APPLICATION OBJECTIVE

- Generation of paper fractions conforming to the European List of Standard Grades of Paper and Board for Recycling (EN643) for use in the production of graphical and non-graphical paper products taking different technical effort and degree of automation into account.

OUTLINE ON APPLICATION FRAMEWORK

PARTICULARLY APPLICABLE FOR WASTE TYPES

<table>
<thead>
<tr>
<th>Glass</th>
<th>Paper / paperboard</th>
<th>Biowaste</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light-weight packaging</td>
<td>Mixed household waste</td>
<td>Bulk waste</td>
</tr>
<tr>
<td>Lamps</td>
<td>Textiles</td>
<td>Electrical and electronic waste</td>
</tr>
<tr>
<td>Scrap metal</td>
<td>Waste wood</td>
<td>C&amp;D waste</td>
</tr>
<tr>
<td>Waste oil</td>
<td>Old paint &amp; lacquer</td>
<td>Waste tyres</td>
</tr>
<tr>
<td>Hazardous waste</td>
<td>Branch specific waste</td>
<td>Other waste material</td>
</tr>
</tbody>
</table>

SPECIAL CHARACTERISTICS AND REQUIREMENTS OF THE APPLICATION

Pre-treatment of the input material:
The collection of waste paper with other waste materials and in particular with such that are wet, fatty or otherwise contaminated shall be avoided. The most suitable way to guarantee an efficient recycling and recycling products of high quality is the separation of the material at source and its selective collection. Waste paper which has not been separately collected and is recovered from commingled waste streams or at waste disposal sites, usually shows to have a quality which is rarely good enough for producing low-grade paper applications such as low quality cardboard. Beside separate collection at source no further pre-treatment is necessary before quality sorting.

Options for the utilisation of the generated output:
The different paper fractions obtained with sorting can be directly used in the production of new paper applications or for other forms of recycling. Other recycling options include the use of recovered paper for example as insulating material, for mould fibre applications, in fibre board or as an additive in asphalt.

Options for the disposal of process output and/or residues:
Impurities and disturbing materials removed during the sorting operations must be disposed of. The most prominent options exist with incineration or the processing of refuse derived fuel.

Protective needs:
Of particular importance is the protection from ignition and fire, and operational safety resp. accident prevention at installations with driven equipment (forklift), moving parts (conveyor belts) and loads (paper bales). The processing area and paper material must be protected from weather impacts, especially rainfall, moisture and wind.

Potential health risks:
Source separation and sorting waste paper prior to its use in paper production also has the objective to make sure types of paper containing volatile chemicals such as DIPN (for example included in non-carbon required copy paper) are removed from material streams forwarded to the production of applications with food contact. The process thus can also lower human health risks.

RESTRICTIONS OR INFLUENCE OF EXTERNALITIES ON THE APPLICATION

Infrastructural conditions:
Installations must be well accessible and possess of good connections to main transport lines resp. routes.

Climatic conditions:
The collected paper and sorting facilities should be protected from weather effects which means that especially operating areas and storage yards shall be sheltered from excessive rainfalls and wind.

Employment potentials:
Sorting waste paper, even quality control steps subsequent to automated processes can be manually performed as well. This opens up good employment opportunities whereby it is also possible to employ personnel with lower levels of education and technical qualifications.
Waste treatment and material processing

Sorting of waste paper

**Others:**
Essential for economically viable operations are larger areas of supply and a sufficiently high purity of the input (from separation at source) and especially as the sorted output is concerned. From the growth in electronic communication follow decreasing rates in graphic paper consumption. The decline in the newsprint and office paper until 2020 is estimated to get as low as 50% of the demand this section has seen in 2008. Paper use in cardboard application and for packaging is assessed to rise or remain stable. Sorting operations should be flexibly designed in order to get adjusted and quickly cope with changes on the market.

**TECHNICAL DETAILS**

**GENERAL OVERVIEW**

**ABSTRACT**
The process generally comprises a mechanical processing for the removal of fine matter and disturbing materials (e.g. mineral substances, small metal parts) and sorting operations with a varying degree of automation (e.g. near infrared-NIR, visual spectrometry-VIS, manual sorting) with the aim to obtain different paper grades from separately collected waste paper.

