REVIEW OF WASTE PROCESSING TECHNOLOGY FOR SRF

for
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CONTENTS

1 INTRODUCTION

The processing of residual waste in order to produce a specific fuel fraction provides an alternative method for energy recovery, and is increasingly practised. The fuel fraction is generally referred to as Solid Recovered Fuel (SRF). SRF can take various forms including a loose or flock material, which has been size-reduced or further densified to produce a fuel pellet, the final form of SRF is dependent on the mode of energy recovery. Consequently, there are many methods for producing SRF and these may include some or all of the following processing systems: screening, air classification, dry, pelletising, magnetic recovery.

The aim of this report is to review the technology for SRF processing. The situation in Finland is described in more detail due to the important role of the solid recovered fuels in waste-to-energy issues in Finland. Some technologies utilised in Europe are also reviewed.

2 WASTE-TO-ENERGY IN FINLAND

In Finland, the national waste management strategy is presented in the National Waste Action Plan [1] for the year 2005 reflecting the EU Directives, especially the Waste Directive. The key objective is to prevent the generation of municipal solid waste by 2005 at least 15% of the waste amount predicted and to increase the recovery rate of Municipal Solid Waste (MSW) from present about 40% to more than 70% by the year 2005. There are also targets for waste reduction, material recovery rates for some material fractions like packaging wastes, for doubling the landfill tax, and for reduction figures for combustible and organic materials. It has been estimated that significant additional volumes of MSW should be used for energy on top of the highest priority material recycling. About 1 Mt/a of MSW should be used for energy if no new large-scale recycling alternatives can be found. Waste-to-energy technology in Finland is focused on co-firing in combined heat and power production, mainly on fluid-bed combustion and gasification technologies and advanced gas cleaning. Today there is one MSW incineration plant in the city of Turku (50 000 t/a), and about 300 000 t/a of dry solid recovery fuel is co-fired in industrial and municipal boilers. At present some 20 medium and large-scale fluidised bed boilers co-fire SRF for heat and power production [2]. The quality of Solid Recovered Fuel (SRF) will be based on good source separation and recovered fuel production technology. Landfill disposal is still the dominating alternative for MSW in Finland. However, material recycling and composting of biowaste are the most rapidly growing alternatives.

The Finnish waste management and solid recovered fuel production is based on an efficient and extensive source separation practise. Source separation and kerbside collection make it possible to separate about 50% of the mixed waste for energy use and direct half of the waste stream to material recovery (paper, metals, glass, compost/digestion). Furthermore, a more favourable basis for production of a clean SRF is created by separating impurities at an early stage.

The key strategy in developing waste-to-energy applications has been an integrated approach of total MSW recovery instead of mixed waste mass incineration, where the key topics are:

- source separation
- production and quality control of solid recovered fuel
- co-firing in existing or new CHP plants
- gasification technologies and advanced gas cleaning
- emission control supported by high quality control of fuel
- integrated material and energy recovery, especially metals, glass and paper

In Finland, the dominating solid fuel power plant technology is fluid-bed combustion of biomass, peat and coal. Fluidised bed combustion technology is suitable for co-combustion of different fuels. Intensive combustion behaviour and careful mixing make it possible to burn fuels with a high moisture content. There can be variations in fuel's calorific value without significant changes in combustion temperature level. Both Bubbling Fluidised Bed (BFB) and Circulating Fluidised Bed (CFB) boilers are suitable for co-combustion of SRF fuels.

2.1 WASTE COMPOSITION

The waste owner, i.e. the company, the municipality or the person who owns the waste material, is responsible for the waste handling. The municipalities must provide the collection and handling of household waste and the similar commercial waste.

Handling of commercial waste, construction waste and demolition waste and also the industrial waste are the responsibility of the company producing the waste. These companies can co-operate with the municipality, but because of the differences in the quality of the waste originating from households or from industry, different processing options are often relevant for these waste streams.

Municipal solid waste comprises three main fractions in Finland: household waste, commercial waste from shops, offices and companies, and also process waste from small enterprises because it is collected together with the other MSW fractions. This fraction also contains some construction waste.

Fuel properties of the combustible part of the above mentioned waste fractions are presented in Table 1. The values are long-term mean values based on analyses carried out at VTT Processes. Solid recovered fuels are produced mainly from the dry waste fraction of MSW and from dry commercial waste. Commercial waste contains mainly polyethylene plastics, wood, paper and board.

Table 1. Typical properties of various waste fractions.

		Commercial waste	Construction waste	Household waste
Lower heating value as received	MJ/kg MWh/t	16 – 20 4.4 – 5.6	14 – 15 3.8 - 4.2	13 – 16 3.6 - 4.4
Annual energy content	GWh/a	530	285 - 315	360 - 440
Moisture	wt%	10 - 20	15 - 25	25 - 35
Ash	wt%	5 - 7	1 - 5	5 - 10
Sulphur	wt%	<0.1	<0.1	0.1 - 0.2
Chlorine	wt%	< 0.1 - 0.5	<0.1	0.3 - 1.0

The waste coming from shops, supermarkets, department stores, etc., is good raw material for high-grade recovered solid fuels. The composition of waste from industrial companies varies. Companies producing problematic waste streams are, however, fairly few and identifiable, and the problems associated with these wastes controllable. The waste from households is more diverse and concern the whole population. A better fuel can be produced from commercial waste with current technology than from household waste.

2.2 SOURCE SEPARATION SCHEMES OF HOUSEHOLD WASTE

The existing source separation system in Finland is based on source separation of 2–6 fractions in households and commercial waste sources like offices, superstores, etc. Various cities do not always apply the same source separation procedure due to historical or local reasons. Typically paper, biowaste and dry waste are collected in households of the major cities. Kerbside collection of some waste fractions, e.g. paper, cardboard, glass and metals, is combined with household separation. Source separation is the key of good material separation for recovery and for the production of high quality SRF.

The composition of household waste separated using two 5-bin and a 2-bin separation scheme is presented in Figure 1 [3]. The composition of the dry fraction and energy fraction, which are used as feedstock for solid recovered fuel production, were further analysed by hand-picking. The dry fraction still contains almost 30% of biowaste and about 15% of other impurities. The energy waste obtained in one of the 5-bin separation schemes was considerably "cleaner" due to the fact that a separate bin for landfill waste was provided in that particular scheme. Correspondingly, the yield is much lower than in the other schemes.

