tr>
<td>Finland</td>
<td>26,2%</td>
<td>24%</td>
</tr>
<tr>
<td>Sweden</td>
<td>32,4%</td>
<td>46%</td>
</tr>
</tbody>
</table>

As can be seen from the table, the results from the two sources are more or less in harmony with an exception for Sweden. It is thus a need for further investigations related to the plastic packaging recycling figures from Sweden. According to Eurostat plastic packaging recycling in Sweden peaked in 2006 on 43,8%, but is then reduced to 32,4% in 2010.

1.1.4 Nordic studies on plastic waste

In this chapter we will refer to some recent Nordic studies assessing the amounts of plastic waste and recovery. Some of these studies have evaluated the potential for increased recycling too.

1.1.4.1 Norwegian studies on plastic waste

Statistics Norway, SSB, has assessed the plastic waste generated in Norway. According to a not published study in total 482 Kt were generated in 2010, e.g. about 95 kg/capita. The total amount of plastic waste is in the table below split on plastic applications/waste fractions.

16 EUROSTAT & Plastics Europe
17 Økt utnyttelse av ressursene i plastavfall, Mepex rapport utført for KLIF, 2012
Table 6 Calculated plastic waste for Norway, by source\textsuperscript{18}

<table>
<thead>
<tr>
<th>Application</th>
<th>Waste amount, Kt</th>
<th>% share</th>
</tr>
</thead>
<tbody>
<tr>
<td>Packaging\textsuperscript{1) }</td>
<td>194</td>
<td>40 %</td>
</tr>
<tr>
<td>Building/ construction</td>
<td>95</td>
<td>19 %</td>
</tr>
<tr>
<td>ELV</td>
<td>16,5</td>
<td>4 %</td>
</tr>
<tr>
<td>WEEE</td>
<td>65</td>
<td>13 %</td>
</tr>
<tr>
<td>Housewares</td>
<td>21</td>
<td>5 %</td>
</tr>
<tr>
<td>Agricultures</td>
<td>3</td>
<td>1 %</td>
</tr>
<tr>
<td>Furniture</td>
<td>20</td>
<td>4 %</td>
</tr>
<tr>
<td>Leisure boats/ composites</td>
<td>1,5</td>
<td>0,3 %</td>
</tr>
<tr>
<td>Other</td>
<td>66</td>
<td>13 %</td>
</tr>
<tr>
<td>Total</td>
<td>482</td>
<td>100 %</td>
</tr>
</tbody>
</table>

\textsuperscript{1) Including agriculture film}

As can be seen from the table, the generated amounts of plastic waste exceed by far the results from the PlasticsEurope survey, e.g. 482 vs. 240 Kt.

Based on different sources, inclusive the above mentioned studies, further analyses have been undertaken by Mepex in its 2012 report commissioned by Klif. The Mepex report assessed both the generated waste amounts and the potential for increased plastic recycling as follows:

Table 7 Gross potential for increased recycling of plastic waste for Norway\textsuperscript{19}

<table>
<thead>
<tr>
<th>Applications</th>
<th>Total waste, Kt</th>
<th>Recycled waste, Kt</th>
<th>Gross potential for increased recycling, Kt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Packaging</td>
<td>146</td>
<td>53</td>
<td>93</td>
</tr>
<tr>
<td>Housewares</td>
<td>21</td>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td>Building/ construction</td>
<td>34</td>
<td>2,5</td>
<td>31,5</td>
</tr>
<tr>
<td>Furniture</td>
<td>25</td>
<td>0</td>
<td>25</td>
</tr>
<tr>
<td>WEEE</td>
<td>43</td>
<td>3</td>
<td>40</td>
</tr>
<tr>
<td>ELV</td>
<td>16</td>
<td>0,4</td>
<td>16</td>
</tr>
<tr>
<td>Agriculture</td>
<td>20</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Fisheries</td>
<td>15,5</td>
<td>3,5</td>
<td>12</td>
</tr>
<tr>
<td>Leisure boats/ composites</td>
<td>1,5</td>
<td>0</td>
<td>1,5</td>
</tr>
<tr>
<td>Unknown</td>
<td>7</td>
<td>70</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>330</td>
<td>81</td>
<td>249</td>
</tr>
</tbody>
</table>

According to the Mepex study the generated amount of plastic waste was 330 Kt in 2010, e.g. about 66 kg/ capita. The analyses specified also typical Nordic waste fractions such as plastic fishing equipment (fishing gears/ nets, ropes, fish farming rings etc.) and leisure

\textsuperscript{18} Statistics Norway 2010

\textsuperscript{19} Økt utnyttelse av ressursene i plastavfall, Mepex rapport utført for KLIF, 2012
boats/composites, the latter a tiny waste fraction today that is expected to increase in the future.

The Mepex report also examined the reasons behind the differences between the available studies. The main differences on generated amounts were found in long lived products such as building materials and WEEE. Statistics Norway bases their statistics on defined average life time of each product group, while PlasticsEurope base their study on what is collected.

The Mepex report concludes that 249 Kt, not recycled in 2010, can be regarded as a gross potential for increased recycling. Since 100% recycling is not realistic an assessment was made in order to estimate a net, a realistic, potential for increased recycling. The net potential for increased recycling of plastic waste was estimated to 71Kt, in total recycling could then increase to a level of 152 Kt, e.g. a recycling rate of 45% in 2020 based on the same generated plastic waste amount as in 2010.

For packaging it is estimated a net potential of 63% recycling. Even though Norway today has a high recycling rate on packaging compared to other countries, packaging is still the main potential for increased recycling of plastics. An increase of 39Kt is possible and realistic based on defined initiatives, of which 27Kt from the household sector only. In addition 5Kt of plastic household articles can be recycled.

The study assumed the recycling of plastics from furniture will remain on a low level. The net potential is estimated to 12% only as no action is proposed in this field. Furniture like matrasses and carpets contain also textiles (recycling of furniture might thus be studied further for any material used).

Recycling of leisure boats and other composite products is not examined in the report. The generated amounts are based on Statistics Norway. No recycling initiatives are examined due to the low volumes reported so far.

2020 was chosen as a year for planning as it takes time to obtain results from the proposed actions for increased recycling. As we might expect;

- increased volumes of plastic waste
- better knowledge
- and improved systems

the potential for plastic recycling might be even higher. On the other hand plastics might be less recyclable which can be a challenge for increased recycling.
Table 8 Plastic waste generated and recycled amount in 2010, net potential for increased recycling and net potential for recycling in 2020 and % recycling rate 2020, Norway

<table>
<thead>
<tr>
<th>Fraction</th>
<th>Total amount plastic waste 2010</th>
<th>Recycled 2010</th>
<th>Net potential for increased recycling</th>
<th>Realistic potential for total recycling 2020</th>
<th>Recycling rate 2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Packaging</td>
<td>146 569</td>
<td>53 400</td>
<td>39 000</td>
<td>92 400</td>
<td>63 %</td>
</tr>
<tr>
<td>Housewares</td>
<td>21 000</td>
<td>1 000</td>
<td>5 000</td>
<td>6 000</td>
<td>28 %</td>
</tr>
<tr>
<td>Building/ construction</td>
<td>34 000</td>
<td>2 500</td>
<td>5 000</td>
<td>7 500</td>
<td>22 %</td>
</tr>
<tr>
<td>Furniture</td>
<td>25 000</td>
<td>0</td>
<td>3 000</td>
<td>3 000</td>
<td>12 %</td>
</tr>
<tr>
<td>WEEE</td>
<td>43 000</td>
<td>3 000</td>
<td>9 000</td>
<td>12 000</td>
<td>27 %</td>
</tr>
<tr>
<td>ELV</td>
<td>16 500</td>
<td>400</td>
<td>4 800</td>
<td>5 200</td>
<td>31 %</td>
</tr>
<tr>
<td>Agriculture</td>
<td>20 000</td>
<td>10 200</td>
<td>3 000</td>
<td>13 200</td>
<td>66 %</td>
</tr>
<tr>
<td>Fisheries</td>
<td>15 500</td>
<td>3 500</td>
<td>5 000</td>
<td>8 500</td>
<td>54 %</td>
</tr>
<tr>
<td>Leisure boats/composites</td>
<td>1 500</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0 %</td>
</tr>
<tr>
<td>Unknown</td>
<td>7 000</td>
<td>7000</td>
<td>0</td>
<td>(7 000)</td>
<td></td>
</tr>
<tr>
<td>SUM</td>
<td>330 069</td>
<td>81000</td>
<td>70 800</td>
<td>151 800</td>
<td>45 %</td>
</tr>
</tbody>
</table>

The net potential estimates are taking the following into consideration:

- Estimated results of eight defined actions in order to increase recycling
- Challenges related to low recyclability of different plastic applications
- Challenges related to technology and markets
- Restrictions in the national waste law and other relevant legislation related to hazardous substances relevant for several products, including non-hazardous products difficult to sort from products containing hazardous substances

As mentioned the estimates of recycling potentials for 2020 are based on the generated waste amounts of 2010. However different prognoses indicate an annual growth of plastic waste of 5%, partly based on increased use of plastics, partly based on the fact that long lived plastic products, such as leisure boats, sooner or later will be discarded. In addition some products have shorter life as before, e.g. EEE products. Assumed a 5% annual growth of plastic waste, the plastic waste will increase by 65% to 545 Kt from 2010 to 2020.

1.1.4.2 Swedish studies on plastic waste

KTH has made an estimate for Naturvårdsverket concluding that the plastic waste amounts to 689 Kt, e.g. ca. 76 kg/capita in 2006. The table below illustrates the amounts generated and amounts of plastic waste separate collected.

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20 Økt utnyttelse av ressursene i plastavfall, MepeX rapport utført for KLIF, 2012
21 Potential för ökad materialåtervinning av hushållsavfall och industriavfall, KTH, 2010
Table 9 Plastic wastes in Sweden 2006\(^\text{22}\)

<table>
<thead>
<tr>
<th>Source</th>
<th>Plastic waste in total, Kt</th>
<th>Separate collected plastic waste, Kt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Households</td>
<td>321</td>
<td>39</td>
</tr>
<tr>
<td>Trade and industry</td>
<td>368</td>
<td>120</td>
</tr>
<tr>
<td>Total</td>
<td>689</td>
<td>159</td>
</tr>
</tbody>
</table>

The KTH report “Potential för ökad materialåtervinning av hushållsavfall och industri­avfall” estimates that separate sorted amount can be increased from 159 Kt today to 246 Kt in 2030 in a “business as usual”-scenario. For a “increased recycling” scenario separate sorting of plastics might be increased to as much as 1 226 Kt in 2030. This means a recycling of 136 kg/ capita compared with ca. 10 kg/capita today. The report assumes a high growth of plastic wastes.

The report “Avfall i Sverige” estimated non-hazardous plastic waste by source in 2008.\(^\text{23}\) The table below illustrates the sources of plastic waste. The results are rather different from Norwegian studies.

![Plastic wastes Sweden](image)

Figure 8 Plastic waste by source in Sweden\(^\text{24}\)

Commissioned by Naturvårdsverket SMED published the report “Kartlägging av avfalls­strömmer i Sverige” in 2012.\(^\text{25}\) SMED bases its analyses on production figures from the PlasticsEurope survey. SMED estimates the total plastic waste in 2010 in Sweden to 558 Kt, (62 kg/capita) while Plastics- the Facts estimated the waste to 363 Kt (40 kg/ capita). The difference might partly be explained that the latter study just comprise collected post-consumer plastic waste, while SMED includes also production waste.

\(^{22}\) KTH 2012
\(^{23}\) Avfall i Sverige 2008, Naturvårdsverket 2010
\(^{24}\) Naturvårdsverket 2008
\(^{25}\) Kartlägging av avfallsströmmer i Sverige, SMED for Naturvårdsverket, 2012
SMED estimates the plastic waste from the household sector to 298 Kt, e.g. 33 kg/ capita; (exclusive WEEE, ELV)

- 46 Kt from separate sorted packaging, 50%
- 151 Kt packaging collected with the residual waste, no recycling
- 42 Kt other plastics collected with the residual waste, no recycling
- 1 Kt from food waste collection, no recycling
- 19 Kt beverage containers (PET, Returpack system), 100% recycled
- 39 Kt bulky waste, 8% recycled (Bulky waste contain mostly PP and PE)

SMED estimates that 68 Kt plastic waste from household are delivered to recyclers (for sorting and recycling), of which 45 Kt in Sweden, the rest is exported to Germany. 230 Kt of plastic waste from households were energy recovered in Sweden.

SMED estimates the amount of plastic waste from:

- Building and construction to 43 Kt of which less than 1 Kt was recycled.
- WEEE to 34 Kt of which 1 Kt was recycled in Sweden and 14 Kt exported for recycling. This means a recycling rate of 44% (delivered amounts)
- Industry and trade (source separated plastics) to 134 Kt of which 45 Kt was recycled in Sweden while no data was obtained on exported amount for recycling. (These figures include production waste too). About 80Kt of separate collected plastics were energy recovered in cement kilns, 9 Kt to other energy recovery.
- ELV to 18 Kt with nothing recycled as most plastic ends in the “shredder light fraction” normally energy recovered. The segment comprises also trucks, caravans etc., but these kinds of vehicles are often exported for reuse.
- Agriculture (ensilage) 18 Kt of which 16 Kt was recycled abroad.
- Medicals 13 Kt of which nothing was recycled.

SMED also gives estimates on import and export of plastic waste, e.g. 300 Kt of imports, mostly from Norway, and 91 Kt of export. According to SMED it has not been possible to verify the export/ import figures from the customs (confidential information).

The SMED study concludes that in total 144 Kt were recycled in 2010, of which 91 Kt in Sweden. The recycling figures are based on delivered amounts to sorting/ recycling operators, not taking any loss in the sorting process into consideration. This definition is not in line with standards and practice in other countries.

The study also assesses challenges related to a further increase of recycling of plastic waste from different sources. SMED concludes that there are potentials for increased collection and recycling of plastic waste stemming from households. In addition more waste from WEEE, ELV and building and construction can be recycled.
1.1.4.3 Danish studies on plastic waste
Data from PlasticsEurope on packaging differs from data which the Danish EPA reports on an annually basis to the EU commission according to EU directive on packaging. The Danish calculations on the amount of plastic packaging put on the market are based on data from Statistics Denmark. In general data from PlasticsEurope overestimates the amount with up to 20% (2009).26

1.1.4.4 Finnish studies on plastic waste
So far no studies found. According to operators in the market waste analyses indicate that the plastic waste amounts are higher than the figures in the PlasticsEurope and the Eurostat reports.

1.1.4.5 Icelandic studies on plastic packaging waste
The basic data used for the calculation of the plastic packaging quantity placed on the Icelandic market originates from the Custom Agency. The companies importing and exporting products are obliged to report the quantity of products per tariff codes.