**BASIC REQUIREMENTS**
- The input must be collected separately from other waste and material streams
- Material has no greater pollutions and is relatively dry. The novel European List of Standard Grades of Paper and Board for Recycling (adopting the EN643 as of 2013) prescribes an allowable maximum of non-paper content and unwanted matter for each paper grade. In general the limit is set for such material at not more than 3% by weight in aggregate.

**EXPECTED RESULTS**
- Grades of Paper and Board for Recycling with a defined quality; when conforming to EN643 these are, for example:
  - **1.11 Sorted graphic paper for deinking:** Sorted graphic paper, consisting of a minimum of 80 % newspapers and magazines. It has to contain at least 30 % newspapers and 40 % magazines. Print products which are not suitable for deinking are limited to 1.5 %.
  - **1.02 Mixed papers and boards (sorted):** A mixture of various qualities of paper and board, containing a maximum of 40 % of newspapers and magazines.
  - **1.04 Supermarket corrugated paper and board:** Used paper and board packaging, containing a minimum of 70 % of corrugated board, the rest being solid board and wrapping papers.
- Sorted output with non-paper components and unwanted material in the paper fractions below maximum tolerance levels (e.g. according to EN643 maximum of 1.5% non-paper for the majority of grades)

**SPECIFIC ADVANTAGES**
Are differently assessed depending on the employed process scheme and plant configuration

- **Basic configuration**
  - simple techniques, thus relatively moderate capital costs and low maintenance expenses
  - very reliable, i.e. little failure prone (95% effectively available)
  - high flexibility

- **Advanced configuration**
  - automated processes (i.e. use of NIR detection techniques), thus little labor intensive
  - higher purity of the output due to mechanized and sensor-supported pre-sorting
  - significantly higher throughput than with basic configuration possible

**SPECIFIC DISADVANTAGES**
Are differently assessed depending on the employed process scheme and plant configuration

- **Basic configuration**
  - highly personnel intensive (high labour demand)
  - comparatively low throughput

- **Advanced configuration**
  - relatively capital intensive due to the more sophisticated and sensitive equipment used
  - personnel with quite a high qualification needed
  - energy demand comparatively higher

**Status October 2015**
A continuous feeding of the input and its segregation and even distribution on the conveyor is essential to make optimal use of the sorting capacity and ensure high efficiency of the process.

In the basic configuration, the technical arrangement consists of a processing by way of mechanical-physical process steps (e.g. screening, magnet separation, gravitational, suction or blow techniques) for the removal of fine materials (e.g. mineral substances, small metal parts) and a subsequent manual sorting into different paper grades. The following scheme applies:

In an advanced configuration, the process is partly automated and sensor-based. Objective of the process is mainly the generation of high quality paper fractions (de-inking grades, grade 1.11) usable for the production of print products (newsprint and magazines). At the beginning, mechanical-physical process steps similar to those employed in the basic configuration are applied for the removal of fine and disturbing matter (e.g. mineral substances). Hereafter, mainly a quality separation of the paper is taking place by means of various techniques and methods, involving among others spikes and ballistic separator devices, various types sensors and also manual sorting. The separation usually leads to fractions of card-/paperboard, newsprint, mixed paper grades and a sorting rest.

Generally a tendency to increase the purity of the sorted fractions is observed and thus to go for highly automated, opto-electronically supported and partly multi-level sorting procedures that end with a manually performed quality control and refinement. Without that last step of after-sorting still significant amounts of de-inkable paper (20–40%) wouldn't be recoverable and lost. Integrating manual sorting steps can reduce this loss by about 50% and results in much better quality and sales revenues in the overall.

How sorting gets organized and which technical arrangement is used in an advanced configuration can be seen in a process scheme displayed in Figure 2. It should be remarked that sequence of the process steps and positioning of the individual component therein can be varied and do not follow uniform patterns.

To be able to react on and cope with the ongoing changes in the kind of paper products and waste paper composition (currently a decrease in office paper and constantly rising amounts of packaging applications and cardboard) thru a highly flexible design and rearrangement of sorting processes is a big challenge but the only option that can secure the operations economic viability.