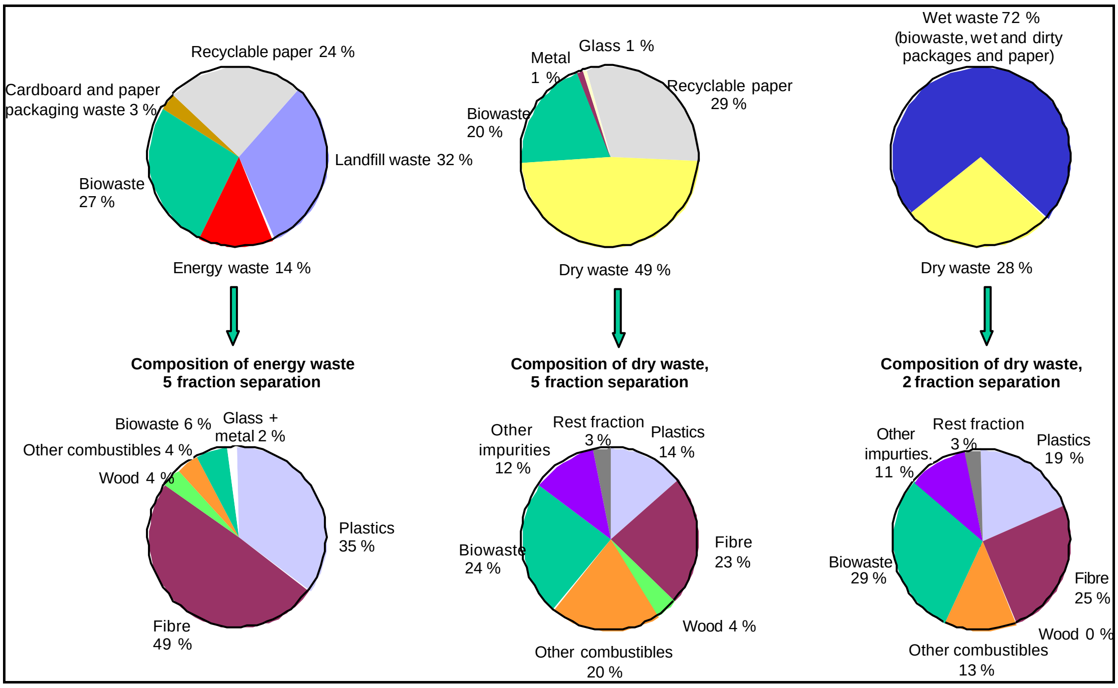

Figure 1. Source separation systems and measured waste fractions [3].

The results indicate that source separation could still be improved in households. An efficient source separation scheme (e.g. energy waste separation) improves the quality of SRF with regard to combustion properties. The amount of chlorines, alkalies and aluminium can be reduced considerably, Table 2 [3]. Data in Table 2 is compiled from a single measurements study and cannot be considered representative in a broader context.

Table 2. Quality of recovered solid fuels produced from energy waste and dry waste.

Element/ characteristics	Energy waste (5 fraction sep.)	Dry waste (5 fraction sep.)	Dry waste (2 fraction sep.)
Cl, w-% d.b.	0.34	0.76	0.82
S, w-% d.b.	0.06	0.10	0.08
N, w-% d.b.	0.4	0.5	0.6
K+Na, w-% d.b.	0.17	0.38	0.37
Al, w-% d.b. (metallic)	0.16	0.63	0.87
Hg, w-% d.b.	<0.1	0.6	0.29
Cd, w-%, d.b.	0.33	1.3	0.43
LHV, MJ/kg (as received)	19.9	16.7	16.4
Moisture, w-% (as received)	11.8	23.0	24.2
Ash, w-% d.b.	7.3	9.7	9.4

Further improvement of the quality of SRF produced from household waste is required to avoid corrosion and fouling tendency of the heat exchange surfaces in high efficiency CHP boilers. These problems are caused by combination of chlorine, different alkali metals, aluminium, etc. in the SRF.

2.3 QUALITY ASSURANCE MANUAL

A national standard for recovered fuels was issued for the SRF quality control for co-firing in large fluid-bed boilers with peat and wood fuels in 2002. The Quality Assurance Manual for Recovered Fuels [4] was created to stimulate the SRF market. The implementation of this Manual has boosted the use of SRF as a complementary fuel by setting up quality classes and defining analysis procedures and recommendations for recovered fuels. The three quality classes are described in Table 3 below.

Table 3. SRF quality classes according to the Quality Assurance Manual.

Topic	Characteristics	Focus of application	Unit	Reporting precision	Quality class		
					I	II	III
1	Chlorine content for dry matter	[1]	% (m/m) [2]	0.01	<0.15	<0.50	<1.50
2	Sulphur content for dry matter	[1]	% (m/m) [2]	0.01	<0.20	<0.30	<0.50
3	Nitrogen content for dry matter	[1]	% (m/m) [2]	0.01	<1.00	<1.50	<2.50
4	Potassium and sodium content for dry matter [3]	[1]	% (m/m) [2]	0.01	<0.20	<0.40	<0.50
5	Aluminium content (metallic) for dry matter	[1]	% (m/m) [2]	0.01	[4]	[5]	[6]
6	Mercury content for dry matter	[1]	mg/kg	0.1	<0.1	<0.2	<0.5
7	Cadmium content, for dry matter	[1]	mg/kg	0.1	<1.0	<4.0	<5.0

1) The limit value concerns a fuel amount of ≤ 1 000 m^3 or a fuel amount produced or delivered during one month, and it shall be verified at least for a respective frequency.
2) % (m/m) denotes the percentage by mass
3) Total content (K+Na) of water-soluble and ion-exchangeable proportion for dry matter.
4) Metallic aluminium is not allowed, but is accepted within the limits of reporting precision
5) Metallic aluminium is removed by source-separation and by the fuel production process
6) Metallic aluminium content is agreed separately

The standard defines the procedures and requirements, by which the quality of recovered fuel, produced for the purpose of energy production from source separated waste, can be controlled and reported unambiguously. In addition to defining the quality class of the SRF fuel according to Table 3, other characteristics and limit values (e.g. other fuel operating properties, heavy metals, and noxious constituents) of the fuel can be agreed upon in the delivery contract using a normative data sheet included in the standard.

The standard covers the whole chain of supply from the source separation of waste to the delivery of recovered fuel. The standard does not concern untreated wood wastes like bark, sawdust, and forestry residues. There is a proposal under preparation for a CEN standard for solid recovered fuel.

3 SOLID RECOVERED FUEL PROCESSING

3.1 PROCESSING OPTIONS

The waste owner, i.e. the company, the municipality or the person who owns the waste material, is responsible for the waste handling. The municipalities must provide the collection and handling of household waste and the similar commercial waste.

Handling of commercial waste, construction waste and demolition waste and also the industrial waste are the responsibility of the company producing the waste. These companies can co-operate with the municipality, but because of the differences in the quality of the waste originating from households or from industry, different processing options are often relevant for these waste streams.

The better source separation usually enables the production of better quality SRF. From commercial, industrial, demolition and construction waste it is usually easier to separate the impurities, like aluminium or PVC. This kind of waste can be processed to a SRF I quality class fuel. Also the processing of such waste does not require complex equipment. Crushers, sieves and magnetic separators combined with good source separation may well be enough for achieving a good quality SRF. For household-derived SRF, more advanced SRF plants are needed. The separation of biowaste and miscellaneous fines is essential.

