## Possibilities and limitations of circular economy in Turku region

GREEN INDUSTRY PARK 13.02.2023



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# Terminology

Terminology	Explanation
Domestic volume	Amount of (waste)material placed on the domestic market.
Treatment capacity	Capacity to utilize waste as material and energy
Recycling capacity	Capacity to utilize waste as a recovered material (energy use excluded)
End of life textiles	Both reusable textiles and textile waste which has been discarded
Textile waste	Discarded textiles not suitable for reuse



# Introduction

### Background:

Turku region has been identified as a potential location for new circular economy based industry. The existing infrastructure and good logistical connections (railway, fairway and highway) enables good accessibility domestically and internationally.

The shut down of Neste oil refinery in Naantali has leaved potential industrial area available for new kind of activity. In previous study<sup>1</sup> textile and plastic waste recycling and biorefining has been identified as the most potential concepts for the area.

### The aim of this study:

- 1. Identify major recycling areas for textile waste, paper and cardboard waste as well as plastic packaging waste in Finland, Sweden and Baltics.
- Provide an overview for waste stream volumes (import, export, domestic volume and recycling capacity) of textile, plastic, and paper and cardboard waste and give an estimation of the treatment capacity need in Finland, Sweden and Baltic.
- 3. Assess the potential of Turku region for possible new waste treatment facility investments compared to other locations in Sweden and Baltics.

The goal is to identify the current state of predefined waste material streams and recognize which one(s) would result in highest added value, in the case of, further processing takes place in the Turku region.



<sup>1</sup>AFRY - Conceptual design of a bio- and circular economy based business ecosystem for the industrial area in Naantali



# Business environment description

As a result of increasing living standards, the increase in material consumption leads to problematic waste flows. Due to the universal nature of the phenomena, solving this type of global challenges often benefits from an international cooperation. It is estimated, that 50 % of total greenhouse gas emissions and 90 % of biodiversity loss and water stress are due to the extraction and processing of resources.

To tackle this issue and to save natural resources, there is need to create new business models in compliance with circular economy.

In a circular economy, the economic growth is disconnected from the use of virgin materials and resources. One of the most important goals of the circular economy is to extend the useful life of materials by creating supporting business environments.

The transition towards a circular economy, especially for the waste streams in focus in this study (plastic packaging waste, textile waste, paper and cardboard waste), is steered by various domestic, sub-international and international regulations, policies and strategies.

# Circular Economy Guidance and Strategies

EU's regulations and policies have a remarkable role for unifying areas's legislation and creating common actions.



# Waste Framework Directive (EU 2018/851)

Waste management concepts and definitions (such as definitions for waste, recycling and recovery) are set in Waste Framework Directive.

Directive requires that waste be managed

- without endangering human health and harming the environment
- without risk to water, air, soil, plants or animals
- without causing a nuisance through noise or odours
- without adversely affecting the countryside or places of special interest

Directive defines when waste ceases to be waste and becomes secondary raw material. It also explains how waste and by-products differ.

Targets in the Waste Framework Directive:

- By 2020, the preparing for re-use and the recycling of waste materials (such as paper, metal, plastic, glass) from households shall be increased to a minimum of overall 50 % by weight.
- By 2020, the preparing for the re-use, recycling and other material recovery, including backfilling operations using waste to substitute other materials, of non-hazardous construction and demolition waste shall be increased to a minimum of 70 % by weight.
- By 2025, the preparing for re-use and the recycling of municipal waste shall be increased to a minimum of 55 %, 60 % and 65 % by weight by 2025, 2030 and 2035 respectively.

#### Foundation of the EU waste management:

Waste prevention is the most preferred option of waste management, and disposal of the waste is the last option for waste management.



# Location survey



# Finland

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Location	
1. Turku region	LSJH and Rester (textile waste recycling), Salo WtE plant, Naantali (Neste) refinery area
2. Porvoo region	Borealis Polymer (possible plastic chemical recycling), Lamor & Resiclo (planned plastic chemical recycling plant), Neste, Port of Kilpilahti
3. Kotka region	Kotkamills (paper deinking plant), Korkeakoski cardboard plant (cardboard recycling), Kotka Energia WtE plant, Port of HaminaKotka
4. Pori region	Corex Cardboard mill (cardboard recycling ), L&T Muoviportti (Merikarvia, recycling of industrial plastics), Port of Pori
5. Riihimäki	Riihimäki: Fortum (Packaging plastic recycling and WtE plants)
6. Kemi	Infinited Fiber (planned, textile waste recycling), Port of Kemi
7. Oulu	Oulu WtE plant, Port of Oulu, Syklo's sorting plant (commercial, industrial, construction & demolition waste), Stora Enso cardboard and pulp mill (no cardboard recycling)



# Sweden

Location	
1. Umeå	Paper, carton and pulp (SCA), WtE.
2. Sundsvall	Waste to Energy, aluminium (Kubal), Ortviken industrial park; pulp (SCA) and textile recyling (Renewcell)
3. Motala	Site Zero plastic recycling, metal industry, plastic manufacturing, railway.
4. Norrköping	Recycled board and paper (Fiskeby), WtE, PET plastic recycling (Veolia), paper mill (Holmen Braviken), port of Norrköping
5. Nymölla	Paper and TreetoTextile (Stora Enso), port of Karlshamn
6. Mörrum	Pulp and textile recycling (Södra Cell), port of Karlshamn
7. Malmö	WtE, textile recycling (Siptex), Malmö Industrial Park Copenhagen Malmö Port
8. Halland	WtE, plastic recycling (Stena Recycling), paper mill (Stora Enso Hylte), Halmstad Port
9. Port of Gävle	Largest port in eastern Sweden