From the total import and export list all tariff codes that include empty packaging are identified and the entire quantity within these tariff codes is defined as packaging. The domestic producers of plastic packaging give information about their produced quantity. Together the production of empty plastic packaging and the import and export of empty plastic packaging give the domestic supply of empty plastic packaging.

All tariff codes in the Custom list are incorporated into a developed packaging model. For each tariff code included in the model there is information about which percentages of the imported and exported total quantity that are plastic packaging and other packaging types. The laid down percentages per tariff code are based on the experience and surveys of the use of packaging. The percentages are multiplied with the imported and exported product quantity. In this way the import and export of filled plastic packaging is calculated. The total quantity of plastic packaging placed on the market is the sum of the supply of the empty plastic packaging and the net sum of the imported and exported filled packaging where plastic packaging is used.27

1.1.4.6 Other Nordic studies on generated plastics waste in special segments
There are several Nordic studies on different waste fractions also including assessments of plastic waste and disposal, here are some examples. Some of these studies are mentioned as part of the qualitative survey for the relevant waste fraction in chapter 3.2.3:

- Danish survey calculates the amount of waste from composites to 7 Kt including composites from discarded wings from wind mills (Genvind presentation at Nordic WS).
- Plastics from end of life leisure boats, Norway (Mepex study for Klif, 2009)

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26 Statistik for genanvendelse af emballageavfald 2009, Econet og Teknologisk Institut for Miljøstyrelsen
27 Olafur Kjartansson, IRF, Iceland, mail 05.09.12
- Plastic waste from ELV, Norway
- Icelandic studies on generated plastic waste from fisheries.
- Norwegian studies on generated waste form plastic equipment from fish farming and fisheries in Norway
- Danish studies on trends; growth production/ consumption, growth waste and growth recycling

1.1.5 Conclusions of quantitative survey

The quantitative survey according to PlasticsEurope are summarized and commented based on Nordic studies as follows:

- Generated plastic post-consumer waste amounts to more than 1,2 Mt in the four Nordic countries, e.g. 45 kg/capita while the EU27+2 average amounts to 48 kg/capita.
  - Nordic reports estimate the amount of plastic waste to be higher; these studies are based on other methods for calculation. Statistics Norway has estimated the plastics waste to 95 kg/capita, the Norwegian Mepex study for Klif, concludes with 66 kg/capita. Based on this Mepex estimate the Nordic plastic waste amount would have been 1,65Mt.
- The generated plastic waste amounts, according to PlasticsEurope, differ a lot between the four Nordic countries, Denmark on top with 56 kg/capita, Sweden and Finland at the lower end with 39 kg/capita, Norway generates 48 kg/capita.
- Denmark, Sweden and Norway show recovery rates above 90 % and high recycling rates compared to most other countries in Europe. Finland recovers about 45 %.
- Plastic packaging represents 61 % of all plastics waste and as much as 73 % of plastic waste recycled in the Nordic countries.
  - The Nordic countries have high recycling rates on beverage containers (PET) due to their deposit systems achieving very high recycling rates. These results are not specified in PlasticsEurope statistics.
- Recycling of plastic waste from WEEE and agriculture (silage film) contribute with each 10 % of what is recycled.
- The small rest of 7% is split between different plastic applications. Only small amounts of Nordic plastics waste from ELV, Building/ construction, housewares, furniture etc. are recycled today.
- According to PlasticsEurope Sweden is one of the leading plastic packaging recycling nations in Europe, but Eurostat shows lower results. The Swedish SMED report stresses that their report counts what is delivered for sorting rather than the amount put into the recycling-process. This might be a reason for different estimates on recycled plastic waste.
- Denmark is the leading plastic packaging recycling nation within the trade and industry segment, but shows poor results on recycling of packaging from households; ranked 29th of EU27+2 nations!
- 39% of the Nordic plastic waste can be found in the residual household waste, another 6% stems from bulky household waste and 13% from municipal waste generated by commercial activities. In total 58% of plastic waste can be found in these mixed waste
streams obviously representing the biggest potential for increased plastics recycling. Other reports confirm this conclusion.

Without having detailed information about methods and basis data of the different studies, it is difficult to evaluate the quality of the figures. However the huge differences on generated plastic waste (Denmark generates 44 % more plastic waste than both Finland and Sweden) underlines the need for further studies. Also the recycling figures could be evaluated in depth as the four nations might define and measure “recycling” differently. Last but not least the generated amounts of waste from long lived applications, such as building materials, should be analyzed further as these figures differ the most between national statistics and other reports.

Econet and Logisys in Denmark analyzed the structure of the packaging statistics in the Nordic countries on behalf of the Nordic Council of Ministers in 2002. The report was based on 1997 packaging statistics. The report concluded that differences between the Nordic countries can be explained by “fundamental differences in the way the statistics are constructed more than the nation’s actual consumption”. As the statistics presented in this report still show huge differences, it might be concluded that a deeper assessment of national Nordic statistics might be repeated both for packaging in general and for plastic packaging and other plastic waste as well.28

These are the conclusion of this quantitative survey:

- The largest potentials for increased recycling of plastic waste in the Nordic countries can be found within the municipal waste, including packaging, household applications and bulky waste both from households and other municipal solid waste sources.
- As long lived products sooner or later will be discarded, other waste fraction might be more important in the future. This includes plastic waste from building/ construction and composites incl. leisure boats, windmills and other products. We might conclude that these sectors represent a growing future potential for more recycling.
- Sweden has already achieved good results within WEEE plastics recycling; more can be done on a Nordic basis.
- More efforts have to be made in order to start recycling of plastics waste from ELV, building/ construction waste, discarded furniture, leisure boats and other composite products.
- Learning from Iceland, also other Nordic countries have a potential for increased recycling of fishing gears and other equipment from fisheries and fish farming.
- Based on Norwegian study for Klif a 45% overall recycling rate for plastic waste might be realistic in 2020. This is based on a recycling rate of 63% for packaging, still lifting the average recycling rate for all plastic waste.

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28 A Survey of Nordic Packaging Data Collection Methods, Tema Nord 2003:562, Ole Kaysen, Jan Jakobsen,
1.2 A qualitative survey on plastic waste

This quality survey on plastic waste will be presented as follows:

- Key qualitative topics, 3.2.1
  - Environmental impacts in general
  - Hazardous substances in plastic wastes
  - Nordic competitive advantages
- An overall quality assessment of plastic waste in general, 3.2.2
- A quality survey on relevant plastic waste fractions, 3.3.3

1.2.1 Key qualitative topics

1.2.1.1 Environmental impacts in general

The waste hierarchy (described in attachment 5.1) favors recycling to energy recovery solution. Most LCAs also favor recycling to energy recovery solutions for plastic waste fractions.29

A Wrap study has assessed the environmental impact of different waste treatment options for several waste fractions. For plastic waste WRAP studied 28 different environmental analyses/studies. The most relevant eight studies, comprising packaging of five different polymers and a mixed fraction and WEEE (TV) of three polymers, show that mechanical recycling in most cases are regarded as a better option than energy recovery, landfill and pyrolysis.

The WRAP study covers climate change potential, depletion of natural resources, energy demand, water consumption, acidification, photochemical oxidation, eutrophication and also human toxicity. The results show that mechanical recycling is the best alternative regarding climate change potential, depletion of natural resources and energy demand. Incineration with energy recovery performs quite poorly regarding climate gas emissions. Landfill turns out to be the option with the greatest environmental burden. Pyrolysis is still in early development and only included in two of the studies. The good results of mechanical recycling are based on the assumption that material production is avoided by recycling (substitution). A typical substitution case is “Bottle- to- Bottle” recycling.30

The general results for all plastic applications are in line with Norwegian studies on plastic packaging waste.31 Net climate gain for recycling compared with energy recovery, is 1,9 - 2,7 kg CO₂/ kg plastic packaging based on different assumption on energy sources replaced. Saved energy is estimated to 7- 12 kWh/ kg plastic packaging. Sensitivity analyses related to production loss show different results, however mechanical recycling is in all alternatives the better option.

There are many new plastic types; either biobased (such as PLA, TPS and PHA) and/or biodegradable plastics (such as PCL, PBSU, PVOH) entering the markets. They all have still a very low market share, but the market shares are expected to grow. There are some LCAs made on “Bio” plastics. Even though renewable resources are used, more energy (oil) is often needed to produce these plastics. GMO (genetically modified organism) and food supply are also issues related to biobased plastics. Last but not least the issue of recycling and the impacts on recycling of other plastics has to be taken into account. Biobased conventional plastics, e.g. PE, called green PE or plant based PET, might be recycled as other PE and PET waste fractions. Increased use, step by step, of renewable resources is probably positive for the environmental footprint of plastics taking food supply, GMO etc. into consideration. Plastics made from renewable resources will also perform better, regarding greenhouse gases, when energy recovered.

Cost/ benefit analyses sometimes give other results than the LCAs. Based on available data a cost/ benefit analysis might for example favor large scale recovery solutions to a recycling alternative. Such energy recovery options are well established and efficient in the Nordic region. These poor cost/ benefit results for recycling applies very much to smaller plastic fractions and new recycling schemes and processes where start- up and collection costs are high and markets for the recycled products are not mature.

On the other hand measures such as new technologies (central sorting) and new instruments might favor recycling also in cost/ benefit analyses. The Mepex report for Klif analyzed 10 actions for increased recycling; seven actions showed a net benefit, while three came out with a net cost, including some of the alternatives for packaging and ELV. However, based on new technologies and new instruments a net benefit was obtained for all plastic waste fraction studied; packaging, WEEE, ELV, fishing equipment and rigid plastics collected at recycling stations. The cost/ benefit assessments were based on a net gain of 2, 0 ton CO$_2$/ ton plastic recycled. The value of 1 ton CO$_2$ was estimated to NOK 385/ ton, equal the basis for the national diesel tax.

The conclusion is that the results of cost/ benefit in many cases are dependent on the model and the technology chosen. Both for packaging and ELV the alternative strategies described in the study can both increase the level of recycling and make the actions profitable for society. The experience for recycling industry is also; it makes sense to recycle most plastic products, but profits are dependent on a “critical mass”, e.g. a certain volume is needed. Wherever a critical mass of a certain plastic type can be sorted out for recycling, recycling makes sense both for the economics as for business.

### 1.2.1.2 Hazardous substances in plastic wastes

In order to give an update on the issue of hazardous substances related to plastics recycling, the topic is first related to the EU process on End of waste criteria following a brief summary of recent other EU and Nordic reports on this issue. These reports describe in more detail relevant substances related to different plastic applications, the environmental
and health impacts and the European and national legislation in this field. Furthermore some EU initiatives on routines and methods for the recycling industry are described.

Plastic products and plastic waste contains different additives in order to obtain the wanted properties of the products. As part of the End of Waste process for plastics, the EU Commission elaborated in brief on the issue of additives and hazardous substances in plastic waste and also explained the link between end of waste criteria and different EU legislation.

Most additives of the original waste plastic, except e.g. lubricants or catalysts, are not consumed, altered or degraded during the melting process of mechanical recycling (much unlike glass or metal recycling), so these are kept and found in the pellets.

There are hundreds of additives in the EU market, and their presence in the plastics can vary largely, from a few percentages and up to 50-60%. Some of them are sought after in recycling, as they are much needed in the recycled product (e.g. stabilizers, hardeners, plasticizers, structural fillers). Some of them may have no function in the recycled product (UV absorbers, flame retardants) or need correction measures (odor, color). In most cases, re-adjustment of additives is needed in the manufacture of recycled plastic products.

More than 99% of the additives appear to have no environmental or health risk. The recycling of these well identified, no-risk polymers and additives shall be encouraged. Currently, only very few problem substances used in/as additives have been identified as bearing environmental and/or health risk, notably:

- Bisphenol A (curing agent in polycarbonate and epoxy resins)
- Low molecular weight phthalates (plasticizers): DEHP, BBP, DBD, DIBP, but not high molecular weight ones such as DINP and DIDP.
- Halogenated flame retardants
- Toxic heavy metals (colorants and stabilizers): Cadmium, Chromium6, Lead and Mercury.

Some of these substances have been voluntarily phased out by the industry, and they are present as legacy but are not being re-introduced in the plastic cycles through virgin plastics. The presence of these substances in waste is currently handled via specific legislation, essentially WEEE and ROHS, and to a certain extent REACH (e.g. Annex XVII on restriction of uses of recycled material). The presence of these substances in plastic products is handled by REACH (and CLP for labeling), the POPs Regulation, and specific food contact legislation for this type of use. Should these substances be present, REACH is to ensure the provision of environment and health information through the supply chain. Once the plastic products are used and become waste, this information chain is broken. Reprocessors and especially converters have to re-establish the information chain, in the first place by characterizing thoroughly the recycled plastic output. This characterization is also essential for the identification of residues of materials that were in contact with the plastic during its use (e.g. solvents), or substances are added/formed during re-processing (e.g. flame retardant reaction products). Spectrograph or chromatograph-like characterization is essential and commonplace in sensitive applications such as food contact.

The main objective of a Regulation on EoW is to facilitate the recycling of plastic of high quality. It is also to clarify and harmonies the characteristics required for EoW plastic, and the legislative

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34 European Commission, DG Joint Research Centre, mail correspondence to all EoW stakeholders by A. Villanueva, 11.05.11
background for operation of recyclers and authorities once it enters into force. The EoW regulation shall not be used to duplicate existing control mechanisms, although it shall complement these mechanisms where they would appear not to provide sufficient safeguards under precautionary aspects specific to recycled material. Ideally, the EoW regulation shall be shaped as simple as possible, restricting the presence of non-plastic material, and clarifying for all parties the application of the boundary existing legislation for waste (WEEE, ROHS) and non-waste (REACH, POPs). Emphasis shall be placed in the EoW regulation on operational quality control of the output material.

The Norwegian report for Klif lists ten substances on the Norwegian national priority list that have been or still are used as an additive in plastics:\(^ \text{35} \)

1. Bisphenol A (BPA)
2. Lead and lead compounds (Pb)
3. Brominated flame retardants (Penta-BDE, octa-BDE, deca-BDE, HBCDD and TBBPA)
4. Diethylhexylphtalate (DEHP)
5. Cadmium and Cadmium compounds (Cd)
6. Short-chain chlorinated paraffins (SCCP)
7. Chromium and chromium compounds (Cr)
8. Highly chlorinated medium-chain chlorinated paraffins (MCCP)
9. Pentachlorophenol (PCP)
10. Mercury (Hg)

The study also lists some other hazardous substances, including copper compounds used for leisure boats (antifouling) and in fish farming nets (impregnation).

Furthermore the report describes in which products the hazardous substances can be found and refer to the limits for hazardous waste according to Norwegian waste legislation. These limits are not checked with other Nordic legislation, but according to the attached minutes of the Nordic Workshop some operators in the market say there are differences within the Nordic countries, a fact that complicates their operation and disturb a well-functioning market.