A typical Finnish waste management scheme is illustrated in Figure 2. There are about 20 waste recovery/sorting plants in operation in Finland and several smaller crushing plants for combustible industrial and commercial waste material. The SRF production technology is continuously developed to facilitate more efficient material recycling and better fuel quality.

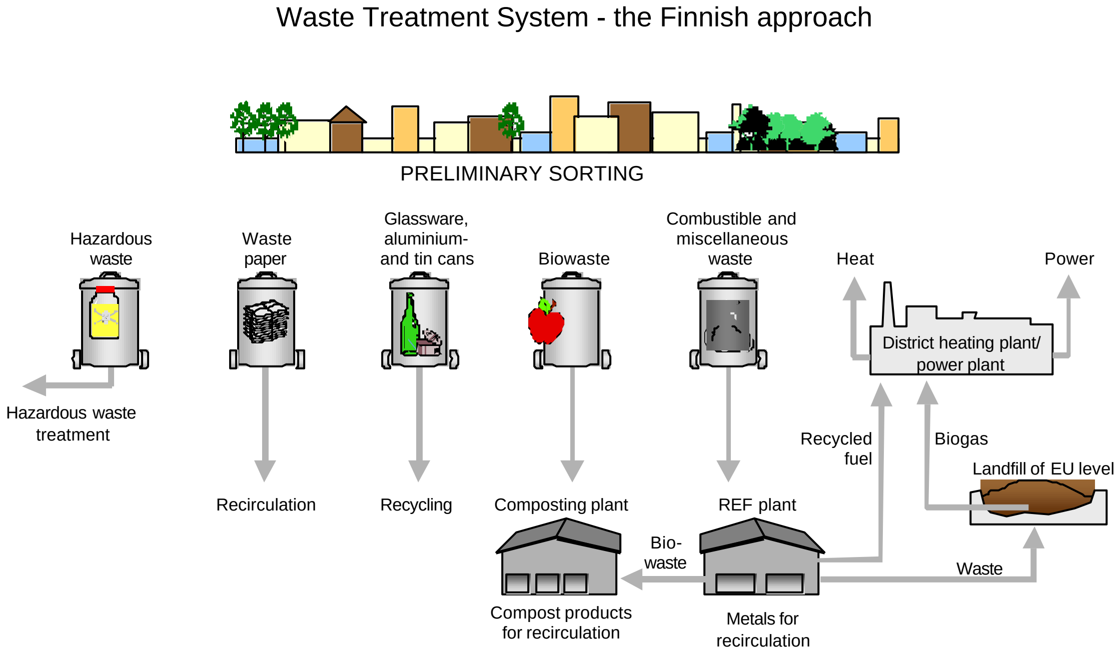

Figure 2. Urban waste management scheme and SRF production.

3.2 SRF PRODUCTION FROM HOUSEHOLD WASTE

Source separated household waste requires a fairly complicated production plant including operations like crushing, magnetic separators, screening, eddy-current for non-magnetic materials, pneumatic separation and optic sorting. The purpose is to separate the impurities (typically biowaste, glass, metals, aluminium, PVC) as well as possible and to produce good quality SRF to be used in fluidised bed energy recovery plants. These plants have typically an annual capacity of about 40 000 tonnes. High quality recovered fuels (SRF I) can also be produced from commercial waste. In this production scheme the sieving of the pre-crushed "energy waste" is usually bypassed because the waste contains little biowaste and fine impurities. Figure 3 presents a flow diagram of a typical SRF production plant.

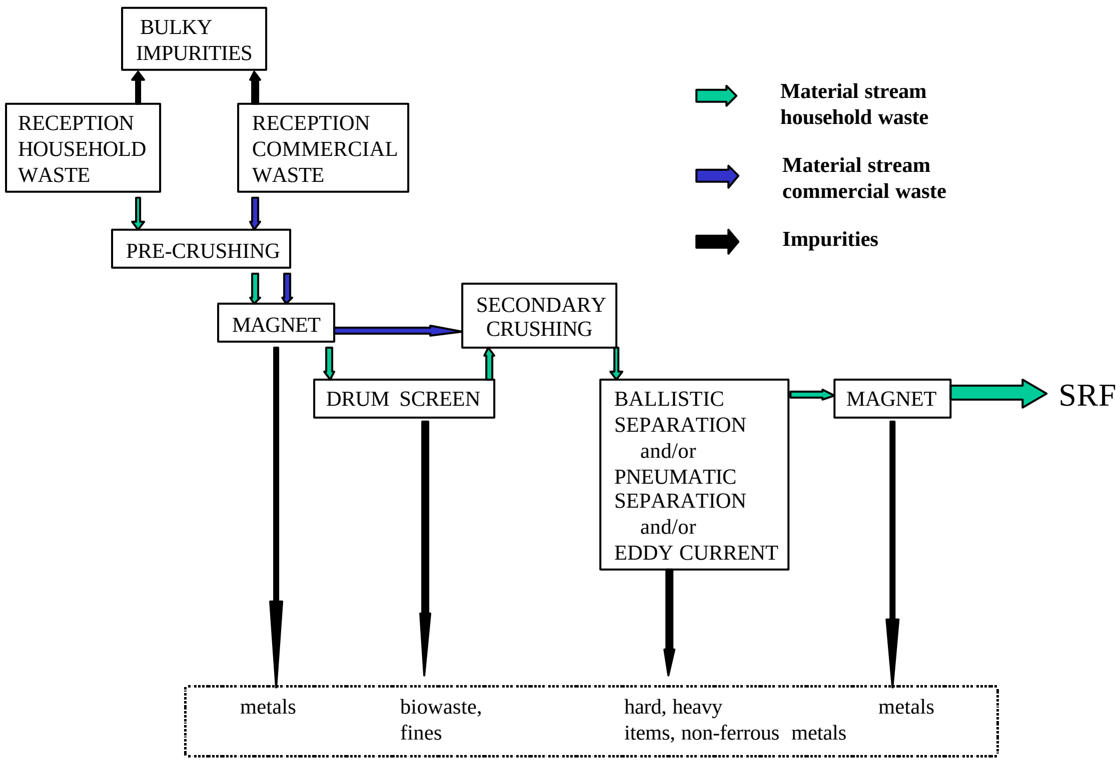

Figure 3. SRF production from household waste and commercial waste.