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# Baltic states

Location	
1. Vilnius region (Lithuania)	AB Plasta (polyethylene waste recycling), ECSO (polyethylene film recycling), Somlitam (various LDPE films recycling), CountryPlast (PET waste recycling), Repro-PET (PET bottles recycling, Lentvaris), Maldis (polyethylene film recycling, Madziunai), Grigeo Recycling (Second-hand paper collection and preparation for recycling), Lietuvos Energija (WtE and bio cogeneration plant)
2. Klaipeda (Lithuania)	Vitopas (industrial and packaging plastic recycling), NEOGROUP (industrial PET scrap recycling), GREN (WtE cogeneration plant), port of Klaipeda
3. Jelgava region (Latvia)	PET Baltija (PET bottles recycling), Grindplast (HDPE waste recycling), Nordic Plast (polyethylene packaging waste recycling, Olaine)
4. Tallinn region (Estonia)	Orkos (LDPE recycling, Maardu), WeeRec (polyethylene and polypropylene waste recyling, Kiiu), Eesti Energia (WtE CHP plant, Maardu), port of Tallin
5. Tartu (Estonia)	Lipland (LDPE, HDPE, LLDPE, MDPE, polyprolyene waste recycling)
6. Ceres Parish (Latvia)	Galangal (LDPE, HDPE, agrofilm, bigbags, PET cardboard and MIX paper recycling)
7. Panevezys region (Latvia)	Poliforma (plastic recycling), Meksas (plastic recycling, Krekenava)
8. Räpina (Estonia)	Räpina Paberivabrik (manufacturing paper, cardboard and construction carton products from recycled materials)
9. Rapla (Estonia)	TRV Plast (plastic recycling and production)
10. Kekava Parish (Latvia)	Clear R (LDPE, HDPE and PP-big bags recycling)
11. Cesis (Latvia)	Balticfloc (wastepaper recycling)
12. Kaunas (Lithuania)	GREN (WtE cogeneration plant)



## Material flow analysis: Plastic packaging waste



# Plastic recycling value chain





# Plastic packaging plastic waste: Finland



<sup>1</sup>Finnish customs Uljas database <sup>2</sup>Packaging waste statistics <sup>3</sup> Estimate based on environmental permits and news



# Plastic packaging waste: Finland

- Total amount of generated plastic waste in Finland is estimated to be 332 000 t/a, of which appr. 130 000 t/a is plastic packaging waste.
- Of the plastic packaging waste, less than 1/3 is generated in commercial activities and more than 2/3 in households.
- Collected amount of plastic packaging waste from households has increased rapidly after separate collection was started in 2016. Collected amount has increased from under 20 000 t/a to over 50 000 t/a in just 4 years.
- Information on collected amount of plastic waste from industry and construction is not available.
- Recycling rate for non-refund packaging waste in Finland in 2021 was 23,70 %, and target for 2025 is 50 %.<sup>1</sup>
- Recycling rate of commercial plastic packaging waste is approximately 40 %.<sup>2</sup>

- The biggest plastic recycling plants in Finland are currently operated by Fortum Waste Solutions in Riihimäki (packaging waste from households) and L&T Muoviportti in Merikarvia (commercial and industrial waste).
- Smaller plants are located for example in Lappeenranta (Wimao) and Laihia (Pohjanmaan Hyötyjätekuljetus).
   Salpakierto in Lahti has some sorting capacity suitable for plastic waste. There are also other smaller plants but it is difficult to get public information on the production capacities. However, the capacity is not significant on national level.
- Amount of generated plastic waste in agriculture in Finland is appr. 12 000 t/a.  $^{3}$
- Several projects for chemical plastic recycling are in pilot or development phase in Finland: Lamor & Resiclo (Kilpilahti, Porvoo), Neste (Porvoo), Borealis (SPIRIT-programme), VTT / Olefy Tech (Espoo), Finnfoam (Salo), Pohjanmaan Hyötyjätekuljetus (Laihia)

<sup>1</sup>Suomen uusiomuovi, Finnish Plastics Recycling Ltd <sup>2</sup> YLE <sup>3</sup> Ministry of Agriculture and Forestry



# Plastic packaging waste: Finland

- Fortum Waste Solutions in Riihimäki is the main recycling plant in Finland, currently capable of processing approximately half of the collected post-consumer packaging waste (nonrefund packaging). Current capacity of the plant is appr. 18 000 - 20 000 t/a.
- Fortum has received environmental permit that allows expansion of the plant to capacity 80 000 t/a. Investment decision and the coming capacity haven't been announced yet.
- Chart on the right column shows the needed increase in collection rates, in order to reach the targeted recycling rate for non-refund packaging waste for 2025 (50 %).
- Conclusion: More treatment capacity and better recycling efficiency are needed. Finnish Plastics Recycling Ltd, the authorized extended producer responsibility organization in Finland has been stating this frequently.<sup>1</sup>
- **Possibility:** Recycling of the currently non-recycled streams.
- The recycling capacity is expected to increase significantly in near future if planned chemical recycling plants (e.g. Neste) will be realized and are capable of recycling currently nonrecyclable streams.