The study briefly lists main hazardous substances used application by application. Furthermore the report describes how hazardous substances can be spread by material recycling, incineration and landfilling. The report refers to different initiatives to meet the challenges of hazardous substances in different products; the EuPC initiative REACH Club and the EU “RiskCycle” project. The report also proposes a project in order to develop and disseminate knowledge about recycling and hazardous substances; a project to include operators in the value chain and the national EPA (Klif).

Commissioned by the Swedish EPA, Naturvårdsverket, a study published in 2012 updated the knowledge on hazardous substances and plastics recycling. \(^ \text{36} \) The report concludes that focus so far has been related to WEEE and flame retardants. There is less knowledge about hazardous substances in the plastic waste from household products,

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\(^ {35} \) Økt utnyttelse av ressursene i plastavfall, Mepex Consult for Klif, 2012
\(^ {36} \) Vad vet vi om faliga ämnena vid materialåtervinning av plast? Naturvårdsverket/ IVL Svenska Miljöinstitutet 2012
building materials and ELV. Regarding packaging hazardous substances are not regarded as an obstacle for plastics recycling.

The report says that the professionals within WEEE are well aware of the issue, but in general the waste management industry has a low knowledge, e.g. on REACH. The professionals use different technologies (NIR, XRF, sink/float etc.) and methods (product lists) in order to sort the plastic fractions to avoid recycling of hazardous substances. However it might be a challenge to obtain complete information of the content of all products (and product parts) used in the market. Often, in order to avoid mistakes, plastics suitable for recycling are energy recovered instead. A high degree of energy recovery is also due to the fact that identification technologies still have certain limitations (including identification and sorting different kinds of flame retardants) and the fact that identification and sorting can be costly compared with the net value of the plastic waste material.

The report also describes the practice on ELV dismantling; normally plastics are part of the SRF (shredder light fraction) comprising about 20% of the ELV waste. The SRF is energy recovered in Sweden. In Germany however new technologies are used in order to recycle more of the ELV plastic waste, often back to new car parts. The long life of cars is a challenge as older cars contain hazardous substances that have been banned more recently.

The long life is also an issue for building materials; Old PVC products may contain cadmium, while cadmium has not been used in new PVC products in Europe since 2001. Most plastic waste from building/ construction are incinerated or landfilled. Better traceability and new instruments are needed in order to increase recycling of plastic building materials.

The report also lists several projects that might increase the knowledge of hazardous substances in plastic waste that will be finalized within end of 2012, including Chemitec, RISKCYCLE (EU), EQP, “Hållbar avfallshantering”, “Hållbar avfallshantering av plastskärmar”/HÅPLA (WEEE) and ELV DEMON and some other more general Swedish studies.

The report concludes that we still need more knowledge to categorize plastics for recycling according to our knowledge and our control. Such a categorization might be useful in order to increase recycling. So far information is missing for most product groups (beyond WEEE) and for many hazardous substances (e.g. phthalates). Obtaining necessary knowledge is a challenge as new products are introduced every day to the Nordic market from producers all over the world. In addition traceability of information and making the information available for the waste management industry and the recyclers are key challenges.

A Swedish report on “Recycling of WEEE Plastics Containing Brominated Flame Retardants- a Swedish perspective”, made for the Swedish EPA in 2010 is one example of studies on hazardous substances focusing the most of WEEE and Brominated Flame Retardants. The report estimates that 1/3 of WEEE plastics handled in Sweden contains BFR. These plastics are energy recovered in Sweden at plants with permissions to incinerate hazardous waste. The remaining 2/3 of the plastics are exported for recycling in China. The
use of BFRs in EEE products is expected to decrease in Sweden. Swedish recyclers want that the hazardous substances are phased out rather than exemptions are given. 37

**A new Swedish Chemicals Agency report commissioned by the Swedish Government** assesses the needs for changes in EU and national policies. 38 The study includes a proposal for an EU strategy on “Non-toxic resource efficient material cycles” whereby different legislations should be better coordinated (waste, product, health and chemical legislation).

The report gives an updated overview on the issue of chemicals within EU. The report is also focusing on the topic eco-design and issues related to specific plastic applications (WEE, ELV, toys, building materials et.) inclusive the new issue of nano and “cocktail effects” where more knowledge are needed. Chapter 8 is focusing on hazardous substances related to waste treatment including some proposals for changes. In chapter 11 consequences related to textiles are described as well.

**Swedish Chemicals Agency** published in December 2012 the results from a project assessing how industry uses recycled materials in their products, their policies on using recycling materials, how they control the quality of the material and which requirements regarding hazardous substances they make towards the suppliers of recycled material. The study is based on interviews with ten companies within toys and other products intended for children, shoes, clothing, interior products and EEE. 39

**Swedish Chemicals Agency** has listed some further Nordic relevant reports: 40

- Toxic Substances in Articles: The need for Information (TemaNord 2008:596)
- REACH Trigger for Information on Substances of Very High Concern (SVHC) - An Assessment of the 0.1% Limit in Articles (TemaNord 2010:514)
- Information on Chemicals in Electronic Products - A study of needs, gaps, obstacles and solutions to provide and access information on chemicals in electronic products (TemaNord 2011:524)

**Swedish Chemicals Agency** refers also to reports and case studies used within the SAICM-project on chemicals used in products (CiP): 41

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37 Recycling of WEEE Plastics Containing Brominated Flame Retardants- a Swedish perspective”, Recycling Development AB and Vascaia, made for the Swedish EPA, 2010
38 Bättre EU-regler för en giftfri miljö, Kemikalieinspktionen 2012
39 “Material Recycling without Hazardous Substances – Experiences and future outlook of ten manufacturers of consumer products”, IIIIEE study commissioned by Kemikalieinspktionen, 2012 (PM 14/12): http://www.kemi.se/sv/Innehall/Publikationer/PM/
40 Anne-Marie Johansson, Kemikalieinspktionen/ Swedish Chemicals Agency
41 Anne-Marie Johansson, Kemikalieinspktionen/ Swedish Chemicals Agency
The Finnish Environmental Institute, SYKE, is participating in a study where, among other things, a survey is done on the hazardous substances found in construction and demolition waste. No information available so far.

The Norwegian committee on hazardous substances proposed in their report to their Government (NOU 2010:9) several actions in order to meet the national objectives of phasing out all hazardous substances within 2020. The proposals comprise several general activities for increased competence and more international cooperation. In addition it was proposed actions to obtain better control of the waste streams by increasing the collection of waste containing hazardous substances and securing dismantling/ sorting at an early stage in the value chain. Better routines are needed for ELV, WEEE and building materials the report concluded. Substitution proposals comprised both leisure boats (antifouling) and fish farming nets (copper as impregnation).

At the Nordic workshop some Norwegian operators within WEEE and fisheries stressed that non- harmonized rules is a barrier to recycling and harm the development of a Nordic recycling market. See minutes attached.

The dynamics in this field can be illustrated by the recent Danish recent initiative to ban the four phthalates DEHP, DBP, DIBP and BBP in all consumer products, e.g. beyond toys.42

Nano technology is entering the markets. Soon these substances will be found in the waste, inclusive the plastic waste. The impact on recycling has been assessed in a new study commissioned by the German Hans-Böckler-Stiftung des Deutschen Gewerkschaftsbundes (DGB). The study „Bedeutung von Nanomaterialien beim Recycling von Abfällen“ gives an overview of products where nano is used. The study concludes that recyclers have to take

42 Plastnet.se, 04.09.12
the same health precautions as manufacturers and more knowledge is needed both regarding health risks and environmental impacts. 43

The EU Commission published in 2011 a report on plastic waste; “Ecological and human health impacts”.44 This report, however, focuses the most on plastic waste ending up in the nature, e.g. as marine littering. Better waste management systems and more recycling are described as part of the solution for marine littering. The proposed target of full recyclability of plastic waste stimulates recycling and reduces the negative impacts of plastics discarded in nature as well.

The EU Commission released on 31st October 2012 a staff working report on marine littering. The report gives an overview of EU policies, legislation and initiatives related to marine litter. As plastics is part of the littering problem, better take back systems, including fishing equipment, leisure boats and other plastic products, might be part of the solution.45

The EU Commission Green paper on plastic waste, expected to be released in February 2012, might give further knowledge regarding hazardous substances. In addition several initiatives on plastics recycling are expected.

The European Commission is drawing up a new implementation plan under the Stockholm Convention on Persistent Organic Pollutants (POP).46 The POP Regulation requires the Commission to draw up a plan for the implementation of the Union’s obligations under the Stockholm Convention and, when appropriate, to review the plan and update it. The new plan will update the previous 2007 plan whose actions have been nearly finalized. It will include several new actions for the EU to meet its international obligations and add the new substances that were added to the Stockholm Convention and the POP Protocol in the course of 2009 and 2011. The consultation aims at providing the European Commission with views and comments of stakeholders, citizens, NGOs and business on the draft implementation plan on POPs. The consultation was open until 25 October 2012.

The German EPA, Umwelt Bundes Amt, published in 2012 the report; “Reach and the recycling of plastics”.47 This study is meant as a reference manual for an appropriate implementation of the REACH requirements for the operators of recycling plants.

Unlike the abovementioned reports, often focusing on the environmental problems, this German document introduces practical solutions for the recyclers of plastic waste. The key issue is that recyclers are subject to REACH duties as substances leave the waste regime and thus once again become products. Recyclers are thus “manufacturers” under the REACH definition, since they manufacture a chemical substance, a mixture or an article in

43 Euwid Recycling und Entsorgung 46.2012 (20.11.2012)


46 EU Environment Policy Brief, Issue 62, July/ August 2012

47 Reach and the recycling of plastics, Umwelt Bundes Amt, 08/2012
which chemical substances are contained. Recyclers are subject to the same rules under REACH as any other substance manufacturer.

However there are special exemptions from registration described in this report. As also recyclers are obliged to carry out appropriate classification and labeling, the German report describes various methods for correctly providing information about substances, responsible handling of waste stream impurities and adequate documentation. The report also describes procedures to be followed and aids for the preparation of the various types of information to be given to customers, e.g. safety data sheets. References are made to several organizations in Europe that can assist recyclers to implement good routines in order to meet the requirements.

As Germany is regarded as one of the leading European countries both within plastic recycling and environmental affairs, much attention has been given to find practical solutions. The implementation of REACH and GHS (Globally Harmonized System) is described in different articles that might be used as basis for further work also in the Nordic region.48

The conclusion regarding the issue of recycling and hazardous substances:

- Up to now plastic recycling has focused the most on the largest volumes, e.g. packaging and agriculture film where the challenges related to hazardous substances are limited.

- The Nordic countries have also recycled some plastic waste from WEEE. Within this area the issue of flame retardants has had broad attention. Professionals are well aware of the issue of hazardous substances, but in general the waste management industry has a low knowledge. There are still a potential to recycle more based on better technologies, routines and also higher and well defined ambitions related to recycling.

- Limited amounts of plastic waste are so far recycled from the more challenging areas, e.g. ELV, building and construction, furniture and leisure boats/ composites. Poor results on recycling might partly be due to the hazardous substance issues. In addition there are few instruments in place to boost recycling within these areas. (Chicken and the egg case) Knowledge within the whole value chains has to be developed based on instruments focusing on both issues; recycling/ resources and hazardous substances. Knowledge might be developed partly motivated by the future value of the materials in these sectors and/ or obligations to recycle these plastic products.

1.2.1.3 Nordic competitive advantages

A Nordic competitive advantage can be obtained in different ways by initiatives related to the issues of plastic recycling and hazardous substances:

48 Implementation of REACH and GHS, Müll und Abfall, Dr. Beate Kummer, 4/2012
• Industry will put the issues on the agenda in general. This might lead to more awareness and better competence that again might lead to a more proactive approach on eco-design of products, better routines taking stricter requirements into account, both in the Nordic markets and abroad.

• Nordic manufacturers of plastic applications for export, including wind energy, leisure boats, building materials, furniture, fishing equipment etc. might offer their clients in the export markets better waste solutions than their competitors, e.g. recyclable products and even take-back-/ recycling services included. Such solutions might again help the customers to be greener and save costs related to disposal of the discarded products.

• Nordic Producers of identification and sorting technology might obtain an advantage based on increased requirements within their home markets (identification of hazardous substances).

• Experience and knowledge from plastic recycling can be used in the process of developing EU and other international legal framework, giving the Nordic countries a political advantage.

• Scientists and consultants involved in the process might build up competence to be used internationally.

Opportunities and possible competitive advantages are elaborated as part of the following qualitative survey in chapter 3.2.2 and 3.2.3

1.2.2 An overall qualitative survey on plastics

In this chapter key qualitative issues related to plastic recycling in general are described in the table below. Some of the quantitative facts from chapter 3.1 are summarized in this table as well.

This table shall give an overview related to all plastic waste. In the following chapter 3.2.3 further details will be given on specific plastic waste fractions.

If not otherwise explained all figures are related to 2010 and the four biggest Nordic countries Denmark, Finland, Norway and Sweden.

<table>
<thead>
<tr>
<th>Nr</th>
<th>Issue</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Tons of plastic waste 2010</td>
<td>Different results from different statistics and surveys: -Estimate 1.1 (PlasticsEurope): 1.6 Mt (Mepex) -E.g. 44 kg - 66 kg/inhabitant (national statistics in Norway; 95 kg/capita)</td>
</tr>
<tr>
<td>2</td>
<td>Polymers and in plastic waste</td>
<td>The big five polymers contributes with more than 75 % of the plastic waste (PE, PP, PS, PET and PVC)</td>
</tr>
<tr>
<td>3</td>
<td>Hazardous substances in plastic waste</td>
<td>See chapter 3.2.1.2 Trend; based on new technology new additives are developed and introduced in order to improve performance of plastics and to replace other</td>
</tr>
</tbody>
</table>
materials, such as steel in cars, glass in beverage bottles etc.

Industry also replaces hazardous substances with less harmful substances sometimes in advance of legislation, sometimes due to legal requirements.

Plastic waste from long lived products, e.g. plastic leisure boats, cars, cables and pipes can contain different substances from different time periods (back to the 60’s) and from different producers from all over the world.

Controlling imported goods is a key in order to reduce hazardous substances in future plastic waste.

| 4 | Waste per applications (Products) | In EU27+2 packaging contributed by 62% of all plastic waste, followed by building/construction 6%, agriculture plastics 5%, WEEE 5% and ELV 5% (PlasticsEurope).

Mepex study for Klif estimates a higher amount of the Norwegian plastic waste than PlasticsEurope, the share of packaging is here 44%, while the share of other applications are higher than in the PlasticsEurope study.