Pirkanmaan Jätehuolto Oy is owned by 23 municipalities in Tampere area and it is serving some 376 000 inhabitants. At one of its landfill sites the company runs an SRF production plant with a capacity of 30 000 SRF t/a. Both commercial and household waste is accepted. From household waste recovered fuel of quality class SRF II–III is produced in a production line comprising the following process steps:

- coarse pre-sorting of large impurities on the floor of the receiving hall
- magnets (belt and drum), metal detector (can be used if waste contains much metals)
- primary shredding, below about 150 mm
- magnet, separation of metals
- screening in a sieve drum, separation of biowaste and fines
- ballistic separation of heavy impurities (glass, PVC)
- secondary shredding, below about 50 mm
- magnet separation of metals
- baling and covering of the product (if stored for longer time)

A layout of the Tarastenjärvi plant is presented in Figure 4.

Figure 4. The Tarastenjärvi SRF production plant.

SRF fuel is utilised by several fluidised bed boilers to produce power and district heat. The biowaste is composted of the residue fractions at the site and it is mostly used for covering of the landfill. Metal and glass are recycled.

The material streams and some fuel properties are presented in Table 4 and 5 [5]. The SRF production efficiency of the plant has been between 75 and 81%.

Table 4. Product and residue streams of the Tarastenjärvi plant.

Year	Waste input, t	SRF output, t	Metals, t	Fines, t	Heavy residues, t	Landfill residue, t
2000	23809	17790	772	4731	163	568
2001	21721	17649	738	3546	94	429
2002	22676	17368	792	4406	104	368

Table 5. Some fuel properties of SRF produced from commercial waste and source separated household waste (dry fraction). Mean values over the period 1998-2003.

	SRF from commercial waste (energy waste)	SRF from household waste (dry waste)
Moisture, w-%	17.0	30.3
Ash, w-% d.b.	9.3	10.3
LHV, MJ/kg d.b.	21.4	21.7
LHV, MJ/kg as recieved	17.2	14.4
Chlorine, w-% d.b.	0.43	0.49
Met. Aluminium, w-% d.b.	0.29	0.41

A similar SRF plant is operated by Loimihämeen Jätehuolto Oy. The fuel from this plant is transported directly to the power plant (66 MWth, BFB) nearby owned by Vapo Oy, Figure 5.

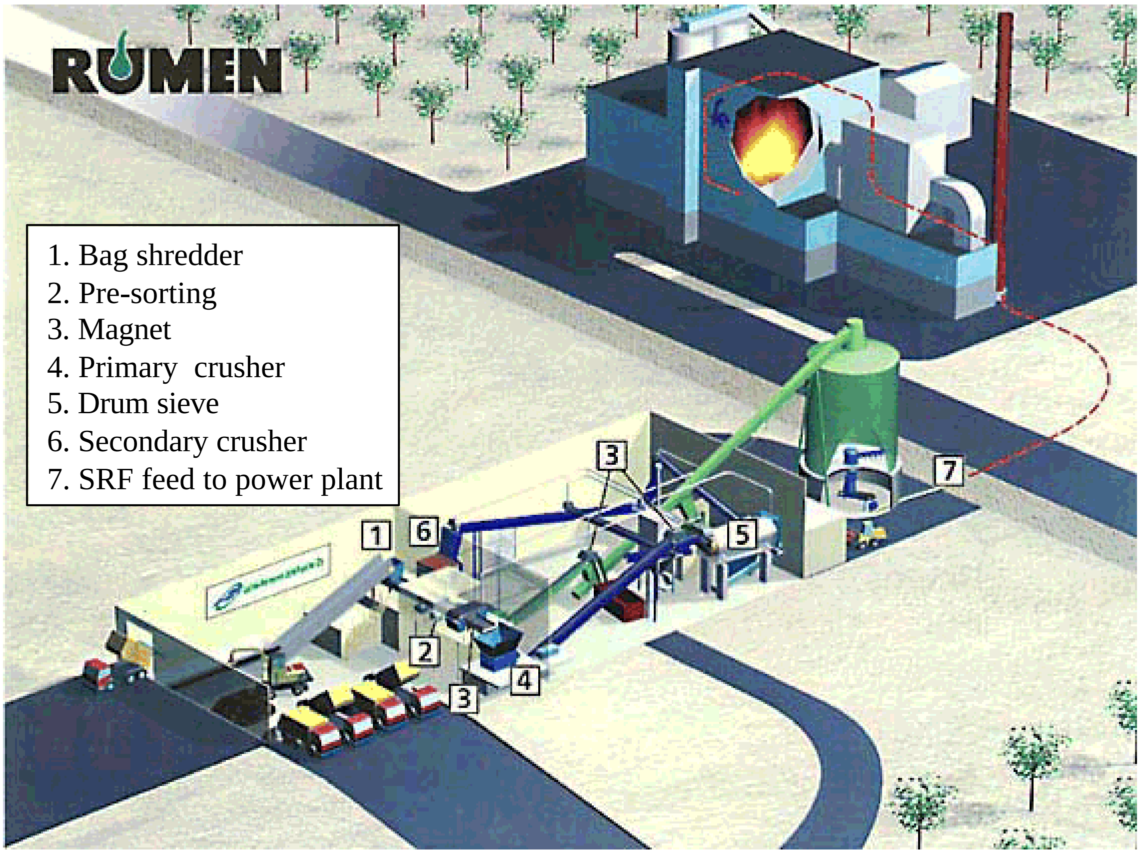

Figure 5. SRF production connected to a power plant.

The present operating values of the Loimihämeen Jätehuolto plant are [6]:

- input waste stream 15 000 t/a
- SRF production 8000–9000 t/a (mostly paper, card board, wood, fibres, plastics)
- biological waste 4000–5000 t/a

- metals (Fe, Al) 300–500 t/a
- residues to landfill 800–1000 t/a.

The plant is operating at short capacity mainly because of a lack of fuel demand. The aim of the company is to increase the production to about 45 000 t/a by the year 2007.

3.3 SRF PLANTS PROCESSING COMMERCIAL WASTE

Plants processing commercial waste (mainly package waste) are usually technically more simple than SRF plants that process household waste. The quality of the produced SRF is also better; the quality class is SRF I or SRF II. The SRF plants usually include one or two crushers, magnetic separators and possibly an Eddy Current for non-ferrous metals. A typical of 20 000 t/a commercial waste SRF is presented in Figure 6. These plants produce very little residues. The metals and non-ferrous metals separated from the waste stream are mainly recycled. The fuel produced has a mean particle size of below 50 mm, has a high energy value, about 16–20 MJ/kg, and a low moisture content of 10–20%.

Figure 6. Processing of commercial waste: shredder, magnet and Eddy Current.

A new SRF processing plant was taken into operation by Lassila & Tikanoja Oy in 2003 using new crushing technology by BMH-Wood Technology Oy. A single rotor crusher equipped with a interchangeable screen plate reduces the particle size of the commercial waste to below 50–100 mm in one step, depending of the screen size. The design capacity of the crusher is 20 t/h. The process is technically fairly simple, Figure 7. After crushing the metals are removed by magnets and the SRF fluff is eventually baled. A solid recovered fuel of quality class SRF II or better is produced at the plant.