<sup>1</sup>Suomen uusiomuovi, Finnish Plastics Recycling Ltd 17 13/02/2023 POSSIBILITIES AND LIMITATIONS OF CIRCULAR ECONOMY IN TURKU REGION



 $\ast$  With current produced volumes, 50 % recycling rate would correspond to 64 000 t/a recycled plastic.

\*\* If Fortum builds the total permitted capacity 80 000 t/a, the recycling rate of the facility needs to be appr. 80 % to reach required 50 % recycling rate.

\*\*\* With current efficiency, collection rate would need to be close to 90  $^{\circ}$ 



Recycling of non-refund plastic packaging

# Plastic packaging waste: Sweden

Import (2020) 115 000 t/a Export (2020) 130 000 t/a Domestic volume 220 000 t/a

n treatment capacity in

Plastic waste for recycling is imported mainly from Norway. This includes other than packaging waste. Green-listed plastic waste for recycling is exported mainly to Lithuania and Germany. This includes other than packaging waste.

Source: Fråne et al. 2022. Kartläggning av plastflöden i Sverige 2020. Naturvårdsverket rapport 7038. ISBN 978-91-620-7038-0

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Amount of plastic packaging placed on the market in Sweden. Excluded are redeemable PETbottles (28 000 t/a) and private imports.

All plastic on the Swedish market is estimated at least 660 000 t/a and all plastic waste at 644 000 t/a, of which almost 90 % to energy recovery.



Recycling

capacity

100 000 t/a



## Plastic packaging waste: Sweden

- Total amount of plastic waste separately collected in Sweden is 340 000 t/a, of which 103 000 t is plastic packaging waste (excluding redeemable PET-bottles).
- The recycling rate of plastic packaging is 27 % (excluding redeemable PET-bottles).
- Consumer packaging waste is sorted in Motala (51 000 t/a 2020, of which 33 000 reject) by NIR-technology (PP, HDPE, LDPE, PET). Sorted material is exported, mainly to Germany, for granulation and recycling.
- Omni Polymers recycling plant for plastic packaging waste in 2022, wash and granulation of recycled plastic packaging waste. Annual production capacity 15 000 t polyolefin granulat.
- Plastic recycling (sorting to pellet) for industrial and agricultural plastic by Stena Recycling (10 000 t/a), Novoplast and Reviva Plastics (12 000 t/a).
- Van Werven hard plastics sorting capacity 45 000 t/a.

Source: Fråne et al. 2022. Kartläggning av plastflöden i Sverige 2020. Naturvårdsverket rapport 7038. ISBN 978-91-620-7038-0

- A new plastic recycling plant in Motala Site Zero, is expected to start operations in 2023. It will double the recycling capacity to 200 000 t/a plastic packaging and will sort also EPS, PS and PVC. In 2025 also washing and granulation will be in place. The chemical plastic recycling plant will be able to handle all of Sweden's consumer plastic packaging.
- Borealis Stenungsund chemical plastic recycling is estimated to start in 2025.
- Important gaps in knowledge includes how sorted plastic waste from the manufacturing industry is treated, how large the amounts of plastic is in generated mixed operational waste and sorting residues in 2020, and how exported waste is treated abroad.
- Conclusion: Most of the recycled plastic is currently exported, and the Swedish market can therefore be a source for recycled material for recycling processes. However, new facilities for sorting, processing and mechanical and chemical recycling are planned to be built in Sweden. The recycling capacity that would be optimal for different recycling facilities or technologies in Sweden is not known. However, there should be satisfactory conditions for creating a national or Nordic, recycling system of the most common plastic flows.



## Plastic packaging waste: Baltic states

Import (2020/2021)127 000 t/a

The biggest plastic waste importer among the Baltic States is Lithuania. Both Latvia and Lithuania have well developed plastic recycling systems.

Export (2021) 71 000 t/a

Domestic volume (2019/2020)168 000 t/a

Some of the plastic waste will be exported to other Baltic states. Both Latvia and Lithuania export less than a half of the amount of plastic waste than what they import, controversially to Estonia that exports 3 times more than what it imports.

Unable to exclude PET waste from the figure, due to insufficient data.

Recycling capacity (2022)

at least

90 000 t/a

Includes known capacities approximately 40% of the operating treatment facilities and excludes the capacity of treatment of PETs.



## Plastic packaging waste: Baltic states

- In 2019, the total amount of domestic plastic waste were 83 000 tons in Lithuania and 42 000 tons in Latvia. In Estonia, the same value was 43 000 tons in 2020. Redeemable PETbottles are included in the domestic volume figures.
- Lithuania has one of the highest plastic packaging recycling rates in the EU. In 2019, the recycling rate peaked at 70% and has slightly decreased to 56% in 2020, which is partly due to restricted rules in the reporting system. In the same year, the recycling rates were 41% in Estonia and 36% in Latvia.
- Latvia and Lithuania both have well developed plastic waste recycling and treatment systems. Both countries import 2 times more plastic waste than what they export, controversially to Estonia that exports 4 times more than it imports. Some of the generated plastic waste in Estonia will be exported to Latvia and Lithuania.