Other studies show different results, especially for non-packaging applications. |

| 5 | Trends regarding the amount of plastic waste | Estimated long term EU27+2 annual growth of 2-3% in the consumption of plastics products. The long term growth of plastic waste will probably grow even faster due to the fact that long life products of the past sooner or later will be wasted, e.g. products from building/constructions, ELV and leisure boats. In addition, some products might get a shorter life span due to the technical development and changes in consumption patterns.

The Norwegian Mepex report has illustrated the trend with a 5% growth of plastic waste from 2010 to 2020, such a growth rate equals a 63% increase of the generated in plastics waste over 10 years. |

| 6 | Tons of recycled plastic waste 2010 | 321 Kt plastic waste from the 4 Nordic countries were recycled in 2010, of which 73% were packaging waste, 10% WEEE and 10% agri film.

More studies are needed to verify the recycling data as some reports are rather based on “collected” amounts, rather than “recycled” |

| 7 | General potentials and drivers for increased recycling of plastic waste in a European perspective | In general the potential for increased recycling is high; the Norwegian study for Klif concluded that 45% recycling for all plastic waste might be realistic in 2020. The potential is higher for packaging, 63%, lower for materials such as furniture 12%, building 22% etc. that so far is rarely recycled at all. The potential for these applications will probably take more time to exploit as legislation, take-back systems and technology are not in place yet.

Based on political ambitions hazardous substances will be replaced by less harmful alternatives. This development implies that almost all plastics could be recycled in the future. In the meantime solutions have to be found for identification, sorting and treatment of plastic waste that should not be recycled. A long term vision and a step by step approach are thus needed. |
Drivers for increased recycling:
- Higher prices for plastics in general due to higher prices of raw materials and energy
- Increased demand for recycled plastics and thus higher prices for recycled material based on the fact that recycled material is more and more competitive to virgin material, partly due to improved quality, partly due to eco design requirements, even by law
- Higher ambitions among companies (See Nordic work shop presentation from IKEA; 50% recycled plastics in average in products)
- Higher recycling targets and other instruments to boost recycling, incl. sorting requirements for all waste fractions containing plastics
- Legislation that can make it possible to find solutions to both increase recycling and take the issue of hazardous into account, e.g. for ELV, building and construction etc.
- Bans and increased costs on alternative waste treatment; landfilling and energy recovery solutions. E.g. making sorting plastic waste for recycling profitable for the waste holder.
- Better design for recycling, both based on the eco-design directives and initiatives within the market, e.g. European PET Bottle Platform.\(^{49}\)
- A transparent market with certified recyclers; a European certification system is in the pipeline.\(^{50}\)
- Better awareness, knowledge and demand from consumers and local authorities (procurement of goods)

Most plastics might be recycled. Limitations are linked to:
- Economic barriers; lack of economy of scale, too small waste streams
- Market conditions; turbulent market conditions, risk connected to quality/hazardous substances
- Technical challenges; dismantling complex products and recycling of some complex plastic materials
- Hazardous; the fact that some plastic waste contains hazardous substances and the challenges related to identification and sorting of what plastics is hazardous waste and not makes it less interesting and also risky “to bother” about such waste streams
- Legislation, often regarded as insufficient and contradictory, often related to subsidies for alternative disposal, e.g. energy recovery, insufficient recyclability requirements, illegal shipments of waste out of Europe, inconsistencies in the field of waste, products and materials.

A maze of local, regional, national and EU waste regulations currently in force is mentioned as an obstacle for trade in recycled goods.

For recycling in Europe relatively cheap east bound shipping costs and substandard health, safety and environmental management of recycling processes outside Europe are key elements.

\(^{49}\) [http://www.petbottleplatform.eu/](http://www.petbottleplatform.eu/)
The drivers and barriers might be summarized by the 3-pronged recycling approach by Plastics Recyclers Europe published November 2012.  

According to their brochure "How to boost plastics recycling and increase resource efficiency" Plastics Recyclers Europe promotes their messages as follows:

1. Ban on landfill:
   - About 40% of plastics waste is landfilled in Europe today.
   - With a target of 70% plastics recycling in 2020, more than 160,000 jobs will be created.

2. Higher Recycling Targets:
   - Today only 24% of plastics are collected for recycling in Europe.

3. Eco-Design for plastics recycling:
   - The European PET Bottle Platform (EPBP) is quoted as an example.

An overall EU strategy is described in Thematic Strategy on Waste Prevention and Recycling.

Waste Framework Directive (WFD) and the waste Shipment regulation represent the general framework. Article 1 of WFD is regarded as the “Constitution” of European waste law stressing the objectives related to environmental impacts, resource conservation and resource efficiency.

WFD has fixed targets of 50% (households) and 70% (building, construction and demolition) for recycling/preparation for reuse for plastics, metals, paper and glass in total within 2020. Targets are however understood and implemented differently in the member states. Reinforcement or even new targets will be discussed and decided within 2014. WFD requires also separate collection to be introduced for paper, plastics, glass and metal, but other solutions are possible too. Extended producer responsibility (EPR) is an approach supported by WFR. The principle of Life Cycle thinking regarding the waste hierarchy is also ruled in the WFD. See guidelines of WFD in attachment, chapter 5.1

According to WFD the recycling markets shall be supported by setting end-of-waste criteria (EoW-criteria). EoW-criteria for plastics are in progress as a joint process with all stakeholders. Several reports have been made during this process. See also chapter 3.2.1.2 on the relation between EoW and hazardous substances and other EU regulations.

Waste prevention is a new dimension in the WFD and each state has to establish waste prevention plans within 2013. Prevention comprises also hazardous substances in the waste. Within 2014 possible prevention objectives for 2020 will be decided.

In addition to the mentioned waste framework regulations, EU has directives on waste treatment, such as landfill directive and incineration.

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51 www.plasticsrecyclers.eu
52 End-of-waste criteria for waste plastic for conversion, technical proposal, first working document, November 2011, IPTS, Sevilla in cooperation with JRC/IPTS
directive. Recycling standards are planned. A possible ban on landfiling of plastic can be discussed as part of other diversion targets.

Last but not least there are several directives on specific waste streams, such as packaging, ELV and WEEE.

The Internal market directive for Packaging and Packaging waste has a 22.5% mechanical recycling target for 2008. New targets are expected to be fixed within 2014.

ELV and WEEE directives have no direct target on recycling of plastics but the new WEEE directive increases the scope and the collection objectives.

The ELV recycling ambitions of 85% recycling within 2015, combined with an increasing share of plastics in cars means that also an increasing part of the plastics have to be recycled in the future.

A new general ambition for increased recycling is an element in the recent EU Roadmap to a Resource efficient Europe. This in order to reduce GHG emissions and also secure raw materials for the European economy. In order to increase resource efficiency the resolution called for a major overhaul of the “secondary-material market”.

The EU study on Coherence of Waste Legislation published in March 2012 presents a critical analysis of the waste stream directives contributing towards resource efficiency and a recycling society. Such a study is regarded as a good basis for further harmonization for a well-functioning recycling market, even for plastics.

A green paper on Plastic waste is expected in February 2013. It is expected that recycling rather than energy recovery will be focused.

The EU Commission released on 31st October 2012 a staff working report on marine littering. This document should form the basis for a discussion with Member States and stakeholders with a view to defining an appropriate policy agenda over the coming years. More recycling might be part of the solution.

EU has implemented an Ecodesign directive (2009/125/EC). Ecodesign has so far been related to energy savings. Now ecodesign also comprise design for recycling, starting up with TVs and image displays.

As basis for future instruments an EU Commission study was published in April 2011; Plastic Waste in the Environment. The objective of the study is to gather and analyze available data and information on plastic generation and waste, current waste management options and the related environmental and health impacts. It is also aims to consider potential additional measures that can be taken at various levels to reduce plastic

54 Identiplast 2012, Warsaw, 6th Nov.2012, Presentation by Dr. Helmut Maurer, DG Env/ EU Commission.
waste and its associated impacts; e.g. a basis document for further policies on plastics.55

As basis for future instruments another EU Commission study was published in April 2012; Use of economic instruments and waste management performances. The report proposes different policy options relevant also for both plastics and textiles. 56

Regulations and projects related to hazardous substances are described in chapter 3.2.2

| 9 | Nordic national ambitions on plastics recycling | Relevant ambitions are mostly related to specific targets for plastic packaging. Norway (since 1995) and Sweden (since 1994) have higher targets (30 %) than the EU minimum targets (22, 5 %). Finland, Iceland and Denmark stick to the minimum targets. Germany and Netherlands have higher targets, while UK now is discussing targets beyond 40% too. New waste plans are in progress in the Nordic countries, a revision of ambitions and recycling targets on plastic packaging and even other plastic waste are expected.

However the Nordic countries have higher recovery and/or recycling targets (or other stronger instruments) for beverage containers (deposit systems). Iceland has recycling targets also related to fishing equipment. These ambitions are partly related to the issue of littering rather than recycling.

General waste legislation and specific legislation for WEEE and ELV seem not to define concrete ambitions for plastic recycling.

Overall national recovery and recycling ambition is not regarded as a relevant ambition for the (rather small and light) plastic waste fraction.

Plastic waste is an important element (up to 50%) for the heat value of the waste being incinerated. Promoting energy from waste has been a key element in overall waste/ energy policies so far and also a major consequence of recent restrictions on landflling of waste. |

| 10 | Key national legislation | A key instrument in the Nordic region is related to landfill restrictions on specific waste fractions. There are different kinds of landfill bans in the Region. In Norway the ban is related to biodegradable organic waste fractions, plastics might thus still be landfilled. However the landfill restrictions have anyway an impact on plastic waste as more residual waste now is being incinerated. In Sweden however plastic waste can’t be landfill.

Due to the bans/ the strict land fill rules, the landfill taxes on landfill are thus less relevant.

Taxes on incineration are removed/ reduced in Sweden and then in

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56 Use of economic instruments and waste management performances, Report by Bios for European Commission, April 2012.
Norway. Denmark still has taxes on incineration.

Denmark has also a stricter regime for waste incineration. Recently restrictions related to the amount of fossil waste; The Amager plant in Copenhagen has to reduce the amount of plastic waste incinerated by 40% within 2030. The Amager requirement might be regarded as a strong measure in order to get far more plastics sorted out for recycling.

General waste legislations are in some cases still to be updated based on the EU Waste Framework Directive. National waste plans have to be made in 2013; Norway is planning a general waste plan instead of a Parliament report. Other countries are also in a process to update national waste policies and waste laws.

Legislation on packaging waste, WEEE and ELV are also based on EU directives. However the Nordic countries have chosen different approaches related to the use of EPR (Extended producer responsibility) and the use of voluntary agreements. (see 11)

Legislation on hazardous waste and transport of hazardous waste are also partly based on EU legislation.

Nordic deposit systems are based on different legal approaches on beverage containers, partly also with taxes and other measures.

| 11 | EPR (Extended producer responsibility) | Some specific EPR schemes are in place, partly based on legislation, partly based on voluntary agreements; Packaging waste, WEEE, ELV and agri-film and even on fishing gears in Iceland. EPR is not common in Denmark.
In other countries, both in Europe and in USA several EPR schemes are established, France has several schemes, California is also active.
A voluntary initiative is an alternative to legislation. The initiative of European PVC industry; Vinyl 2020 and Recovinyl are relevant examples. However the Nordic countries are not connected on the Recovinyl take-back scheme yet.
Based on different projects industry/ the producers are interested to base their efforts on such voluntary agreements. The fishing and fish farming industry in Norway has discussed such a solution. It has been said that without the Government support, as partner of such an agreement, it is difficult to get all private stakeholders involved in a process. The example shows that EPR might have a potential for several plastic applications.
For plastic applications EPR might be relevant for furniture, fishing and fish farming equipment, leisure boats and wind mills and other composite products. Agreements can be made nationally. A Nordic policy and harmonized solutions might add value, support a Nordic market and give a Nordic competitive advantage. The Icelandic agreement on fishing equipment might be a test case.

| 12 | Key projects finalized, EU | In general LIFE+ is the European financial instrument for the environment |
| Action for the “Recycling of Mixed Plastics Waste”  
- A tender has been made in 2012 for a planned project by Enterprise and Industry DG with an objective to increase recycling of mixed plastics and opening up new markets for recycled plastics.  

**Nordic, national**  
**Plastic Zero**  
Plastic ZERO is a project with participation of eight European partners aimed at reducing the amount of plastic in the waste stream for incineration and landfilling. Through public and private cooperation the intention is to find new ways of using resources more efficiently. (See Works shop minutes)  

An important feature of the Plastic Zero project is to set up cooperative forums involving public and private stakeholders, by bringing stakeholders together with shared responsibility. The forums and networks will identify and analyze relevant interfaces between the partners in the value chain, and provide the necessary production technology, infrastructure, physical planning, information, waste services, and technologies for reprocessing. By involving all stakeholders in the value chain there will be an opportunity to rethink product design through cradle-to-cradle methods.  

A key element is to introduce and implement knowledge of plastic waste prevention and cost-effective sorting in enterprises generating plastic waste. Therefore, the project will engage in capacity building by training a number of business waste specialists who can provide on-site support to enterprises.  

Further, the available recycling technologies will be analyzed. The activity will conclude on the present options for recycling and determine the need for innovation of new technologies and systems for recycling of the specific waste materials. Selected technological options will be investigated in practice in cooperation with the business sector, including studies of demonstration plants and further exploitation of promising recycling technologies/ concepts.  

The Plastic Zero project is managed by the City of Copenhagen, Denmark. Cities in Sweden and Finland take part as well.  

**Innosort (DK)**  
Globally, there is an increasing interest in securing a better utilization of scarce resources by reusing waste factions.  

INNOSORT gathers high technology companies within sensor and robot technology, waste handlers and central know-how partners in close collaboration in the development of new technical environmental solutions to sort waste in material factions of high cleanliness to increase the regain of

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58 New technologies for plastic recycling (sorting and reprocessing), Plastic ZERO project, Municipality of Copenhagen, 2012 Unpublished
valuable resources.

The Danish Agency for Science, Technology and Innovation supports the innovation consortium INNOSORT, which consists of the Danish Technological Institute, Eldan Recycling A/S, Puls Design A/S, Industri Tech ApS, Grabow Systems A/S, Dansk Affald A/S, Danbørs A/S, University of Southern Denmark, University of Copenhagen, and DTU Informatics.

**Top waste (DK)**

The main objective of the project is to contribute to improved use of waste for energy or material recycling integrating economic and environmental considerations including resource scarcity.

This is done by developing a coordinated set of four tools to analyze and plan investments and activities, taking into account that the waste management sector and the energy sector are intertwined and will be subject to new market conditions.