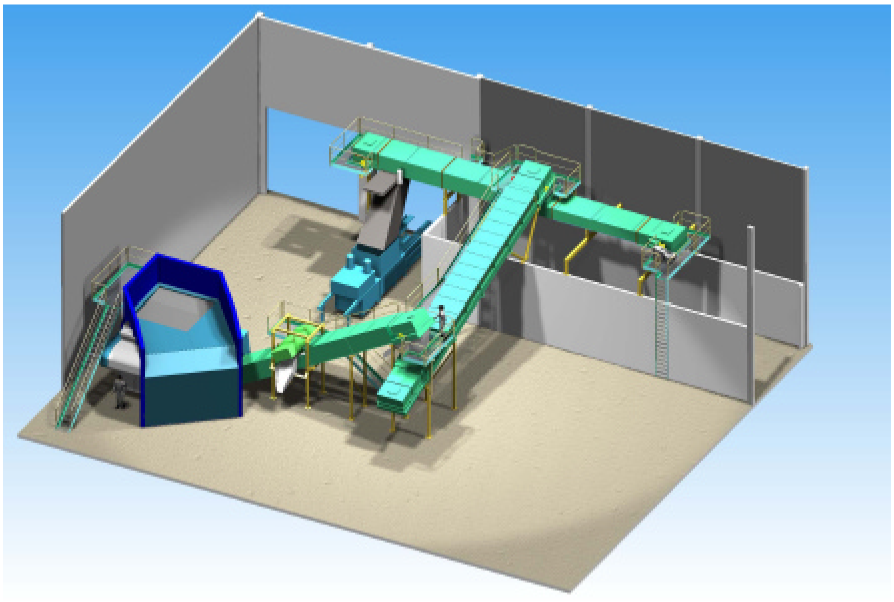

Figure 7. Production of SRF from commercial waste.

3.4 SRF PLANTS PROCESSING CONSTRUCTION AND DEMOLITION WASTE

Wood, soil, stones and stone-like waste, metallic waste, and hazardous waste are source separated at the construction site for different places, enforced by the Finnish Act on building and construction waste. Today, the amount of wood waste, paper, board and plastics from construction and demolition sites is increasingly used for energy instead of landfilling. These fractions are usually treated at separate SRF plants designed for this kind of waste. A new plant commissioned in 2002 processing construction waste in the Helsinki Metropolitan Area (Ekopark Oy) is shown in Figure 8. The plant processes about 35% of the annual 200 000 t construction waste produced in the metropolitan area [7].

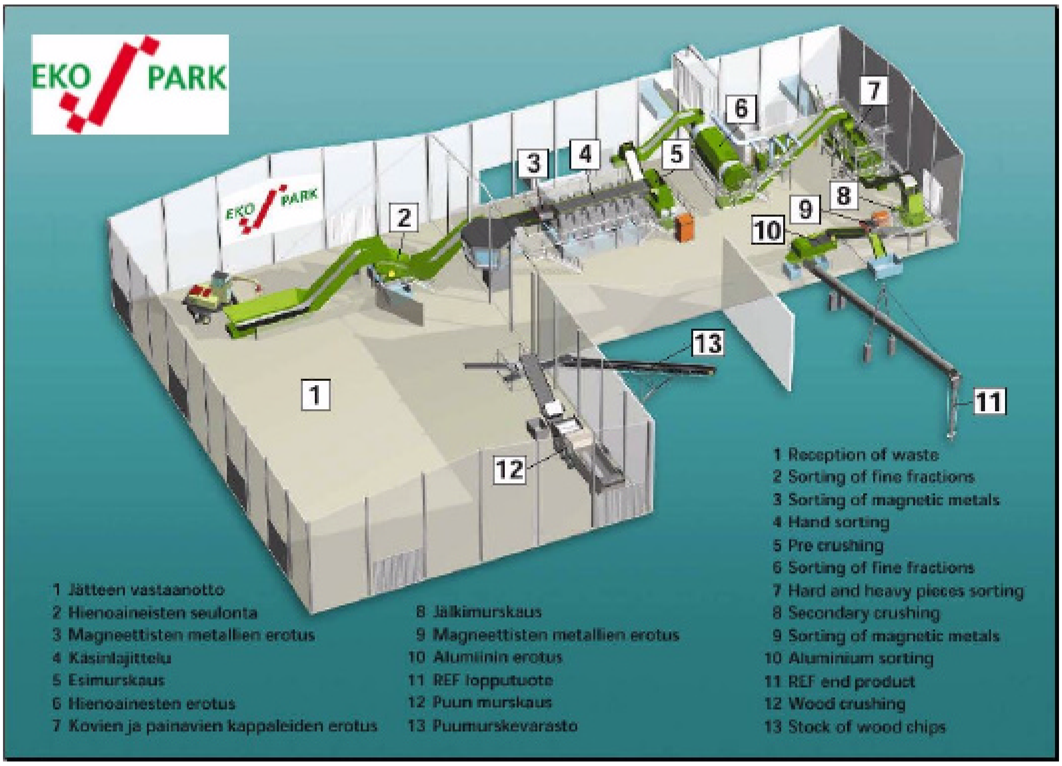

Figure 8. Processing of construction and demolition waste, Rakentajien Ekopark Oy.

The design capacity of the plant is 50 000 t/a. The products and reject of the plant are roughly

- 40% SRF product for energy use
- 20% fines and inert rock material
- 7% metals for recycling
- 33% residues to be landfilled.

The demolition waste plant includes a process step where manual hand-picking is employed to sort out rocks, metals (Cu etc.) and hard plastics (PVC). The hand-picking is carried out before the material is crushed. Excessive fines have, however, been removed by sieving.

3.5 PELLET PRODUCTION FROM WASTE

Ekorosk Oy is covering the Pietarsaari area and the neighbouring municipalities. The waste is source separated to two fractions: so-called wet and dry fraction. The wet fraction includes all the organic material (like biowaste, plants) and the dry fraction all the combustibles (like packages, non-recyclable paper, plastics). The wet and dry fractions are source separated at households to differently coloured bags (black and white, respectively) and all the bags are collected in the same waste bins. The bags are separated by optic sensors, and the wet fraction is taken to the Vaasa biogas plant and the dry one is taken to the Ewapower pelletising plant and then for energy use. Other fractions, like glass, metals and recyclable paper, are collected by kerbside collection. Source separation based on coloured bags and optical sorting is also used in some areas in southern Finland.

The Ewapower pelletising plant includes pre-crushing, magnetic separator, air and drummer sieves, secondary crushing, drying (drum dryer using fuel oil), air separator, pelletiser (three pellet presses, capacity about 5 t/h each), cooling and dust separation. The process is presented in Figure 9. The incoming waste consists of the dry fraction from the source separated household waste (the white bags) and industrial and commercial dry waste from the area.