- Together, there are at least 16 companies recycling and treating plastic waste in the Baltic states, of which 8 are located in Lithuania, and 4 both in Latvia and in Estonia. In addition, there are 4 facilities recycling and treating PET waste, of which 3 are located in Lithuania.
- Only 7/16 of the mentioned companies have stated their annual waste treatment capacities. In total, these 7 facilities alone can treat up to 90 000 tons of plastic waste annually. In addition, 2 out of 4 PET waste treating companies stated as their annual treatment capacity as 70 000 tons of PET waste in total. Considering, more than half of the capacity values missing, the actual treatment capacity can be assumed significantly higher.
- The largest (stated) treatment capacities (of non PET-waste) are in AB Plasta (30 000 tons) and in ECSO (22 400 tons) both located in Vilnius, Lithuania.



## Plastic packaging waste summary

Balance = domestic volume + import - export\* Recycling capacity deficit = Balance - recycling capacity (current or expected)

## **Finland**

Balance: 112 000 t/a

Current recycling capacity deficit: 93 000 t/a

Expected recycling capacity deficit in the future: -435 000 t/a

## <u>Sweden</u>

Balance: 205 000 t/a

Current recycling capacity deficit: 105 000 t/a

Expected recycling capacity deficit in the future: -55 000t/a

## **Baltic states**

Balance: 225 000 t/a

Current recycling capacity deficit: 135 000 t/a

Expected recycling capacity deficit in the future: n/a

\*Note: exported volume has been substracted from recycling capacity deficit in this calculation. Exported amount could also be seen as additional raw material for new recycling industry in the future.



# Plastic packaging waste conclusions

- Incineration of plastic packaging waste is not taken into account in material flow analysis.
- Total recycling capacity estimation is problematic as different plastic grades need different kind of processing. The presented recycling capacity does not take into account different plastic grades.
- Plastic packaging waste data (domestic volume, recycling, import/export) from Baltic is scattered/uncertain/not available and it includes major uncertainties.
- Sorting capacity can be a bottleneck for plastic recycling
- Large chemical plastic recycling plants have been planned in Finland and Sweden, but the realization of the investments contains uncertainties.

## MATERIAL FLOW ANALYSIS **Plastic packaging waste import-export flows**



# Recycling companies for plastic (packaging) waste

Finland	Sweden	Baltic states		
Fortum	Svensk Plaståtervinning (Site Zero)	Orkos Meksas		CountryPlast
L&T	Borealis Polymers	Weerec	Vitopas	
Salpakierto	Hällstorp Recycling	Lipland	NEOGROUP	
Lamor & Resiclo	Rez Power	TRV Plast	Polylema	
VTT Finland, Olefy tech	Eastman	Clear R	Maldis	
Neste	Stena Recycling	Galangal	Repro-PET	
Finnfoam	FTI	Grindplast	AB Plasta	
Wimao		Nordic Plast	ECSO	
Borealis Polymers		Polifoma	Somlita	



# Material flow analysis: Paper and cardboard waste





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## Paper and cardboard waste: Finland

Import (2021<sup>1</sup>)

48 000 t/a of which paper 9000t and cardboard 39 000t

Imported mainly from Sweden and Estonia.

<sup>1</sup>Finnish custom statistics (Uljas) <sup>2</sup> PIRELY packaging waste statistics <sup>3</sup>Environmental permits Export (2021<sup>1</sup>)

125 000 t/a of which paper 84 000 t and cardboard 41 000t

Exported mainly to Germany and Sweden.

Domestic volume(2019<sup>2</sup>)

187 000 t/a paper\*\*

264 000t/a\* cardboard

\*amount of collected paper waste \*\*Amount of cardboard packages to market in Finland Recycling capacity (2022<sup>3</sup>) Paper: 158 000t/a Cardboard: 389 000 t/a

Maximum treatment capacity of recycled paper and cardboard in Finland.



#### MATERIAL FLOW ANALYSIS

# Paper and cardboard waste: Finland

- Treatment capacity for recycled paper treatment has been decreased due to shut down of Kaipola paper mill in 2021. Paper waste export has been increased since (mainly to Germany and Sweden)
- Maximum paper recycling capacity seems to cover needs, but assumably not all calculated capacity is available
- Cardboard waste recycling seems to have additional capacity in Finland

Data source: Finnish customs statistics (Uljas database)

## Import and export statistics for paper and cardboard waste in Finland

Recycled paper

■Import ■Export



Cardboard waste





## Paper and cardboard waste: Sweden



Imported mainly from Norway, Denmark, Finland.

Skogsindustrierna website

Source:

Exported mainly to Germany.

### Domestic volume

767 000 t/a -149 000 t/a paper waste\* -618 000 t/a cardboard packaging waste\*\*

\*Separately collected paper (2021) \*\*separately collected consumer cardboard packaging waste (2021)\*\*

Recycling capacity 900 000 t/a

Estimated total treatment capacity.



Naturvårdsverket, Sveriges återvinning av förpackningar-rapport, 2021

# Paper and cardboard waste: Sweden

- Treatment capacity for recycled paper treatment has been decreased since 2013, and 2020-2021 a number of paper mill have been shut down (SCA Ortviken Sundsvall, Stora Enso Kvarnsveden). In some remaining paper mills in Hylte and Norrköping is recycled paper no longer used.
   Paper waste export has been increased since (mainly to Germany).
- Maximum paper and cardboard recycling capacity seems to cover needs, but assumably not all calculated capacity is available.
- Recycled paper and consumption of graphic paper is decreasing, but paper and cardboard packaging is increasing. These are global trends.
- A continuing need for recycling and production of paper packaging, including recycling of other material (plastic and aluminium) in the packaging.