The four tools developed make it possible to combine analyses of the waste and energy sectors so that holistic and coherent planning of investments and development of policies are facilitated. The joint cooperation in the project across a range of academic fields will enhance our knowledge in each field as well as bring cross-cutting new insights forward thereby facilitating and promoting innovative solutions. The goal is first to develop an improved understanding of the significance of new organizational regimes and regulatory measures and establish knowledge of new waste treatment technologies and recoverable resources. Secondly interrelated user-friendly tools will be developed allowing for the assessment of future waste resources, as well as cost-optimization and environmental assessments of a range of scenarios describing possible future developments. Furthermore, waste treatment technologies with good potential for being the “Green Tech” of the future will be identified, increasing the potential for export of these technologies.

**Waste Refinery (S)**

Among several projects at the Swedish waste Refinery Centre, PROFU is leading a project on “Perspectives of future waste management”. How to obtain reduced fossil CO$_2$ emissions from waste incineration is one of the questions to be studied. Increased recycling of plastic waste is thus part of possible system solutions discussed. The project is schedules to be finalized within 2012.

**Directions of future developments in waste recycling (SF)**

This Finnish project is expected to be finalized at the end of 2012. Partners are VTT, Aalto University, Finnish Environment Institute and Lappeenrante University of Technology. The study will include an overview of the Finnish situation of waste management in the fields of construction and

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demolition, MSW, WEEE, ELV and commercial/industrial waste, e.g. major relevant waste streams for plastics. The study also assesses opportunities for increased recycling of plastic waste both from households and from agriculture. Feedstock recycling is also described as a possible recovery strategy for further studies.

**Other Finnish studies**
While the Ministry of Environment is still working on the legislation for the producer responsibility of packaging waste, PUR has in 2012 tested out a bring system for plastic packaging from households. The results are not available yet.

SYKE has performed a LCA study on packaging waste collection and recovery for the Northern Finland. Recycling is regarded as beneficial according to this LCA, the costs however are regarded as high.\(^\text{60}\)

| 13 | Collection and sorting of household plastics waste | Municipalities have in general a central role regarding the collection of household waste fractions, e.g. the municipalities have a responsibility for collecting and treatment of the waste stemming from households and sometimes also from other municipal solid waste sources. However the roles are different from country to country. Furthermore the roles of the municipalities are also in debate, e.g. in Sweden related to packaging waste according to a recent proposal.\(^\text{61}\)

Referring to the quantitative survey, the largest potential for increased plastics recycling can be found within residual municipal waste. The definitions of roles and responsibilities are crucial for how these potentials can be exploited. So far in many cases the plastic waste has been used as an energy rich part of the fuel for local incineration plants.

| 14 | Collection and sorting of plastics waste from trade and industry | Collection of waste from trade and industry is for the most based on a free market with keen competition between international, national and local waste management companies. Plastic waste is normally a minor waste fraction for these operators.

Municipalities and their subsidiaries are more or less also involved in this market.

Retailers also take part in collection of plastic packaging as well, utilizing their own logistic capacities. Retailers often return their own plastic film waste, sometimes including used plastic shopping bags and their deposit PET bottles to their distribution centers.

| 15 | Central sorting infrastructure | Central sorting of collected plastic waste, “single stream”: -Collected mixed plastic packaging from households in Norway and Sweden is partly sorted in Sweden, partly exported for sorting and recycling and recovery (Germany). In order to obtain efficiency and a high degree of sorting for recycling, huge high tech plants are needed. Increased collection in the Nordic region might open up for new sorting plants in the Nordic region and thus stimulate the Nordic market.

\(^{60}\) Helena Dahlbo, SYKE, information about Finnish projects, 05.12.12
\(^{61}\) Mot det hållbara samhället, Betänkande av Avfallsutredningen, SOU 2012:56, 2012
Central sorting of collected residual waste:
- Normally no sorting takes place before residual waste is incinerated. However some projects recently have been initiated in order to sort out plastics from residual household waste, both in Norway and in Denmark. Such sorting plants could exploit further volumes of plastic waste for recycling. The first Norwegian plant will be opened outside Oslo in 2014. The planned ROAF plant will sort 50Kt of residual waste annually. It is assumed that 60% of plastics in the waste stream can be recycled, including LDPE, HDPE, PP and PET. According to supplier of sorting technology (NIR technology) the plastic fractions will obtain a purity of 96-97%. A washing plant is planned as a phase 2 as an option. Another planned plant, in Stavanger, will include a washing plant from the beginning. It is assumed that 72% of plastics in the waste stream can be recycled.

Plastic waste fractions from trade and industry are either collected separately or collected as mixed waste directly to incineration. The degree of central sorting of mixed waste is poor. Waste sorting plants are so far focusing on heavy and major waste fractions such as wood and metals. The light weight plastics are seldom sorted out at such plants.

There are some sorting of plastics from collected WEEE, but less from ELV, except form car parts as bumpers (PP).

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<tr>
<th>16</th>
<th>Recycling infrastructure and export</th>
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<tr>
<td></td>
<td>There are today some Nordic plants for recycling of PE-film and one PET recycling plant in Sweden. There are some rigid plastics recyclers as well in the region. In Iceland one recycler also specializes in fishing equipment. Several smaller operators have failed and closed the operation and moved the equipment to low cost countries. On 19th November 2012 the Norwegian flagship film recycler Folldal, established in 1994 went bankrupt. The same week new owners started up again. Based on the recent emerging and functioning global market for baled (and grinded) plastic waste fractions, all Nordic countries export most of their collected plastic waste, partly to the Far East partly to other European countries. Due to the fact that only 1% of the six million Chinese plastic recyclers have proper cleaning systems for their washing operations, plastic recycling in China is regarded as a “dirty” industry. Measures are taken and the Government is now restricting imports of plastic waste that need washing, e.g. plastic film from agriculture and film collected from households. PET bottles have to be grinded and washed. These restrictions might bring balance to the global recycling market and stimulate a fair competition based on equal terms related to environment affairs. However restrictions on imports and exports are not always followed by the market operators and the control is far from tight. Several countries in Europe have stimulated the sorting and recycling industry by financial support. UK has long tradition in export of plastic waste, the last years the Government has supported several new plants in order to boost sorting, recycling and thus also the availability and use of recycled materials in the UK. The policy also increases UK employment.</td>
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Energy recovery infrastructure

The Nordic countries have a good infrastructure of incineration plants and well established district heating systems. In total the region has now an overcapacity and waste is imported from Europe for incineration.

Denmark and Sweden are in the lead, Norway and Finland are also developing their incineration infrastructure. Cement kilns in the Region use partly a fuel based on waste including plastics.

Key technologies

Plastic waste can be identified and sorted according to different polymers (PE, PP etc.), shape and colors (clear, blue etc.) by the use of NIR technology (Near Infrared Sorting). X-ray, ultraviolet (UV) and other optical systems are also used in order to sort the plastics.

WRAO made a series of demonstration trials on novel techniques for the separation of mixed WEEE plastics in 2009, the report gives both an overview technologies as well as what can be achieved.

Tomra Sorting Solutions in Norway is one of the leading providers of sorting equipment worldwide. Similar and other technologies are used in reverse vending machines for deposit containers. Thus the Nordic region already has a competitive edge on sorting technology.

NIR and other technologies are also used for identification and sorting of plastic wastes from other recyclable fractions or from other residual mixed waste.

Sink and float is a common sorting technology in order to sort plastics with different weight, e.g. PE film from laminates, PVC and other materials.

At sorting plants the bags with plastics (and sometimes other waste fractions) will be treated also by a sack-opener, rotary sieve, magnets, wind sifters and eddy current technologies in order to sort the different waste fractions properly into clean fractions for recycling.

Compaction of waste is crucial in order to transport the collected waste as efficient as possible. There are several technologies and suppliers for equipment for compaction of waste fractions, such as film, bottles and EPS. EPS is important for packaging of fish, thus a special Nordic waste fraction. The Danish Runi is a leading provider of EPS compaction equipment.

The operators use different technologies for identifying hazardous substances in plastic material, e.g. according to some flame retardants used. See chapter above on hazardous substances.

There are different technologies for further cleaning and recycling of different polymers with different quality, incl. grinding, washing, agglomeration and extruding. Recyclers also have methods to give the grey and dark recyclate new colors according to the needs of the customer.

As an alternative to mechanical recycling. Mixed fractions of plastic waste might also be treated at chemical recycling plants. Only 0.3% of the plastic

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62 Separation of mixed WEEE plastics, WRAP report, 2009
waste is recycled this way in Europe today. Different projects are in the pipeline, but more research is needed in order to make the technology competitive. According to the packaging directive only mechanical recycling counts as recycling.

| 19  | Key markets for recycled material/products | In general recycled plastics today are used in products within building/construction, packaging, car components. LDPE plastic film can either be recycled into new film products, such as shopping bags and waste sacks or into products like pallets. The better quality of the recylcates the more opportunities are available for the recycled plastics. PET is partly recycled into fiber (fleece), partly B2B (bottle to bottle) and other plastic products, incl. food contact packaging. Also HDPE might now be recycled into food contact packaging, based on strict rules. See also opportunities and barriers for more recycling below |

| 20  | Nordic competitive advantages today | Nordic industry has a strong position in some areas of international business; furniture/design, leisure boats, wind mills, PVC production/PVC building materials. Recycling technologies and solutions might strengthen the competitive position for the above mentioned products and markets. Nordic industry has also a strong position within sorting technologies (Tomra) Nordic research and consultants are active internationally. Nordic Governments have a strong position on the issue of hazardous substances. See also previous chapter 3.2.1.3 on Nordic competitive advantages above |

| 21  | Nordic opportunities to influence regulatory developments in EU | Key Nordic areas today based on Nordic experience and competence; • Collection and recycling of plastic packaging, incl. EPS • Collection and recycling of agri-plastics, ensilage film, mulch film etc. • Collection and recycling of fishing and fish farming equipment • WEEE sorting and recycling • Identification and sorting technology • Competence hazardous substances and regulations Not yet mature: • Possible collection and recycling of composites (Leisure boats, wind mills) • Possible practical solutions for efficient treatment of waste that might contain substances about these joint limits (WEEE and others) |

<p>| 22  | Key environmental aspects of recycling | See chapter 3.2.1.1 |</p>
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| 23     | Nordic opportunities for increased recycling                         | Good results and best practice in some Nordic countries might inspire other Nordic countries based on a willing to learn from each other, both regarding instruments and solutions (Packaging, fishing equipment, agriculture film, WEEE, recycling stations etc.).

Infrastructure for both separate and central sorting can be developed further in order to increase sorting of recyclable plastics.

New technology on sorting mixed plastics fractions for recycling, inclusive technologies to sort out material containing hazardous substances.

New Nordic ambitions for Green Growth might lead to removal of barriers for increased recycling, e.g. fixing higher ambitions/targets, stimulating recycling by different instruments, incl. EPR. In some cases legislation might also be developed in order to both increase plastics recycling and also safe treatment of hazardous substances (ELV).

New EU ambitions such as the resource efficiency strategy, the required national waste plans as of 2014 and the updated packaging directive in 2014 might also directly and indirectly stimulate plastics recycling in the Nordic region.

Increased ambitions and demand for recycled material from Nordic industry might also stimulate recycling. (See IKEA ambitions in the Nordic Workshop minutes). Increased demand for recycled products both from trade and consumers will boost this development as well. Eco design requirements might help, but much can be done on a voluntary basis (IKEA). |
| 24     | Nordic barriers to increased recycling of plastic waste             | The present low national ambitions on plastic recycling (defined by targets and legislation) is a barrier to increased recycling

Legislation and attitudes (mentality) in the Nordic region, at least in Norway, is often based on a cost/ benefit thinking. This means it has been difficult to promote the idea of new recycling schemes due to start-up costs higher than the income from sales in a new market. Several initiatives from industry have been wasted so far due to lack of willingness from Government.

National long term strategies to develop waste to energy solutions and district heating as part of national energy policies might be regarded as a barrier for increased focus on resources and recycling. In addition diversion from landfill has been a key strategy both related to energy and to climate. Both policies have resulted in a more competitive (mixed-) waste to energy solutions related to recycling and even more so due to both overcapacities and removal of taxes on incineration.

Poor infrastructure and legislation related to sorting of waste before further treatment. Recyclable plastics are thus wasted as fuel. |
Hazardous substances in historical plastic waste might complicate collection, sorting and recycling (e.g. need of special approval for waste treatment). Regulations on treatment of hazardous waste and some grey zones in legislation on how the limits shall be interpreted make industry and waste management companies keep out of recycling of fractions that might partly be contaminated. There are several challenges for fish farming nets, WEEE, ELV, building materials etc.

There are limited volumes generated of each plastic waste fraction beyond packaging. It is a challenge to obtain economies of scale.

There is often a low competence and interest for sorting and recycling of plastic waste not covered by legislation. At least it is difficult to join up the value chain without any support from the Government.

Both companies and recycling stations do not manage to sort their plastic waste properly. Plastic waste is thus often just regarded as part of the mixed waste fraction for incineration.

In the international markets for recycled material regulations on food contact have limited the use of recycled material, but legal framework and systems have made this more possible during the last years, e.g. for PET and HDPE bottle to bottle recycling.

Both for these top quality waste fractions and for other plastics waste the market requires that collectors meet defined quality standards. If quality requirements are not met, this might imply costly consequences. This might be costly when the plastic waste is shipped abroad. Operators have also to meet special requirements from Chinese importers. There are also several barriers regarding trans boarder shipment within Europe, even within Germany.

The Nordic countries have been dominated by stronger and more pro-active industries than the plastics industry; promoting the interest of other competing materials. As the newcomer plastics have been the “one to many” and last waste fraction to be sorted. By dismantling of complex waste products (ELV, WEEE etc.), plastics is often regarded as the tricky fraction with the lowest value and thus not given any priority regarding recycling.

In general the markets for plastic recycling are not mature. The operators are often small, the market is not transparent and the volumes limited. The markets are unstable and there have been several bankruptcies during the last years. At the same time the customers of recycled materials are often larger companies (IKEA, Electrolux) who want huge amounts of recycled material to defined qualities.

The plastic recycling market is characterized by business to business quality
criteria. Common quality criteria and certification is needed in order to stimulate and develop the market further. EuCertplast is a project in the pipeline in order to meet this need.63

| 25 | Possible areas for further projects in order to stimulate recycling of plastic waste in general | Some general ideas as a basis for both the Nordic Workshop and the development for specific project ideas summarized in chapter 5.2: |
|    |                                                                                           | Based on the conclusions from the quantitative survey it is a need for a harmonized and better Nordic statistics for the plastic material streams, inclusive waste management and recycling. This includes also practical and harmonized definitions for different kinds of applications- and waste fractions and treatment, e.g. waste, preparing for reuse, recycling, energy recovery. |
|    |                                                                                           | Developing the competence about plastic recycling in society, especially within the plastics industry, other ”producers” / value chains, waste management industry and education institutions. |
|    |                                                                                           | Developing instruments and measures promoting increased recycling of plastic waste in general and also for specific plastic applications. Plastic waste form households and other municipal sources represent the highest potential. |
|    |                                                                                           | Developing instruments and measures to promote design for recycling, also taking the issue of hazardous substances into consideration. |
|    |                                                                                           | Developing instruments and technologies for practical and efficient sorting solutions related both to increased recycling and the issue of hazardous substances, e.g. sorting solutions at recycling stations and for ELV etc. |
|    |                                                                                           | Develop measures to stimulate the use of recyclate in industry; improve transparence in the market, e.g. by optimizing the value chain. |
|    |                                                                                           | Develop and test out collection systems in order to build up volumes on specific fractions, e.g. leisure boats, fishing equipment etc. |

### 1.2.3 A Quality survey on specific plastic waste fractions

#### 1.2.3.1 Packaging

According to the PlasticsEurope survey Norway and Sweden are ranked among the best in Europe on recycling of plastic packaging collected from households. The two countries, e.g.