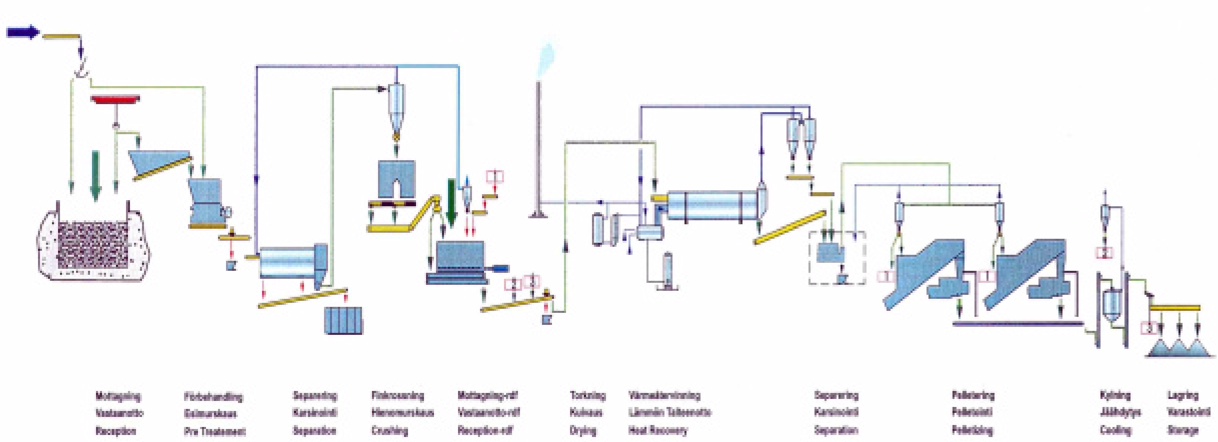

Figure 9. The Ewapower Oy Ab pellet plant.

The pellets have high energy density and they can be stored and combusted in a rational manner. The pellets are used as fuel mixed with wood residue fuel or peat and combusted in a bubbling fluidised bed boiler. The annual capacity is 30 000 t/a of pellets and the heating value of the pellets is 20 MJ/kg. The specifications of the final fuel are presented in Table 6.

Table 6. Properties of pellets produced at Ewapower Oy.

Moisture content	< 6 wt-%
Calorific heating value	21 MJ/kg (dry basis)
Ash content	7–10 wt-% (dry basis)
Volatile matter	80 wt-% (dry basis)
Sulphur content	0.13–0.2 wt-% (dry basis)
Chlorine content	0.4 wt-% (dry basis)
Potassium content	1.7 wt-% (dry basis)
Sodium content	0.2 wt-% (dry basis)
Aluminium content	0.8 wt-% (dry basis)

Pelletising is a rather complicated process and requires drying of the material to be pelletised below about 10% moisture content beside size reduction. Both investment and production costs are considerably higher than for normal SRF production. Due to drying and compacting the energy consumption of the process is rather high. About 15% of the energy content of the product is consumed in the processing. The product is, however, dry and storable, and has a high energy density.

3.6 INDUSTRIAL PRODUCTION WASTE

The forest industry and the packaging industry produce some non-recyclable waste fractions like paper, plastics and wood, which are mainly crushed at their own power plants and co-combusted mixed with the main fuels. The amount of this waste fraction varies annually between 50 000–100 000 t/a. The quality of such waste is usually good (SRF I) as a result of good source separation.

3.7 RECYCLING OF LIQUID PACKAGING

Corenso United Ltd produce core board using recycled fibre from liquid packaging as a raw material, Figure 10. The plant enables the complete exploitation of used packages containing wood fibre, plastic, and aluminium. It will be the first plant in the world that is able to recycle the aluminium in used liquid packaging to create a raw material for foil for its original purpose, while simultaneously exploiting the plastic contained in the packages to produce energy.

Liquid packaging comprises about one-third of plastic and aluminium, which results in a huge landfill load. The fibre material in multi-layer packages can be recycled in core board, and, instead of being dumped as landfill, the aluminium and plastic remaining from the packaging is gasified at Corenso's new gasification plant. The aluminium is recycled as raw material for foil and the plastic fraction used as energy. The new gasification plant helps to fully recycle packaging containing aluminium foil. The method can also be applied to other waste and industrial by-products containing aluminium or other fusible metals.

The new gasification process was developed in cooperation with VTT Processes and supplied by Foster Wheeler Energia Oy. It was commissioned in 2001, and about 40 MW of heat is generated, with an annual total energy production in the region of 165 GWh.

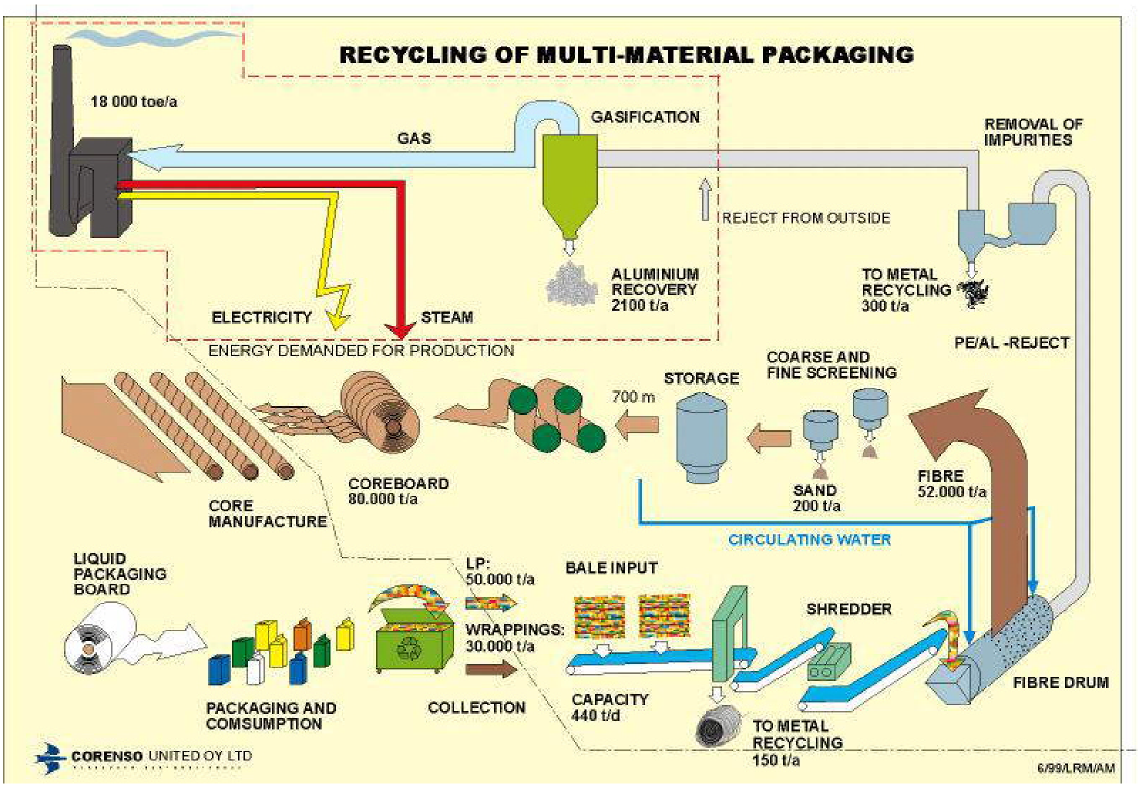

Figure 10. Recyling of liquid packaging, Corenso United Ltd.