---

Waste treatment and material processing

Sorting of waste paper

Figure 2: Example of a sorting arrangement for paper for recycling using an advanced process configuration

| QUANTITY ASPECTS | - differ depending on the employed process scheme and plant configuration
| Basic configuration |
| - The average throughput rate is approx. 5 Mg/h
| - Sorting intensity and depth can be easily adjusted depending on markets and sales strategies
| Advanced configuration |
| - Throughput rates can go as high as approx. 8–12 Mg/h per separate process line
| - Per Mg of plant throughput a proportion of not more than 1.5% disturbing matter should (= plastic foils, styrofoam, fabric, electronic components) be acceptable
| - up to 70% of a mixed paper input should be sortable into de-inking grades (grade 1.11)
| - 30-40% of the suitable paper input can be sorted in mixed grades (1.02) and packaging (1.04)

| SCALE OF APPLICATION | Plants of the advanced configuration are set up in countries/areas with an intensified separate collection and supply of paper for recycling, usually these are facilities of large size

| INTEROPERABILITY | The process can be combined with the actual recycling operations in the paper mill itself and integrated there as a preceding step based on additional installations, external facilities are not necessarily required.

| OPERATIONAL BENCHMARKS: RESOURCE CONSUMPTION |
| ENERGY BALANCE | The energy demand for waste paper sorting operations lies in a range from 20–50 kWh/Mg². Sorting paper for recycling purposes is necessary in order to be able to close material loops efficiently and to obtain an overall environmental benefit through recycling. How this works and where a net benefit from high-quality recycling derives from is shown in the table below:

Table 1: Comparison of energy and raw material needs for paper made from primary (wood) or waste paper fibres³

<table>
<thead>
<tr>
<th></th>
<th>Per kilogram recycling paper</th>
<th>Per kilogram virgin paper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>15 Litres</td>
<td>50 Litres</td>
</tr>
<tr>
<td>Energy</td>
<td>2 kWh</td>
<td>5 kWh</td>
</tr>
<tr>
<td>Fibre source</td>
<td>1.2 kg waste paper input</td>
<td>1 kg of fibrous matter obtained from cellulose supplied/extracted from 2.2 kg wood</td>
</tr>
<tr>
<td>COD</td>
<td>3 g</td>
<td>15 g</td>
</tr>
</tbody>
</table>


³ Based on diverse literature sources, Inter alia German Environment Agency (2000); IFEU Institut (2008), JRC (2012), FÖP (2012)
Paper recycling reduces the need to use primary (wood) fibres for paper production and results in an overall lower consumption of energy for this process. In average an equivalent of 700 kg CO₂ is saved when one ton of waste paper is recycled and used to substitute primary raw materials in paper production⁴. A reference plant of the advanced configuration operating with an annual throughput of 120,000 Mg in Berlin claims to save approx. 75,000 Mg CO₂ in total due to the sorted waste paper it returns to production.

- No other than those technical aggregates mentioned before

- usually up to eight labourers, one of which is the foreman. Manual sorting is performed by six of them and one staff operates flexibly as engine driver and machinist

- to run the process in shifts a higher staff number is required (in the range of 15–20 labourers in total), the staff ratio in relation to the achievable throughput is often more favourable compared to the basic configuration, however

A hall space of approx. 4,000–5,000 m² is needed for an average size facility

The expectable amount of impurities in the source separated input stream in the average is in the range of 3 % by weight, most of that must be disposed of as residual waste

### INVESTMENT COSTS

- the net capital need without building and other auxiliary structures can be estimated in the range of EUR 30,000–80,000 Euro for an average processing line

- depending on the use of, for example, opto-electronic and other sensor based separation units a net investment up to EUR 10 million is required for an average processing line

### OPERATING COSTS

- normally in a range of 15–20 EUR/Mg, of which repair and maintenance costs amount to about 2,000–5,000 EUR per annum (6–8 % of the initial investment)

- normally in the range of 11–15 EUR/Mg, the variability of these costs is however significantly higher depending on the equipment employed and the intensity of after-sorting

### POSSIBLE PROCEEDS

Following prices could be obtained on the central European markets in the first half of 2015:

- Mixed paper (1.02): 70–91 EUR/Mg (compared to 128 EUR/Mg in July 2011)
- Carton and cardboard (1.04): 72–90 EUR/Mg (compared to 129 EUR/Mg in July 2011)
- De-inking grades (1.11): 77–84 EUR/Mg (compared to 120 EUR/Mg in July 2011)

### MASS SPECIFIC OVERALL COSTS

- Essentially determined by the operating costs

- Vary considerably due to the different and often very tailor-made technical solutions found, the range can be estimated with 30–90 EUR/Mg exclusive the proceeds made from sales