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GPN and FTI cooperate on sorting and recycling solutions. The two systems obtain a high share of recycling compared to other nations.

Finland is lagging behind ranked as number 22 in EU27+2. Denmark was ranked as number 29 with 9.3% recycling only. In Finland and Denmark most of the recycled amounts probably are related to PET beverage bottles from the deposit systems. Denmark is however ranked as number one on recycling of plastic packaging from trade and industry (indicating that there might be some statistical error). Iceland also collect plastic packaging as Sweden and Norway.

The different results reflect different legislations and models within the Nordic region. A new packaging decree for Finland is expected soon. While the Norwegian Government has fixed general recycling targets it seems so far that Finland’s new packaging decree will describe more in detail how the plastic packaging shall be collected from the households. New national waste policies and plans are also expected soon both in Denmark, Norway and Sweden. The waste strategies will also comprise packaging waste, inclusive plastics. Both textiles and plastics are regarded as key materials for the Norwegian waste plan in 2013.

As mentioned in the quantitative survey the amounts of plastic packaging waste/capita differ between the Nordic countries. Before fixing % targets, it might be advisable to verify statistics first.

Based on the outcome from the Nordic workshop, there is an interest to join forces in order to develop best practice on both instruments and solutions related to plastic packaging waste within the Nordic area. See project proposal 2.2.1.

1.2.3.2 Plastic waste from households and furniture
Households generate more plastic waste than just plastic packaging, this includes:

- Housewares
- Furniture, inclusive mattresses and carpets and garden furniture
- Sport equipment and leisure
- Toys without WEEE
- WEEE (incl. some toys) - see separate chapter
- ELV - see separate chapter
- Leisure boats - see separate chapter
- Building materials - see separate chapter

As European relevant legislation for recycling is related to products rather than materials, the abovementioned plastic waste fractions either belong to different take-back systems (such as WEEE and ELV) or in some cases still are regarded as residual waste without any obligations or systems in place (Toys, carpets etc.).

In order to capture more plastic waste from households and from other municipal waste sources Germany has developed its packaging waste system, the yellow bin, also to include other “packaging-like” products. The system is called “Wertstofftonne” (= bin for
recyclables) comprising plastic and metal waste and beverage cartons. A national solution by law is still in the pipeline. However several cities have already developed their own “Wertstofftonne”. On a federal level the Germans have not managed to agree on how to define the roles and responsibilities related to this extended solution; the role of the municipalities vs. the private operators. Financing of the extended system is also a topic in discussion; so far the municipalities pay the marginal extra costs for including non-packaging products.

However the systems implemented are working and more plastic waste is collected and recycled together with the plastic packaging, utilizing a well-functioning infrastructure developed during the last 20 years. In order to obtain economy of scale the “Wertstofftonne” could be a relevant solution also for the Nordic region, both for households as for other municipal solid waste sources (small shops, cafés, offices etc.). In Eskilstuna in Sweden such a concept has been studied already. See project proposal 2.2.1.

The above mentioned kerb side system might capture smaller waste items, the Germans often limit the since to A4. Several plastic waste products are thus due their size not suited for kerb side collection systems. Instead larger plastic products are delivered at recycling stations. However the plastic waste delivered at such stations today are often ending up in the containers for energy recovery. In this way plastic resources are wasted due to poor service at these recycling stations.

Stockholm City in cooperation with the sorter and recycler Swerec has tested out better solutions in order to sort out recyclable rigid plastics for recycling. According to the Mepex report for Klif, good results are obtained thanks to better sorting instructions and guiding based on a close cooperation along the value chain. By targeting concrete products it is easier to sort out products for recycling vs. products for energy recovery and hazardous waste. More focus on recycling and hazardous goes hand in hand. Regarding financing, FTI gives financial support to plastic packaging waste sorted out. See project proposal 2.2.3.

In a similar way Green Dot Norway tests better sorting solutions together with the municipalities in the Mjøsa area. Other countries, e.g. Germany are also doing the same in order to improve the service to the citizens, increase the recycling of plastics (focusing on PE and PP) and find proper solutions for other plastic waste that might be difficult to recycle, partly due to their content of hazardous substances. 64 65

Also private companies have taken initiatives in order to increase recycling of plastic products from households. IKEA, together with WWF tested out collection of plastics at some warehouses. The service was very much appreciated by customers and a lot of plastic products of good quality for recycling were delivered, e.g. a huge amount of plastic furniture. 66 See also Minutes from the Nordic Work shop in attachment, chapter 5.3.

Regarding matrasses take-back schemes have been discussed, e.g. in California. 67 Solutions for carpets are in operation in both California and in Europe, but probably

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directed towards industrial clients, hotels etc. rather than households. The nylon fibers used in carpets might be recycled back to yarns and used in new carpets. The bitumen backing can be recycled into applications such as roofing and road surfaces. PP fibers from carpets are also possible to recycle into plant pots and buckets.\textsuperscript{68, 69}

Referring to the quantitative survey, households, incl. plastic packaging, represent the largest potential for increased recycling. Based on the fact that some Nordic countries have an infrastructure for plastic packaging, it is interesting to assess the opportunities for expanding these systems to comprise defined other plastic applications from households. Efficient solutions for households might also comprise other municipal sources as small shops and offices etc. generating very much the same kinds of plastic waste as households. Small shops and offices are also often situated along the municipal collection routes, even in the same buildings.

Existing waste regulations often assume different responsibilities and roles for households and the commercial sector. This might be regarded as a barrier for the proposed holistic solution comprising both sectors. On the other hand there are good environmental and economic reasons to elaborate on new holistic solutions in order to exploit the potentials for increased recycling in the most efficient way.

Copenhagen has won the European Green capital Award for 2014.\textsuperscript{70} This might be seen as an opportunity for Copenhagen, Denmark and the Nordic region, also regarding the issue of waste management solutions in general and for exploiting the huge potentials for increased collection and recycling of plastic waste in Copenhagen and in the rest of the Nordic region.

\subsection{1.2.3.3 Building, construction and demolition waste}

Within the field of building, construction and demolition waste, there are several relevant activities going on in the Nordic region, most of them are related to the issue of hazardous substances;

- Based on several controls concluding that recycling stations have poor routines related to sorting and disposal of building material waste with hazardous substances, Avfall Norge published a guideline for handling of such waste that might contain hazardous substances in September 2013.\textsuperscript{71}

- Norwegian Protan together with other PVC producers participate in the European scheme Roofcollect in order to develop recycling solutions for thermoplastic membranes. This initiative is again a part of the European PVC Industry initiative VinylPlus. VinylPlus cooperates closely with the Swedish Natural Step. The PVC industry has for several years also developed a European take back system for rigid PVC waste, Recovinyl, mostly PVC

\begin{itemize}
\item \textsuperscript{68} http://calpsc.org/products/carpet
\item \textsuperscript{69} http://www.carpetrecyclinguk.com/index.php
\item \textsuperscript{70} http://ec.europa.eu/environment/europeangreencapital/winning-cities/index.html
\item \textsuperscript{71} http://www.avfallnorge.no/nyheter1.cfm?pArticleId=25827&STARTROW=1
window frames. Nordic countries are so far not part of this scheme. The PVC industry has also developed recycling solution for other PVC waste.  

- According to Swedish Plast och Kemiföretagen a project focusing on concrete cases of plastic waste from building and demolition has been proposed this year together with the PVC Industry and IVL. However the project was not approved by Vinnova. A broader Swedish group of organizations are about to establish a similar project, but financing is not yet approved.

- The Finnish Environmental Institute, SYKE, is participating in a study where, among other things, a survey is done on the hazardous substances found in construction and demolition waste. No information available so far.

- The waste management industry also develops better solutions including better sorting at the building sites. SITA in Sweden promoted 100% sorting solutions towards construction companies in October 2012. The new system includes also prevention measures in order to reduce the amounts of waste generated. Last but not least the solution (SITA Miljöcirkeln® Bygg) offers personal guidance at the construction site.

- Both the Mepex report for Klif and the IVL report conclude that more has to be done in order to increase the knowledge about hazardous substances in the plastic waste within this sector. Furthermore Mepex argued that new instruments have to be seen as part of general regulations on building, construction and demolition waste. The implementation of the Waste framework directive with its 70% recycling target is an opportunity to give the plastic waste more attention in order to stimulate recycling and at the same time take the issue of hazardous substances into consideration.

The Nordic region is a substantial producer of PVC resins and different PVC building materials. The PVC industry even cooperated with the Swedish natural Step. Developing better solutions for PVC waste could thus be a good basis for strengthening a Nordic competitive edge. The same can be the case for other building materials, such as EPS-insulation, PUR products and PE pipes. In addition the development of renewable and recyclable materials and plasticizers might be an area where the Nordic countries can develop an advantage. The PVC-, pipe-, composite-, PUR- industry and other national plastic industry organizations are cooperating both on a Nordic and on a European level. A Nordic approach on waste issues was also appreciated by the plastics industry representatives at the Nordic workshop.

1.2.3.4 ELV

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72 http://www.vinylplus.eu/
73 http://www.sita.se/tjanster/Helhetslosning/Miljocirkeln-bygg/
74 Vad vet vi om faliga ämnem vid materialåtervinning av plast? Naturvårdsverket/ IVL Svenska Miljöinstitutet 2012
In 1965 a car contained about 2% plastics: today the share is about 18%. New cars contain from 90 to 200 kg plastics. The amount of PP is 47 to 77 kg, PUR 12 to 29 kg, followed by Polyamide, PE and PVC. According to the quantitative survey recycling of ELV plastics is still at a very low level.  

According to a Bellona and Mepex report in 2009, at least 50% of the plastics in a car can be dismantled and recycled. 

PP is the main type of plastic used in cars today; probably more composites will be used in the future. Composites replacing metal in aircrafts and cars reduce the weight and thus the fuels consumption. However composites today are far more difficult to recycle than other plastics used in ELV. See chapter 3.2.3.7 on composites below. 

Hazardous substances are found in several car parts, incl. electronic equipment; ELV can be regarded as “WEEE on wheels”, but without the strict WEEE restrictions by law! Based on a test of 90 cars Klif concluded in a recent report that a car consists of 3 to 4 kg of circuit cards, containing different hazardous substances. In addition 20 to 30% of the cars have high values of the flame retardant dekaBDE from the seats in the cars, especially Asiatic cars before 2005 models. As these car parts are not removed today there are reasons to look into the dismantling routines concludes Klif. 

IVL in Sweden published a pre study in September 2012 on dismantling of ELV in Sweden. The objective was to elaborate on how the recycling industry can develop efficient dismantling routines in order to meet the EU 85%+10% recycling and recovery targets of 2015. The conclusion was that increased recycling of plastics might help to meet the recovery target. However dismantling will be costly, but costs can be reduced by use of technology rather than manual dismantling. 

Most international ELV initiatives seem to focus on SRF (shredder light fraction). This means solutions whereby plastic parts are not dismantled separately but grinded with all other materials. The SRF is normally energy recovered or landfilled. 

The Mepex report for Klif assesses different solutions in order both to increase recycling and also secure safer treatment of all hazardous substances. Proper dismantling of the cars can meet both requirements. Based on new instruments related to hazardous substances in the vehicles such solutions might even give a net benefit for society. 

A Swedish project “Ekoeffektivt plastkretslopp genom hållbar återvinning av konstruktionsplaster” focuses on barriers for recycling of plastics from WEEE and ELV in order to close the loop. The project is managed by KTH and IVL. Several industrial partners and organizations take part in this project financed by Formas for the period 2009-2012. 

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75 www.autovinyl.com
76 Bilens indre –materialbruk og miljøgifter, Bellona og Mepex Consult 2009
77 http://www.klif.no/no/Aktuelt/Nyheter/2012/April-2012/Vurderer-strengere-miljokrav-til-bilvrak/
78 Utvärdering av förandrad demontering och återvinning av uttjänte fordon i Sverige, IVL,Förstudie, 2012
79 http://eqp-projekt.se
In Germany new technologies are used in order to recycle more of the ELV plastic waste. One example is the recycling of bumpers (PP). By use of advanced technologies it is possible to clean the bumpers and recycle the plastic waste. A challenge for Germany, and partly also for the Nordic region, is that many used cars are exported and end up as ELV in other countries.

In Poland processing possibilities of selected waste from electronics and cars in the rotational molding technology have been studied. From the tested plastic waste material the most suitable for use in rotational molding technology was polyethylene (PE), then the polyamide (PA) and polypropylene (PP) and finally a copolymer of acrylonitrile-butadiene-styrene (ABS) and high impact polystyrene (HIPS).

1.2.3.5 WEEE
Referring to the chapter on hazardous substances, much of the focus on hazardous substances has so far been related to WEEE and brominated flame retardants. Thus the professional operators and systems within WEEE have obtained a good competence. There is however still a potential for better knowledge on hazardous substances along the EEE value chain. See project proposal 2.2.2.

WEEE is one the fastest growing waste streams and its systematic collection and proper treatment are both preconditions for recycling of all kinds of materials in such applications. BIR expects that the amount of WEEE collected will represent a fivefold increase to 10 Mt in 2019.

The new EU WEEE Directive entering into force in 2012 will improve collection and treatment of WEEE in Europa. So far the Nordic region seems to be a head of most other member states in the field of WEEE and the collection results/capita are much better than the EU average. Further Nordic initiatives can strengthen this competitive advantage.

There are several recent Nordic initiatives taken in the field related to plastics recycling of WEEE and the issue of hazardous substances:

- SMED on behalf of Naturvårdsverket finalized in 2012 a report assessing the WEEE waste streams, focusing on consumer related waste streams. The report is meant as a general follow up tool, incl. indicators, for the Government on the EPR systems.