4 WASTE PROCESSING AT INCINERATION PLANT

Waste incineration plants consist of four main elements: a waste bunker, the combustion ovens, an energy generation plant and a flue gas treatment process. Large waste-to-energy plants utilising moving grate systems can accept unsorted waste (excluding hazardous waste) from industry and community. Recycling is, however, becoming increasingly popular, and separation processes are used to extract certain materials from the input fuel and from the residual bottom ash.

The VAM waste incineration plant in Wijster, Holland, has a capacity of 720 000 ton/a, producing 48 MW of electric power, Figure 11. The waste coming to the plant has been source separated in a two bin system. Biowaste, mostly green waste from gardens etc., is separated and the “dry” waste in grey bins is brought to the incineration plant.

The plant has three complete incineration lines. The waste is processed before entering the grate fired boilers. Each processing line consists of sieving, pneumatic separation and magnetic removal of ferrous materials.

Figure 11. VAM waste incineration plant, Holland.

The pre-treatment of the waste is designed to remove recyclable material as paper, plastic and metals before the combustion. Each pre-treatment line consists of two big drum sieves, the sieve openings of 190 and 50 mm. Pneumatic separation and magnets are applied between and after the sieves to remove the recyclables. Figure 12 shows the first rotary sieve and part of the pneumatic system.

Figure 12. Waste pre-treatment at VAM plant.

At the VAM plant paper and plastic fractions are separated for recycling. Programmes are going on to further separate the fibre fraction from the plastics, and to separate different plastic qualities (PET, PE etc.). At present (2001), the paper and plastics are baled and partly wrapped in plastic foil and stored at the plant. The bales are sold to cement kilns for energy purpose. Some of the baled product is treated further (sieving, magnetic separation) to remove more of the inert material. Efforts are under way to find new possibilities to recycle the separated fibre and plastic as material.

Due to restriction in capacity, the combustion units are fired only by the fine and lower calorific material separated in the waste pre-treatment. After combustion, the ashes are treated to remove valuable metals.

5 SRF PRODUCTION COMBINED TO ANAEROBIC DIGESTION

Friesland Miljeu Ltd. in Holland is a waste management company owned by 15 municipalities, taking care of waste collection and transport in the area. Avfalsturing Friesland NV, owned by 31 municipalities, focuses on removal of Frisian waste in an environmentally sound way and at lowest possible costs. This company runs a Material Recycling Facility (MRF) including a SRF production plant combined to an anaerobic digestion plant, a treatment plant for demolition wood and composting of garden waste.

The waste treatment and digestion plant was taken into operation in 2002. The capacity of the plant is 230 000 t/a of waste and it consists of three separate digestion lines. The size of each digestion reactor is 3000 m^3. The organic fraction of the waste is separated in the pre-treatment phase and washed in an adjacent washing plant. Part of the biogas is used in electricity production (diesel engines), part is cleaned and sold for other purposes. The flow sheet of the plant is presented in Figure 12.

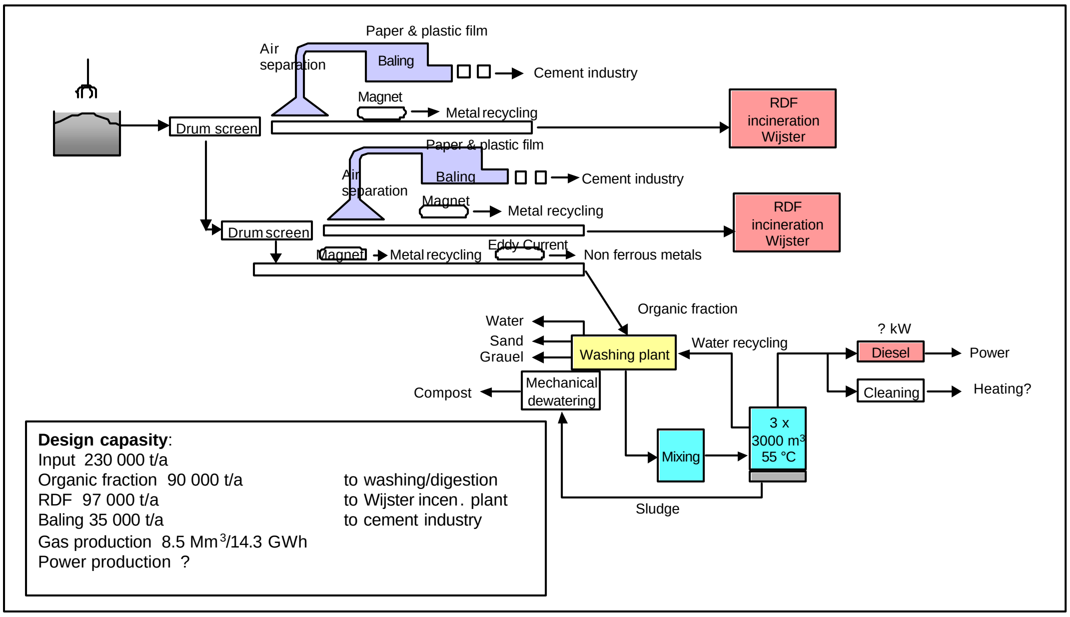

Figure 12. Friesland SRF plant and digestion plant.

The waste treated at the plant is mainly household waste with minor parts of commercial waste from the SME industry. In two parallel process lines fine organic fraction is separated by rotary drum sieves and the light paper and plastic fraction by pneumatic separation, Figure 13. Metals are separated by magnets.

Figure 13. Mechanical separation at Friesland plant.

The fines from the sieving phase are further going through a separation of magnetic and non-ferrous metals before entering a rather complicated washing process. The separated paper and plastic fraction is baled and delivered to waste incineration plants.

The washing plant is designed to remove most of the inert material in the waste, a requirement set by the digestion process. Sand and gravel is removed and used in road construction. The water from the digestion tanks is recycled in the washing plant. The residues from digestion process are mechanically dewatered and composted.

The digestion technology applied in the Friesland plant is based on the Finnish Wasa-process. A similar process was commissioned in Groningen in 2001. The poor quality of the organic waste has caused difficulties in gas production.