## Paper and cardboard waste: Baltic states



1 Trademap statistics (2020-2022)

2 Eurostat statistics

## Paper and cardboard waste: Baltic states

- In the Baltic states, the total annual amount of paper and cardboard waste was approximately 430 000 tons in 2020, of which Lithuania is responsible for about 70% and Estonia only for 5%.
- Lithuania has the highest shares and volumes in terms of import, export and domestic volume among the Baltic states.
- Latvia is the only Baltic country whose exports exceed the amount of its imports and domestic paper and cardboard waste volume.
- The two of the three discovered paper and cardboard recycling facilities correspond to 57 000 tons of annual recycling capacity.
  - Räpina Paberivabrik in Räpina, Estonia (18 000t/a)
  - Grigeo Recycling in Vilnius, Lithuania (39 000t/a)
  - In addition, Balticfloc in Cesis, Latvia (n/a)
- In general, recycling capacity is poorly available.



## Paper and cardboard waste summary

Balance = domestic volume + import - export\* Recycling capacity deficit = Balance - recycling capacity (current or expected)

## **Finland**

Balance: 375 000 t/a

Current recycling capacity deficit: -172 000 t/a

Expected recycling capacity deficit in the future: -172 000 t/a

## <u>Sweden</u>

Balance: 667 000 t/a

Current recycling capacity deficit: -233 000 t/a

Expected recycling capacity deficit in the future: -233 000 t/a

## **Baltic states**

Balance: 188 000 t/a

Current recycling capacity deficit: 131 000 t/a

Expected recycling capacity deficit in the future: n/a

\*Note: exported volume has been substracted from recycling capacity deficit in this calculation. Exported amount could also be seen as additional raw material for new recycling industry in the future.



## Paper and cardboard waste conclusions

- Total recycled paper amount is expected to decrease over time due to decrease of printed media.
  - The recycling capacity can be expected to decrease in the future
- Packaging cardboard amount has been globally increased and the trend is expected to continue in near future.
  - It seems, that Finland and Sweden has excess recycling capacity for cardboard waste
- Most of the recycling capacity for paper and cardboard waste is located in Finland and Sweden (of the countries in consideration). Shut down of UPM Kaipola paper mill caused major decrease in Finland's paper recycling capacity in 2021.

MATERIAL FLOW ANALYSIS

## Paper and cardboard waste import-export flows



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# Recycling companies for paper and cardboard waste

Finland	Sweden	Baltic states
Metsä Tissue	Fiskeby Board	Räpina Pabervabrik
Essity	Lessebo Paper	Grigeo Recycling
Termex-Eriste	SCA	Balticfloc
Suomen Selluvilla	Holmen Paper	Stora Enso Packaging Baltics
Ekoeriste	Sylvamo	
Kotkamills		
Stora-Enso		
Corex		



# Material flow analysis: Textile waste

URKU REGIO



MATERIAL FLOW ANALYSIS

# EU Guidance for textiles

The EU strategy for Sustainable and Circular Textiles implement commitment made under the European Green Deal, the new Circular Economy Action plan and the Industrial Strategy.

Some of key actions in the Textile Strategy<sup>1</sup>:

- Design requirement for textiles to make them last longer, easier to repair and recycle
- Requirement on minimum recycled content
- Reverse overproduction and overconsumption
- Propose mandatory Extended Producer Responsibility for textiles with ecomodulation of fees
- Restrict the export of textile waste

Waste Directive required member states to set up the separate collection for textile waste at least by 1/2025.<sup>2</sup>

• In Finland, the separate collection has implemented from 01/2023

<sup>1</sup>European Comission 2022. Sustainable and Circular Textiles by 2030. Factsheet 30.11.2022. <sup>2</sup>Waste Framework Directive 2018/851

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MATERIAL FLOW ANALYSIS

## Textile recycling value chain



Modified from: Palmgren & Hinkka. Kustannusmalli poistotekstiilin keräyksestä, lajittelusta ja kierrätysprosesseista. Telaketju 2021. Available: https://telaketju.turkuamk.fi/uploads/2021/03/eade3116-telaketju-webinaari\_2021\_3\_palmgren.pdf



## Textile waste: Finland

Import (2019<sup>1</sup>) 6 t/a

Imports are mainly from Poland (staple fiber) and Denmark (cotton thread waste). Reusable textiles exported mainly by charity organisations. Destination of separately collected textile

waste is not known.

Export (2019<sup>1</sup>)

14 t/a separately

collected textile

waste &

14 500 t/a

reusable textiles

Separate collection of textile wastes expanded in 2023: The amount of textiles in mixed waste will decrease and same time the separately collected textile waste will increase.

Domestic volume (2019<sup>1</sup>)

85 000 t/a end of

life textiles

-15 000 t/a material

recovered textile waste

- 18 000 t/a reusable textiles

- 52 000 t/a textiles for energy recovery Sorting capacity (in 2022<sup>2&3</sup>)

11 000 t/a

Sorting and recycling capacity will increase in near future.