- A Swedish project “Ekoeffektivt plastkretslopp genom hållbar återvinning av konstruktionsplaster” focuses on barriers for recycling of plastics from WEEE and ELV in

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80 From bumpers to bumpers, Identiplast 2012 presentation, Warsaw, Lillian Wolny, WIPAG
81 Analysis of processing possibilities of selected waste from WEEE and ELV in rotational molding technology Identiplast 2012, Warsawa; Paper and presentation, Dr.Eng. Marek Szostak, Poznan University of Technology
82 Identifying opportunities across the PE and PP value chains, presentation by Surendra Borad, BIR, 15.05.12, Brussels
83 Kartläggning av flöden och upplagrade mängder av elektriska och elektroniska produkter I Sverige 2010, SMED for Naturvårdverket, 2012
order to close the loop. The project is managed by KTH and IVL. Several industrial partners and organizations take part in this project financed by Formas for the period 2009-2012.  

- SWEREA IVF, a Swedish research institute, coordinates a long-term cable recycling program with partners from the whole cable value chain. According to a recent paper the project conclude that plastic waste can be sorted into a light polyolefin fraction and a heavier PVC fraction. The polyolefin fraction is made as a fuel while the PVC fraction is suited for mechanical recycling.

Like in the above mentioned Nordic WEEE projects the European industry is also active in order to develop knowledge and better solutions on a European level: The European Flame Retardant Association (EFRA) initiated in 2011 a full-scale recycling project on flame retardant plastics from post-consumer flat television sets. The consortium consists of television set and monitor manufacturers, plastic and flame retardant manufacturers, waste management operators and recyclers. The project is carried out in close cooperation with REWARD, a 3 year project in the EcoInnovation program and funded by the EU commission. The objective is to check the industrial feasibility of recycling of plastics largely used in electronics mainly in Flat Panel Displays (including LCDs). The joint EFRA recycle study with REWARD describes the plastics composition, different techniques of identification, size reduction and separation. These starting points can be used; they provide guidance on how to achieve the desired plastic quality, and where these requirements will take into account the miscibility limitations of the different plastics.

WRAP made a report in 2009 on separation of mixed WEEE plastics giving an overview of existing techniques and a list of viable solutions. In UK the WEEE plastics recyclers have joined forces in a working group as part of the British Plastics Federation Recycling group.

Stena Technoworld is one of the leading Nordic companies within the WEEE sector operating in all Nordic countries. See minutes from the Nordic Workshop attached, chapter 5.3.3.

1.2.3.6 Plastic waste from the agriculture sector
Norway and Iceland have established well-functioning systems for recycling of ensilage film as part of their packaging waste systems. Sweden has also a take back scheme, Swepretur, a separate operation to the packaging system FTI. Finland has also a system, operated by EKOKEM, but the collected plastic waste is energy recovered rather than recycled.

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84 [http://eqp-projekt.se](http://eqp-projekt.se)
85 New technology for recycling of plastic from cable waste, Vinnova project 2010-2013, Jicable Conference paper, Paris 2011, Annika Boss
86 Recycling of plastics containing flame retardants in electronic waste, a technical and environmental challenge for a sustainable solution, Identiplast 2012 Paper, Warsaw; Lein Tange, ICL-IP Europe, representing EFRA
87 Separation of mixed WEEE plastics, WRAP report, 2009
Also Spain, France and Germany have recycling schemes for ensilage film and pesticide containers and even agro-textiles. Other countries have not yet managed to develop efficient national schemes for agriculture -plastics. Therefor EU has discussed to develop European instruments in order to increase recycling of all the agriculture –plastics in Europe. The EU Commission green paper expected in February 2013 might include some initiatives in order to boost recycling in this field too. The ensilage film (PELLD)is well suited for recycling.

The Nordic countries have a competitive advantage in this field, but most of the collected agriculture film is now exported for recycling in other countries. The leading film recycler in Norway went bankrupt on 19th November 2012, however new owners have started up again.

1.2.3.7 Leisure boats and other composites
Composites are materials which are used in products like airplanes where low weight and high strength are to be combined. Composites consist of reinforced material, usually glass fibers and of plastic matrix which works as adhesive.

Based on experience and available reports, plastic leisure boats (boats up to 24 feet) last for many years. However, sooner or later, even plastic boats are discarded. In Norway there are 1 million leisure boats; most of them are made of plastics, e.g. composites (GRP, glass reinforced plastics). According to a Mepex report commissioned by Klif in 2009, it is expected that the plastic waste from leisure boats will increase significantly in the next 10 years. The report also concludes that recycling of leisure boats have to take the issue of hazardous substances into consideration.  

Even though marine littering is on the top of the agenda, there is no EU focus on discarded leisure boats. However The Nordic Council of Ministers has initiated a project in order to assess the opportunities for collection and recovery of leisure boats. A Nordic workshop on the situation today in the Nordic countries and coming challenges will be organized in Stockholm on 3rd December 2012. As almost half of the European leisure boats are found in the Nordic countries, the Nordic region has a good reason to be proactive in this field.

In Finland the company Kuusakoski has some years of experience from collection, dismantling, recycling and recovery of end of life leisure boats.

In Norway SINTEF, the composite industry, the leisure boats organization NORBOAT and the waste management industry have joined forces in order to develop recycling technologies for composites from discarded leisure boats. The project has developed technologies in order to separate the resins and the glass fiber used in the composite material. This means that both components can be used again as raw materials.

89 Kartlegging av miljøproblemer. Vurdering av Tiltak og virkemidler, utrangerte fritidsbåter, Mepex Consult for SFT (Klif), 2008
The project was financed by The Research Council of Norway. 92

About 1 Mt of composites is consumed yearly in Europe, of which only 7 % is used in leisure boats. According to the Composites industry composites are used in several applications in Europe: 93

- Aerospace, automotive (transport), 14%
- Building materials, incl. wind energy, wind turbine blades 36%
- Electric and electronic products, 14%
- Containers (incl. reuse containers for gas) and pipes (35% share in Norway)
- Leisure boats, 7%
- Offshore industry/ Marine (25-35% share in Norway)
- Industrial
- Sport (ski etc.), 7%

Products, like aircrafts have a long life, thus we might regard composites as the waste stream of the future; Wind turbine blades have an average life of 20 years. According to industry the generated waste so far amounts to 10-15 % of what is produced. In Denmark the annual waste is according to the GenVind project estimated to 7Kt. In the long run the composite waste obviously will increase.

Composites are complex materials and applications are often also mixed with other plastics and other materials. More research is needed both for recycling technology and for developing markets for recycled materials. EPR has been discussed as an instrument in order to boost the development wind turbine blades. 94

The Norwegian Composite industry (NKF) has taken part in GjenComp, a Norwegian project for increased recycling of composite waste.

In Denmark GenVind is working on technological solutions for composites from wind energy. The objective is to develop technologies for recycling and develop a market for the recycled material. The total budget amounts to DKK 43, 5 million and supported by The Danish Agency for Science, Technology and Innovation. The project was presented at the Nordic Workshop, see minutes attached in chapter 5.3.3.

Denmark is a leader within wind energy solutions. The Nordic countries have an active composites industry and also long traditions within production of leisure boats. Developing better solutions for recycling and recovery of composites can give a Nordic competitive advantage for these sectors. As composites are expected to be increasingly used in cars and as building materials, composites recycling technology will have a strategic importance.

1.2.3.8 Fishing equipment

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93 GRP - Production in Europe, 2007-2010, Norsk Komposittforbund, 2012
94 R. Cherrington, 2012, Producer responsibility: Defining the incentive for recycling composite wind turbine blades in Europe
Compared to other regions, fishing and fish farming are major industries in the Nordic countries. Export of fish is important to the economy of both Norway and Iceland. Clean water and high standards related to health, safety and environment are important issues for the competitiveness of the fishing industry.

Marine littering is threats to fisheries. Organized collection of discarded fishing- and fish farming equipment might be part of the solution to reduce marine littering. Such equipment comprises fishing gears (nets, trawls etc.), ropes and cages and feeding pipes from fish farming.

In Iceland a take back system for fishing gears has been in operation for some years. Based on an agreement in 2005, LÍÚ – Federation of Icelandic Fishing Vessel Owner is operating receiving stations and is also responsible for the recovery of all nets delivered. The recycling target was increased step by step up to 60% in 2007. The waste amount is estimated to 1,1Kt. The Icelandic recycling scheme was presented at the Nordic Workshop, more information can be found in the minutes attached this report, chapter 5.3.3.

In Norway several initiatives have been taken by the fishing and fish farming industry, surveys have been made and a voluntary EPR system for fish farming equipment (mostly plastics) has been elaborated. The experience so far is that such a system is difficult to develop without any agreement or other instruments from the Government. Furthermore a cooperation between industry and the Government is needed due to the issue of hazardous substances, e.g. in the fish farming nets.95

A key driver behind a take back system for the fish farming industry was a strict requirement from major salmon customers in the UK; e.g. a requirement related to documented waste management routines, incl. recycling.96 This indicates that a recycling solution gives a competitive advantage, may be even a future precondition for business!

The fish and fish farming industry in Norway generates about 15Kt of plastic waste from discarded equipment, of which the cages contributes with almost 50%, ropes and nets with about 20 % each. In 2011 about 20 % of this waste was recycled. A realistic recycling rate is estimated to about 50 % for 2020.97

The Danish fishing industry and some of the harbors have found solutions for discarded fishing equipment. A limited number of harbors make it easier to organize take back schemes, especially when financing can be included in the harbor fee system.

Both as part of an overall recycling strategy and a marine littering initiative, a joint Nordic initiative could promote best practice on both solutions and instruments. Joint Nordic efforts can also be a basis for an efficient infrastructure for recycling activities within the region and a well-functioning market for used equipment.

95 www.kystertur.no
96 Innsamling og gjenvinning av utrangert utstyr fra oppdrettsnæringen, Mepex for AquARENA 2009
97 Økt utnyttelse av ressursene i plastavfall, Mepex Consult for Klif, 2012
Fish farming cages (rings) are made from PEHD by Nordic pipe producers. New take back solutions can thus comprise all pipes in addition to the fish farming rings in order to obtain economies of scale. As regards recycling of ropes (often PP) a take back system could in the same way comprise discarded ropes from other sources, such as other marine and offshore activities.

1.2.4 Plastic waste from other sectors
Plast och Kemiföretagen in Sweden is involved in a project focusing on plastic waste from hospitals.

In the USA the Healthcare Plastics Recycling Council (HPRC), in partnership with Stanford University Medical Center, conducted a six-month pilot study to develop a better understanding of plastic waste characterization within healthcare facility.98

The sport industry is another industry where such a study could be relevant; Plastic is used as material to make artificial grass for football and ski jumping, chair and roofing of arenas, various equipment and clothing. The London Olympics procurement experience might give further inspiration.

These projects and ideas illustrate that industry specific studies are needed to close the plastic loop, industry by industry

1.3 Summary of the plastic waste surveys
The surveys show several opportunities for more recycling of plastic waste. Furthermore it is underlined that increased focus on recycling might lead to more attention on hazardous substances. In this way optimized waste management solutions can be obtained, e.g. taking both the issue of resources as hazardous substances into consideration. Proper sorting for recycling might imply a proper sorting also on hazardous substances.

There are several plastic waste streams and the amounts of plastic waste in each stream are limited in the Nordic region. It might therefore be a challenge to develop efficient recycling solutions and a well-functioning recycling market in each country. A Nordic approach might therefore stimulate the development of a Nordic market with economy of scale and more competition.

In the short run, both the quantitative and qualitative surveys conclude that there are potentials for increased recycling of plastic packaging and other used products from households and other municipal waste sources. In addition the results achieved within WEEE can be further improved in the short run. Based on existing solutions and infrastructure significant increases can be made within a few years for these waste fractions. Use of new technology recycling can be further increased. Based on the Icelandic experiences, much can be done within fishing- and fish farming equipment in the short run too.

98 Plastics Recycling Update Newsletter, 30.11.12
In the long run the potential for increased recycling is related to long-lived products. We might call it the plastic waste of the future. In these fields today both recycling results and competence on hazardous substances are poor. More efforts have to be made in order to develop competence, technologies, solutions and instruments. In many cases hazardous substances is a key issue. The building/construction and demolition sector has the highest potential for increased recycling. In addition there is a growing potential also for ELV, furniture, leisure boats, wind energy plants and other composite waste. In order to develop Nordic competitive advantages it is important that the Nordic countries are proactive also related to these long-lived products.

2 Textile survey

2.1 A quantitative survey on textile waste

2.1.1 Eurostat waste statistics
The member states of EU (together with the EFTA countries) are obliged to report waste statistics to Eurostat according to the waste statistic regulation (EC No 2150/2002). The obligation includes specified figures of generation and treatment of textile waste. Despite this, Eurostat or other EU bodies like EEA or equivalent) have not published figures of textile waste in the member states as long as we can uncover.

2.1.2 National waste statistics
Many national statistical offices or pollution authorities have released waste statistics on textiles. Although we have not made any compilation of figures from different countries we still have an impression that these figures are covering different part of the total textile amount and they are not easily comparable country by country.

2.1.3 Other surveys and statistics
Beside the official statistics there are conducted several reports and statistics by different organizations. Most of these studies are concentrating on describing or developing the collection, reuse and recycling, while the statistics are more or less made as a necessary background.

We will not go in detail in presenting all the different work done on textile collection and recycling. Nevertheless, we particularly emphasize the work done in the UK by Defra (Department for Environment, Food and Rural Affairs) and cooperating organizations in the program "Sustainable Clothing Roadmap". Since 2007, this program has carried out a targeted effort to identify challenges, engage stakeholders and develop actions and implementations.

2.1.4 Selected Nordic surveys

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Nordic Council of Ministers (NCM) has commissioned a comprehensive report\textsuperscript{100} describing the material flow of textile waste in three Nordic countries (Finland, Sweden and Denmark). The report also discusses policy measures to prevent textile waste. The following summary points are highlighted in the summary:

- Half of the textile products purchased by consumers are discarded as waste
- Textile consumption has been increasing
- Charity organizations are dominating the textile collection
- The estimated quantity of second-hand products is based on many assumptions
- There are gaps between the total amount of textile used and the total amounts discarded and exported
- The mass flow of textiles within the use phase (institutional vs. private users) is not well known
- Very limited recycling of fabric for other purposes takes place
- Textile recycling industry has faded away in the Nordic region
- The flow of exported second-hand textile products is not well known

The report also describes and discusses policy measures to prevent textile waste and enhance recycling and reuse of textiles. Extended producer responsibility (EPR) is given a thorough description in the report.

SMED (Swedish Environmental Emission Data) made a report\textsuperscript{101} in 2011 describing the amounts of textile waste in Sweden. The calculation method (and figures for Sweden) from this report is reused in the NCM report from 2012.

Swedish Environmental Research Institute (IVL) made a report\textsuperscript{102} in 2011 considering alternative policies and measures for “Improved waste management of textiles”. The report gives a comprehensive description of environmental challenges and recommendations for improvements in different stages in the material chain.