The mechanical SRF processing plant is quite massive compared to the technology used in Finland. The plant is completely automated. The aim is to use the separated paper and plastic fractions for material recycling, but currently the baled product was delivered to waste-to-energy plants and cement kilns. Mass flows of the Friesland plant are shown in Figure 14.

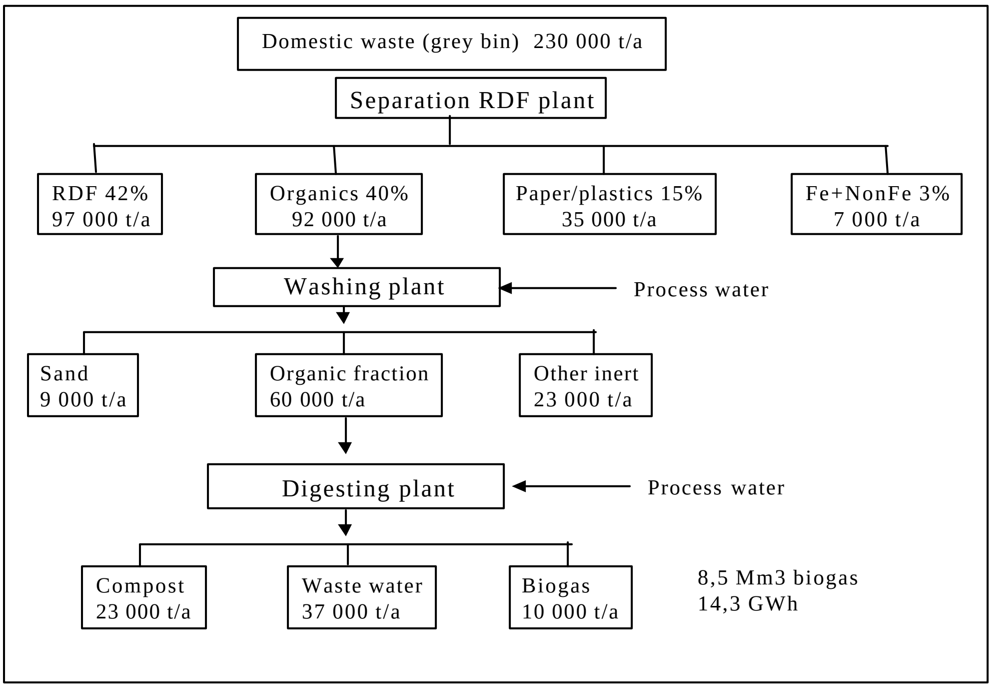

Figure 14. Mass flows of the Friesland plant.

6 SRF PRODUCTION FROM OFFICE WASTE

The SITA Wiebe GmbH plant in Bielefeld, Germany, represents a typical SRF plant for dry commercial waste. The plant processes 60 000 t/a (about 20 t/h) of "office waste" to SRF in a fairly simple process scheme, Figure 15.

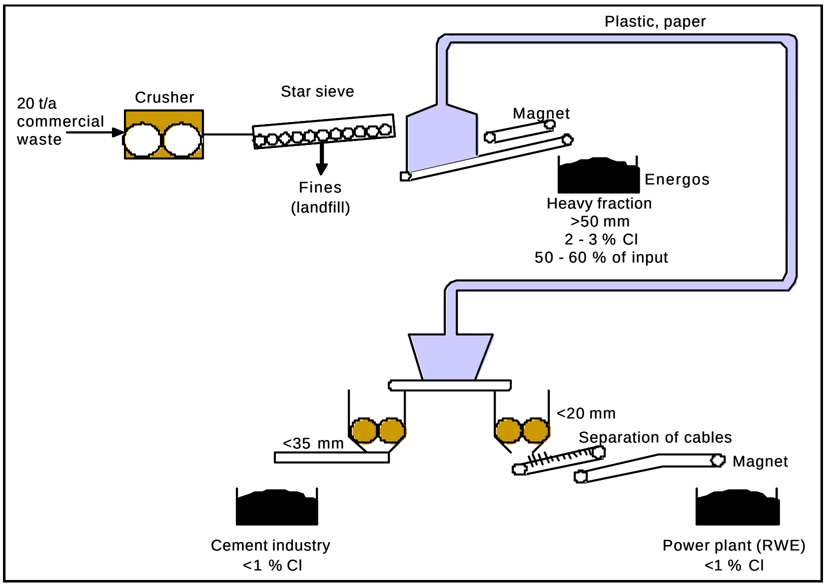

Figure 15. Flow sheet of the SITA plant in Bielefeld, Germany.

The waste is pre-crushed below a particle size of 200 mm in a two-rotor crusher. The fluff is screened on a star screen and the fines are separated and landfilled, Figure 16.

Figure 16. The star screen with discs made of rubber.

The light fraction containing mainly paper and plastics is separated after the screen pneumatically and blown to two WEIMA Super-Jumbo crushers. These are one-rotor crushers equipped with sieve plates. The light fraction is crushed to below 35 mm for cement kilns and below 20 mm for waste-to-energy plants, Figure 17. The course and heavy fraction left from the pneumatic separation is delivered to a nearby ENERGOS waste incineration plant.

Figure 17. Secondary crushing of paper and plastic fraction.

The layout of the SITA plant is quite simple. Built in an existing industry hall it is, however, rather dark, noisy and dirty. Incoming waste contains obviously batches from both commercial and industrial sources. Production costs are reported to be about 70 €/t.

7 CONCLUSIONS

Source separation and material recycling has long traditions in Finland. Fluidised bed combustion and gasification is extensively used in combined heat and power production from various biofuels and fossil fuels. Production of solid recovered fuels in Finland has been developed and utilised to meet the fuel specifications for the fluidised bed co-combustion and gasification energy recovery processes. To avoid fouling and corrosion problems in the boiler it is extremely important that the content of certain impurities, such as chlorine, alkalis and aluminium, can be brought down to acceptable levels.

Fluidised bed combustion is very fuel-flexible and particularly well suited for co-combustion of waste derived fuels. High steam values and consequently high power production efficiency can be obtained when the share of SRF is kept on a level of 10-20%. The system differs in many aspects from the conventional MSW incineration in large grate fired mass burn facilities commonly used in Europe. The environmental performance of both systems is, however, regulated by the Waste Incineration Directive, which sets uniform emission limits to both systems.

Solid recovered fuel production and energy use represent an integrated waste management system, emphasizing a simultaneous and efficient material and energy recovery from waste. Production and energy use must be design in such a way that they fit together. Source separation of household waste makes collection of clean waste fractions, like paper, cardboard, glass, metals etc., possible for extensive material recovery. Processing industrial and commercial waste and the energy fraction of household waste to SRF produces a fairly clean fuel fraction. Several reject streams of the process, i.e. metals and non-ferrous metals, can be recovered. Biological residues and fines are used for composting. The process can be optimised for material recovery and for removing harmful components, like chlorine and aluminium, with regard to efficient fluidised bed combustion.

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