---

⁴ German Environment Agency: Umweltbundesamt Texte 46/2015: The Climate Change Mitigation Potential of the Waste Sector

⁵ German Statistical Office: Index of selling prices in wholesale trade of paper for recycling and scrap metals, August 2015, Wiesbaden
### Sorting of waste paper

**Status October 2015**

**MISCELLANEOUS**

**MARKET INFORMATION**

**REFERENCE FACILITIES**

(Nota the list of sites and/or firms does not constitute a complete compilation)

Sorting installations of the two different types of configurations can be found in large number across Europe and in many developed countries elsewhere around the globe. Plants of the advanced configuration in Germany are for example:

- Altpapier Sortierung Dachau GmbH [www.asd-entsorgung.de](http://www.asd-entsorgung.de)
- Wertstoffunion Berlin [www.wertstoffunion.de](http://www.wertstoffunion.de)

Further plants of this type are listed in a database of the Federal State of Brandenburg.

Complete system solutions are offered inter alia by:

- Sutco Recycling Technik GmbH [www.sutco.de](http://www.sutco.de)
- Entsorgungstechnik Bavaria GmbH [www.entsorgungstechnik-bavaria.de](http://www.entsorgungstechnik-bavaria.de)

**RECOGNIZED PRODUCER AND PROVIDER FIRMS**

(Note: the list of firms does not constitute a complete compilation of companies)

Almost all large waste management providers in Germany undertake the processing of paper for recycling in facilities set up in various configurations. Some relevant company references are:

- Sulo [www.sulo.com](http://www.sulo.com)
- SUEZ Deutschland [www.suez-deutschland.de](http://www.suez-deutschland.de)
- Remondis [www.remondis.de](http://www.remondis.de)
- Alba-Gruppe [www.alba.info](http://www.alba.info)

The aggregates and equipment used for the process belong to the pool of technical equipment which is generally available and in use for mechanical operations in the waste management sector. In particular these are:

**Feedhopper/conveyor:**

- Ludden & Mennekes, Meppen [www.ludden.de](http://www.ludden.de)
- Spezialmaschinen & Recyclingtechnik, Chemnitz [www.sr-recyclingtechnik.com](http://www.sr-recyclingtechnik.com)

**Classifier/screens:**

- Mogensen GmbH & Co. KG, Wedel [www.mogensen.de](http://www.mogensen.de)
- EuRec Technology GmbH, Merkers [www.eurec-technology.com](http://www.eurec-technology.com)
- Spaleck – Förder- und Separiertechnik [www.spaleck.de](http://www.spaleck.de)

**Suction equipments:**

- NESTRO Lufttechnik GmbH, Schkölen/Thüringen [www.nestro.com](http://www.nestro.com)

**Metal separators (Fe and non-Fe):**

- Steinert Elektromagnetbau GmbH, Köln [www.steiertglobal.com](http://www.steiertglobal.com)
- IMRO Maschinenbau GmbH, Uffenheim [www.imro-maschinenbau.de](http://www.imro-maschinenbau.de)
- Wagner Magnete GmbH & Co. KG, Heimertingen [www.wagner-magnete.de](http://www.wagner-magnete.de)

**Press/balers:**

- HSM GmbH + Co. KG, Salem [www.hsm.eu](http://www.hsm.eu)

**Sensor-supported sorting:**

- Tomra Systems GmbH [www.tomra.de](http://www.tomra.de)
- Sesotec GmbH [www.sesotec.com](http://www.sesotec.com)

**ADDITIONAL REMARKS AND REFERENCE DOCUMENTS**

The paper industry in Europe represented by the CEPI (www.cepi.org), initiated a voluntary agreement by which was declared that paper recycling will be further enhanced among others through investments in technological developments, research and by way of a further promotion and increased effort towards separate paper recovery and the utilization of paper for recycling in production. Many other organizations in Europe (e.g. European Recovered Paper Council) and at national level (e.g. German Pulp and Paper Association) join in these kinds of efforts. Voluntary commitments and/or declarations of the industry have the purpose to ensure that recycling is continuously being enhanced and introduced to production without that massive interventions and legislative pressure must be developed or mandatory requirements set by the state in order to establish a functioning paper recycling system.