The Norwegian Climate and Pollution Agency commissioned a report in 2012, “Increased recycling of textile waste and other waste types” performed by the Norwegian National Institute for Consumer Research. The report gives a detailed description of the textile waste amounts in Norway, how it is handled, environmental impact, recycling technology and evaluation of policy instruments.

In Denmark the Innovation network for Environmental Technology performed a study\textsuperscript{103} in 2012 on “Gaps in Recycling Technologies”. The report describes 13 different challenges and recommends several projects for improvements.

\textsuperscript{102} D. Palm 2011. Improved waste management of textiles. IVL Report B1976
\textsuperscript{103} 2012. N. H. Kløverpris og M. Strandesen. Gaps i genanvendelsesprosesser. Innovationsnetværk for Miljøteknologi.
2.1.5 Textile amounts - compiled figures for the Nordic countries

2.1.5.1 Supply of textile products

Presented at the Nordic workshop Mepex has compiled figures of textiles supplied to the market in the Nordic countries. For Finland, Sweden and Denmark the figures are based on the calculations in Tojo et.al. 2012. For Norway and the other Nordic countries the figures are calculated by Mepex with the method used by Tojo et.al. (same method as Carlsson et.al. 2011).

A significant limitation in the calculations of Tojo and Carlsson is that they only include clothes and home textiles. Shoes, leather products, industrial fabrics etc. are not included. There are indications\textsuperscript{104} that clothes constitute for only 50 \% of the total amount of textile waste. The German textile waste management organization reports total textile waste of 28kg/ capita. To meet this deficiency Mepex has extended the calculations to include some extra groups, first in the Norwegian figures and then extended to the Nordic countries by up scaling based on population.

![Figure 9 Annual supply of textiles in Nordic countries, 2010. Furniture and industrial textiles are not included](image)

The calculations indicate that the total supply of textiles, excluding furniture and industrial textiles, are 600 000 tons in the Nordic countries. Clothes and home textiles account for about 65 \%, footwear 18\%, carpets 13 \% and sports and leisure equipment 4 \%. These amounts equivalent about 23 kg per capita, of which 15 kg are clothes and home textiles, 4 kg footwear, 3 kg carpets and 1 kg sports and leisure equipment. Regarding carpets see more information in the plastic survey in chapter 3.2.3.2 as carpets also contains plastics and/or synthetic fibers.

Taking a closer look at the different countries the figures are restricted only to clothes and home textiles calculated by the method described by Carlsson et.al. The figures show 131 830 tons in Sweden, followed by 89 034 tons in Denmark, 88 566 tons in Norway and 70 210 tons in Finland. The amount of clothes and home textiles in the other Nordic

countries and areas (Iceland, Greenland, Faroe Islands and Åland) are calculated to 6,862 tons.

Figure 10 Annual supply of clothes and home textiles, 2010. Tons

Converting the figures to kg per capita gives some differences between the countries. Norway shows the highest amount (17.67 kg) followed by Denmark (15.95 kg), Sweden (13.90 kg) and Finland (13.07 kg).

2.1.5.2 Waste amounts and treatment

The waste volume\(^{105}\) of textiles is not identical to the quantity supplied to the market. The reason for that can be that the products mostly have a period of use longer than one year. It can also be explained by the fact that clothes are stored after use, reduced in weight by wear etc. We have no basis to say anything definite about the relationship between supply amount and waste amount beyond general considerations that indicates that the supply amount probably is higher than the amount of waste. As far as we know there are no thorough studies of these relationships. In the calculations of Tojo and Carlsson the discrepancy between supply and waste amount is described as “unknown”, “accumulation” or “sources of error and uncertainty”. In this report we call it “unknown/storage”.

\(^{105}\) See attachment, chapter 5.1 about definitions of waste, “waste” in this report includes textiles collected for reuse
Figure 11 Treatment of waste of clothes and home textiles in Nordic countries, 2010. Tons

Figure 11 shows that about half (53 %) of the textile waste in Nordic countries is sent to landfill or waste incineration, quart (24 %) of it goes to unknown treatment or storage and the rest is either exported for reuse (17 %), reused in the origin country (4 %) or sent to material recycling (2 %). Compared with most other waste materials the material recycling is very low for textile waste while reuse is higher than for most other kinds of waste materials.

Figure 12 Treatment of waste of clothes and home textiles in different Nordic countries, 2010

Taking a closer look at the differences between the Nordic countries it appears that Finland is a bit different from the other nations. Both material recycling and domestic reuse are higher while export for reuse is lower. It is also worth noting that the discrepancy between supplied amount of textiles and waste amount is low, therefore the “unknown/storage is low in Finland.
2.2 A qualitative survey on textile waste

Attachment, chapter 5.1 contains relevant definitions according to the Guidelines of the EU Waste Framework Directive comprising waste, reuse, preparing for reuse and recycling. The question whether collected textiles are waste or not is discussed in these attached Guidelines.

Also in the attachment there are description of textiles, uses of textiles, sources and types of textiles and textile recycling.

Last but not least the attachment also comprises a chapter discussing the links between plastics and textiles.

2.2.1 Textile recycling – challenges, technology and possible solutions.

2.2.1.1 Collection for reuse

The collection of textiles in the Nordic region is usually organized by placing containers in municipal recycling centers, nearby shops etc. In Finland some municipalities set up collection containers for textiles, but the main entity engaged in collection is charity organizations, organizations focusing on reuse rather than recycling. Door to door collection is very limited in all Nordic countries. Studies show that the collection is mainly aimed at private households. Collection of industrial textiles and clothing and textiles from other industries is very limited.

In all the Nordic countries charity organizations are the main collectors of textiles. Some few charity organizations (Salvation Army, Red Cross, Humana/UFF) are operating in all the Nordic countries. These operators collect a large proportion of the total amount. There are also a large number of smaller organizations, some of them covering entire countries and some collecting in restricted areas. In addition to charitable organizations also some private actors and in some cases municipal waste companies are involved in collection. One must also be aware that there are some collection in the grey/black market doing door to door collection in some cases combined by thefts (from organized collection).

There has been growing interest among private consumers to reuse clothes not only via charity organizations, but increasingly via venues such as Internet and flea markets, without intermediate actors. It is also worth to emphasize that internal reuse in families, by gifts to friends etc. is very common in all Nordic countries, and probably constitute the most important form of reuse when it comes to volume. However, this is not included in the figures presented in this report.

2.2.1.2 Sorting for reuse\textsuperscript{106, 101}

Clothes collected for reuse need basically to undergo sorting before they can be reused. In most cases sorting takes place in centralized sorting centers. These are designed for manual sorting in an appropriate manner. Automated sorting with NIR or similar technology does not occur in the region. Most of the sorting plants are owned and operated by charity

\textsuperscript{106} Humana, personal information collected by Mepex Consult in visit to Humana sorting plants in Bulgaria and Lithuania, 2012.
organizations. There are also some private owned sorting plants. Many sorting plants are situated in the Nordic countries, but a large amount of the collected textiles are sent to sorting plants outside the region, mostly to Baltic and other Eastern European countries.

There is an international market for used clothes, both unsorted and sorted. A significant proportion of the collected Nordic clothes is sold in these markets, either as unsorted to other sorting plants or sorted for sale in second hand shops etc.

It is the use of the clothes, for example winter underwear, that determine what qualities are being sorted. It is not unusual that the best and most attractive clothes are sorted out for sale in second hand shops operated by the charity organizations in the Nordic countries. Beyond this there are special qualities for sale in the Baltic and Eastern European countries, Asian countries and African countries. Most sorting plants also sort out qualities for material recycling, but the low prices obtained in these markets compared to the prices in the reuse market is an initiative to maximize reuse. A small amount of the collected clothes is not usable for either reuse or material recycling and therefore sent to waste treatment plants.

2.2.1.3 Technology for material recycling
There is some tradition of material recycling industry in the Nordic countries, but over the last year most of it has faded away. Most of the industry was small scale, but an example of rather large scale textile recycling is Stena Recycling factory in Almhult, closed for more than 15 years ago. The factory was sorting textiles made from natural fibers (cotton and wool) which, at its peak time, employed 200 people. The company sold both the yarn made from recycled fibers, as well as fabrics as insulation materials, etc. Another example is the Norwegian company ULTIMAT that developed a technology for making building insulation out of shoddy. A factory was built but went bankrupt in 2006 after a short period of operation. See minutes of ULTIMAT presentation at the Nordic Workshop in attachment, chapter 5.3.

Recycling of textiles can be made through mechanical or chemical processes. This means that textiles that are unfit for reuse can be recycled by a range of different technologies. Crude ways involve cutting fabrics into rags for use as e.g. wipes. However, textile material can also be shredded for use in other types of products such as bedding flock, insulation or paper, or go through further processing be recycled into new fibers.

There are many examples on highly technological recycling for textile waste:
- The Japanese company Teijin Fiber has a process where they claim the ability to recycle polyester into virgin quality (Carlsson et.al. 2011).
- An EU funded project, Textiles4Textiles has been launched to develop and test a machine that can sort textile waste automatically (using Near Infra-Red Spectroscopy) into fractions based on fiber composition and color (Textiles4Textiles, 2011).
- The Swedish company Re:newcell\textsuperscript{107} has developed a technology for the regeneration of textile fibers from cotton and viscose. They are now constructing a pilot plant to test out the technology in industrial scale.

\textsuperscript{107} http://renewcell.se
2.2.2 Environmental impacts of material recycling of textiles

(The information is mainly taken from the report “Sifo 2012. Increased recycling of textile waste and other waste types. Report to Klif”)

2.2.2.1 Life cycle assessments
Production of natural fabrics like cotton consumes large amounts of water during the cultivation, whereas synthetic materials use large amounts of energy in the production of fibers from oil. Greenhouse gas emissions occur at all stages of the life cycle of textiles. The dominant greenhouse gas emissions stem from energy use and CO₂, CH₄ and N₂O from cotton production.

The largest proportion of hazardous emissions during the life cycle of textiles is caused by the use of pesticides and chemicals in the manufacture of fiber raw materials and textile production. This applies particularly to the use of pesticides in the production of cotton. Contamination of soil by production can lead to deforestation, soil erosion, and water pollution, and can affect the flora and fauna drastically. Biodiversity is affected by the use of pesticides.

There are major differences in the results of the environmental impact of different treatment methods for textile waste. Most LCA studies on textiles have focused on the environmental consequences of the substitution effect, energy use and greenhouse gas emissions. The greatest environmental benefits are at increased lifetime and reuse, which reduces the use of virgin materials. In addition benefits are obtained by reduced energy consumption and greenhouse gas emissions in the production of new textiles.

Incorporation with energy recovery reduces approximately 2-6% of the total energy consumption of textiles lifetime. There is insufficient information about the reductions for recycling, but it is estimated that reuse reduces approximately 20-60% of total energy consumption over the life cycle of textiles. When recycled textiles replace paper wipes the reduction is somewhat lower.

Recycling provides a reduction of between -1200 and -1800 kg CO₂ equivalents per tonne of textile waste, where a portion of the reduction comes from the replacement of a new production of textiles or other materials like paper. Reduction by incineration with energy recovery is much lower than material recycling. The results on the energy recovery vary, and some studies show positive and others negative contribution, especially depending on the fabric is made of natural or synthetic fibers.

2.2.2.2 Hazardous substances in textile waste
Textiles are treated by a variety of chemicals during production to achieve special properties. It may relate to fiber production, dyeing, durability, anti-wrinkle, waterproofing and fire retardants, etc. There may also be residual chemicals from the production of fibers such as pesticides or of processing where such organic solvents are included. Harmful chemicals such as dyes, heavy metals and organic contaminants can get

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into the environment during production, when the fabrics are used or after they are discarded. Cleaning Service is a source of the spread of contaminants.

In addition to the chemicals used there are also other controversial technologies related to textile manufacturing. About half of the cotton on the world market is genetically modified, and the use of nanotechnology is growing.

Materials used in textile production can affect both health and environment. The greatest impact occurs in countries where production of such large quantities of pesticides used in cotton production and contaminated wastewater are discharged from textile mills.

For further information on hazardous substances, see chapter 3.2.2 as the information related to plastics to a certain degree also is relevant for textiles.

2.2.3 Competitive advantage

Like for plastics, see chapter 3.2.3, a Nordic competitive advantage related to textiles can be obtained; e.g. developing better systems both for reuse and recycling can be an advantage for Nordic industry and trade. See also minutes attached of IKEA presentation at the Nordic Workshop, chapter 5.3.

Nordic international companies can also obtain an advantage if they, based on Nordic initiatives, find better solutions for eco-design, reuse and recycling. As textile waste is on the agenda also in EU, Nordic initiatives might give the Nordic countries an advantage as well when developing joint EU policies and directives in this field. The issue of hazardous substances, inclusive nano is of course a key issue for both EU policies and also for global trade agreements.

2.2.4 Regulations and initiatives for recycling of textiles

Neither the EU nor the Nordic countries have legislation that specifically regulates collection and recycling of textile waste. The legal regulations that apply to textile waste are therefore the same as for waste in general. The most important mechanisms that regulate waste treatment are various measures that restrict landfilling through bans or fees. This gives indirect promotion of alternatives to landfilling, such as recycling and reuse. Direct subsidies or support for material recycling or reuse of waste are little used. The waste regulations also involve restrictions on export of specific types of waste, especially when the export goes to countries out of EU/OECD.

When it comes to used textile collected for reuse these are usually not characterized as waste but as textile products. Basically, they are then covered by legal regulations for textile products and products in general. This can involve tax on the import of used textiles for reuse. An example of this is when used textiles are imported into Lithuania from Norway. The product regulations in EU also give restrictions on use of chemical substances through the REACH regulation and the Stockholm convention.

In some of the Nordic countries charity organizations don’t pay tax of their profit as commercial enterprises do. This implies an indirect subsidy of reuse of textile.
There exist different eco-labeling schemes that also involve clothes and textiles (the EU ecolabelling scheme, the Nordic Swan label and the Swedish Good Environmental Choice label etc). These mechanisms may contribute to a larger share of textile products produced in a way that reduces environmental impacts, the products have longer life and that they contain less pollutants.

Extended producer responsibility (EPR) is a possible important measure to enhance reuse and recycling of textiles\textsuperscript{100,102}. EPR is introduced in the EU for electrical appliances and vehicles that gives the producers obligations to collect and recycle end of life products. Some countries have introduced EPR for other products. To some extent, the EPR obligations also can include product design or restrictions on the content of hazardous substances in products.

France introduced EPR for textiles in 2008 as the only country in Europe until now. The French regulation gives producers, distributors and importers of clothes, linen and foot wears obligation by law to provide or manage recycling of their products when they are wasted. They can fulfill the responsibility either by their own, or by joining a scheme accredited by the French public authority. EcoTLC is the only organization in France so far that received the accreditation by the French public authority and has been running the collection, sorting and recycling system on behalf of their members. The member companies pay fees based on the volume of products put on the market the previous year.
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