<sup>1</sup>Textile flows in Finland 2019. <u>https://julkaisut.turkuamk.fi/isbn9789522167873.pdf</u> <sup>2</sup>Environmental permit of Rester's plant <sup>3</sup>Environmental permit of LSJH's pilot plant

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## Textile waste: Finland

- Total amount of generated textile waste in Finland is estimated to be appr. 67 000 t/a, which include textile waste to material recovery (appr. 15 000 t/a<sup>1</sup>) and textiles in mixed waste and to energy recovery (52 000 t/a<sup>1</sup>).
- LSJH and Rester in Paimio are the only companies in Finland with textile sorting lines. Current sorting capacity is appr. 11 000 t/a<sup>2,3</sup> and in the future 31 000 t/a<sup>3,4</sup> 38 000 t/a<sup>2,3</sup>.
  - LSJH's current capacity is 5000 t/a and in the future 19 900 t/a
  - Rester's current environmental permit allow to handle end-of-life textiles 6000 t/a. They received new environmental permit that allows expand the capacity to 18 500 t/a. They have informed that their capacity is 12 000 t/a end-of-life textiles.
- If recycling rate of textiles increase to 50 % (from 22,3 % when only include textile wastes, 67 000 t/a), amount of recycled textile waste will be reach the 33 500 t/a capacity of sorting.
- **Conclusion:** Future sorting capacity seems to be designed to cover potential collection capacity. Recycling rate of textile waste need to be about 60 % before there is need to increase the sorting capacity.

<sup>1</sup>Textile flows in Finland 2019. <u>https://julkaisut.turkuamk.fi/isbn9789522167873.pdf</u> <sup>2</sup>Environmental permit of Rester's plant <sup>3</sup>Environmental permit of LSJH's pilot plant <sup>4</sup>Rester's waste textile processing facility opened its doors in Paimio 2021. https://www.stjm.fi/uutiset/resterinpoistotekstiilien-kasittelylaitos-avasi-ovensa-paimiossa/



Estimation about textile waste recycling in Finland

- Separate textile waste collection begin in 2023
- Year when sorting capacity reach maximum is unknown.
- Textile waste include wastes from both companies and municipalities.



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# Textile waste: Finland

Textiles can be recycled by using it as material (e.g. using fabric as a material), or recycling it mechanically or chemically to fibres, or using it as thermoplastic composites or in thermoplastics.

Currently, LSJH and Rester process textile waste mechanically to fibres. They sort textiles by textile types and process textile fibers for use by other companies. Current sorting capacity is appr. 11 000 t/a and in the future 31 000 t/a - 38 000 t/a. Most likely, the amount of produced fibres are less than this.

Planned production facilities include fabric manufacturing of Infinited Fiber Company (capacity 36 500 t/a of cellulose-based fibers, chemical recycling, textile type unknown), yarn spinning of Pure Waste Textiles (capacity unknown, mechanical recycling) and fabric manufacturing of Spinnova (raw materials recycled share unknown, main material is pulp so recycled raw material would be cellulose-based fibers).

**Conclusion:** Based on this knowledge, consumption of cellulose-based fibers will be high. On the other hand, there is no known planned production for synthetic fibers. Some material distribution of textile waste is presented in the presentation from work '*Cost model of removal text collection, sorting and recycling processes*' by Palmgren R and Hinkka V, 2021. Because textiles contain usually different types of textiles, the share of synthetic fibres from textile waste varies from 11 % to 21 %.

Possibility: Textile production from recycled synthetic fibers.

Material distribution of textile waste (Palmgren & Hinkka 2021)



MATERIAL FLOW ANALYSIS

# Textile waste: Finland

Total amount of collected reusable textiles was 22 500 in 2019. These textile wastes was treated as follows:

- Export: 66,8 % (appr. 15 000 t/a)
- Energy recovery: 16,6 % (appr. 4 000 t/a)
- Reuse (in Finland): 16,2 % (appr. 4 000 t/a)
- Material recovery: 0,4 % (appr. 100 t/a)

Reused share of the exported textiles is not known because it's not clarified if exported amount is sorted textile waste or not. The most important export destinations in volumes are Estonia (31 %), Lithuania (23 %) and Oman (20 %) (2019).



# Textile waste: Sweden

Import n/a

## Export 28 000 t/a reusable textiles

No information on import of imported textile waste. Sorted textile fiber for recycled textile production is imported mostly from Asia.

Most of reusable textiles collected by municipality and charities is exported for sorting, mostly to Baltic and Poland. Domestic volume

130 000 t/a end of life textiles -13 000 t/a separately collected textile waste - 38 000 t/a reusable textiles - 85 000 t/a textiles in mixed waste Recycling capacity 69 000 t/,a Sorting capacity 25 000 t/a

Separate collection of textile wastes will expand in 2025: The amount of textiles in mixed waste will decrease and same time the separately collected textile waste will increase. Treatment capacity for recycled textile is being built, but most material is imported. Domestic textile loops are limited by domestic sorting capacity.



## Textile waste: Sweden

- 12 300 tons of textile waste was collected separately in 2021 from households (3 300 t) and industry.
- The total amount of textile waste is estimated at around 130 000 t/a, the majority ends up as mixed waste to energy.
  - According to SCB statistics on material recycling, in 2020 under 3 000 t textile was recycled.
- Textiles collected by charities is estimated at 38 000 t/a, of which some is reused domestically (8 000 t/a), and a majority (28 000 t/a) is exported for reuse, recycle (est. 20 %) or disposal.
- Most of the separately collected EOL textiles are exported as unsorted textiles to eastern Europe (Poland, Lithuania).

- Renewcell chemical textile recycling in Kristinehamn has a capacity of 7 000 t/a, and the new plant in Ortviken, Sundsvall, will have the capacity of 60 000 t/a.
- Södra Cell plant in Mörrum in southern Sweden is recycling around 30 t/a, with new investments and a target of processing 25 000 t/a recycled textiles.
- Both Renewcell and Södra Cell is fiber-to-fiber, an imports sorted recycled textiles from mostly Asia, amount unknown.
- In Malmö, Siptex textile sorting plant has the capacity of sorting 24 000 t/a textiles. Wargö Innovation pilot plant sorting capacity 500-1000 t/a.



MATERIAL FLOW ANALYSIS

## Textile waste: Baltic states

Import 90 000 t/a

Biggest imports from the UK, the Nordic countries and between the Baltic states.

Export (2020) 70 000 t/a

Most of the imported textile waste will be exported after being sorted to countries, such as, Pakistan, Russia and Ukraine.

## Domestic volume

- 64 000 t/a end of life textiles
-7 000 t/a separately collected textile waste
- 4 000 t/a reusable textiles
- 56 000 t/a textiles in mixed waste

The levels of domestic consumption of new clothes are relatively low in the Baltic states, but are rapidly increasing. Most of the textile waste is collected as mixed waste. Recycling capacity

unknown

Treatment capacity in Baltics consists of sorting and preparing textile waste to be exported to other countries. No mechanical or chemical recycling capacity identified.



## Textile waste: Baltic states

- The total generated amount of end-of-life textiles is approximately 64 000 tons in the Baltics annually. From this amount, only 7000 tons are collected separately, of which only 4000 tons are considered reusable. This results in almost half of separately collected textiles ending up either to landfills or incineration. Together, more than 55 000 tons of textile waste end up to either incineration or landfills each year.
- Baltic states form 3 out 4 biggest importers of used textiles in EU per capita. Together the Baltic states import over 90 000 tonnes of used textiles annually, of which the biggest importer is Lithuania, responsible for 60 000 tonnes. Approximately one quarter of the imported textile waste comes from the Nordic countries. Approximately 60% (60 000 tons) of the imported textiles are estimated to be reusable.
- Most of these textile send up sorted in the Baltic states from which they will be further exported in other countries, such as Pakistan, Ukraine, Togo and the Russian Federation, where they will be recycled or/and reused. Approximately 25% of the imported textiles end up being reused in the Baltics, and the remaining 10% will either end up to landfills or incineration.

- Currently, there is a lack of capacity to recycle post-consumer textile and/or there is no textile recycling industry at all. One of the reasons is the high costs of recycling technology.
- The level of consuming new clothes is low in Latvia and Lithuania but is continuously increasing. Second-hand clothing consumption, on the other hand, corresponds up to 1/6 to 1/3 of all consumption.
- Currently, the quality and condition with imported end-of-life textiles is significantly higher compared to the increasingly weakening quality of domestic, separately collected end-of-life textiles in the Baltic states. This results in lack of motivation for investors to invest in recycling technologies.
- The Baltic states is part of the Nordic circular textile ecosystem.



## Textile waste summary

Balance = domestic volume + import - export\* Recycling capacity deficit = Balance - recycling capacity (current or expected)

## **Finland**

Balance: 70 000 t/a

Current sorting capacity deficit: 59 000 t/a

Expected sorting capacity in the future: 39 000 t/a

Current recycling capacity deficit: 70 000 t/a

Expected recycling capacity deficit in the future: 34 000 t/a

## <u>Sweden</u>

Balance: 102 000 t/a

Current sorting capacity deficit: 77 000 t/a

Expected sorting capacity in the future: n/a

Current recycling capacity deficit: 33 000 t/a

Expected recycling capacity deficit in the future: 17 000 t/a

## **Baltic states**

Balance: 27 000 t/a

Current sorting capacity deficit: n/a

Expected sorting capacity in the future: n/a

Current recycling capacity deficit: n/a

Expected recycling capacity deficit in the future: n/a

\*Note: exported volume has been substracted from recycling capacity deficit in this calculation. Exported amount could also be seen as additional raw material for new recycling industry in the future.



## Textile waste conclusions

- Textile waste recycling has hardly started, recycling capacity will increase in Finland and Sweden in the near future.
  - More capacity will be needed
- Sorting capacity can be bottleneck for textile recycling. A lot of sorting is done in Baltic states but exact capacity information is poorly available.
- Significant amount of textile waste ends up in energy recovery.
- Planned textile recycling facilities in Finland and Sweden focuses on the treatment of cellulose-based fibers while synthetic fiber based textiles have demand for recycling options.



## End of life textiles import-export flows



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# Recycling companies for textile waste

Finland	Sweden	Baltic states
Rester	Renewcell	
LSJH	Siptex/Sysav	
Infinited Fiber	Wargö Innovation	
Spinnova	Södra	
Pure Textile Waste		



# Comparison of alternatives



# Comparison criteria

Location and logistics	Access and availability to domestic and foreign markets; port, rail and road connections
Existing recycling industry in the area	Existing or planned recycling industry in the area are considered as benefit.
Supporting industry in the area	Possible existing or planned supporting industry such as WtE or other material utilization possibilities (industrial symbiosis and synergies) in the area are considered as benefit.
Infrastructure	Infrastructure relevant to industrial activities (water supply- and energy infrastructure), accessible renewable energy sources etc.
Material availability	Domestic material availability and possibility to transport materials abroad.
Other factors	Other relevant factors will be written below the figure.

	Two or more negative factors			
-	One negative factor			
+	One supporting factor			
++	Two or more supporting factors			



## Paper and cardboard waste

	Finland	Finland	Sweden	Sweden	
	Turku Region	Kotka	Norrköping	Umeå	
Location and logistics	++	++	++	+	
Existing recycling industry in the area	-	++	++	++	
Supporting industry in the area	+	++	++	+	
Infrastructure	++	++	++	+	
Material availability	++	++	++	+	
Other criteria					

+ Port of Naantali, good logistical connections.

- No existing paper or cardboard industry in the area.
- + Naantali WtE plant.
- + Existing infra.

+ Large port, connections to Baltics and Europe.

+ Good railway and road connections to inland.

+Both paper and cardboard recycling facilities in the area.

+ Kotka WtE plant.

+ Large port and logistics centres, good rail and road connections.

- + Existing recycling industry, paper industry, IT and logistics.
- + Existing ecoindustrial park.

+ SCA packaging, pulp industry, car industry. International port and railway connections.

- North location, not much recycling industry.



## Plastic packaging waste

	Finland	Finland	Sweden	Baltic states
	Turku Region	Porvoo	Motala	Vilnius
Location and logistics	++	++	-	+
Existing recycling industry in the area	-	+	+	++
Supporting industry in the area	+	++	+	+
Infrastructure	++	++	+	+
Material availability	+/-	+/-	+	+
Other criteria		+		

+ Port of Kilpilahti,

+ Port of Naantali,	good logistical connections.		+ Short, land connection to Centra
good logistical connections.	+ Existing industrial	+ Site Zero investment.	Europe. + Extensive existing
+ No existing plastic	+Planned chemical	+ Existing industry.	industry.
recycling industry.	recycling facility.	+ Renewable energy.	+ Strong knowledge
+Naantali WtE.	+/- Recycling capacity	+ Railway connection	on polymer recycling
+/- Recycling capacity	increasing in Finland	to port.	- No ports, inland
increasing in Finland	(competition about materials?)	- No international	location.
(competition about		port, inland location.	- Not one specific
materials?).	+ There is strong		Industrial
	polymers in the area.		concentration.



#### COMPARISON OF ALTERNATIVES

## Textile waste

	Finland	Finland	Sweden	Baltic
	Turku Region	Kemi	Sundsvall	Not specific area
Location and logistics	++	++	++	+
Existing recycling industry in the area	a ++		++	-
Supporting industry in the area	+	+	++	+/-
Infrastructure	++	++	+	+/-
Material availability	+/-	+	+	++
Other criteria		+/- Uses cellulose-based raw materials	+/- Uses cellulose-based raw materials	
	<ul> <li>+ Port of Naantali,</li> <li>good logistical</li> <li>connections.</li> <li>+ Sorting facility of</li> <li>textiles nearby.</li> <li>+/- Material</li> <li>availability depends</li> <li>on demanded textile</li> <li>types.</li> </ul>	<ul> <li>+ Port of Kemi Improve logistics even location is remote.</li> <li>+ Supporting industry (textile sorting) locate remote but exists.</li> <li>+ The old paper mill provides good infrastructure and energy infrastructure (e.g. Nordic Hydrogen Route) is developed in the area.</li> <li>- There is no existing recycling</li> </ul>	<ul> <li>+ Ortviken industrial site.</li> <li>+ Supporting paper and pulp industry.</li> <li>+ Material is available, and it is purchased mostly from Asia but also domestically.</li> </ul>	<ul> <li>+ Extensive material availability.</li> <li>+ Significant sorting capacity.</li> <li>+ Relatively good logistical connections.</li> <li>- Lack of supporting industries, e.g. textile treatment facilities.</li> </ul>



# Summary and conclusions

## Summary

## Paper and Cardboard waste

- Especially cardboard waste seems to have excess recycling capacity in Nordics (in various locations).
- Paper waste recycling capacity has been shut down recently in Finland and Sweden and material has been imported to Middle Europe (e.g. Germany) for recycling
- Paper waste amount is expected to decrease and cardboard waste increase in the future

## Plastic packaging waste

- Scarcity of plastic packaging waste recycling capacity was identified in the examined area. Currently, major part of collected plastic packaging waste is exported and a significant share of plastics goes to energy recovery as a part of municipal solid mixed waste.
- Sorting of plastic packaging waste is a bottleneck for the recycling and more sorting capacity is needed.
- In addition, separate recycling processes are needed for sorted plastic types and there is lack of recycling capacity as well.
- Recycling and sorting capacity is likely to increase in near future especially in Finland and Sweden as many investment plans have been announced.

## **Textile waste**

- Recycling of textile waste has hardly started and it mainly focuses on cellulose based textile fibres.
   Synthetic textile fibres lack of recycling alternatives in the examined area.
- More recycling capacity is planned in Finland and Sweden
- Baltics focuses at the moment on the sorting of end of life textiles and has no actual recycling capacity



## Conclusions

## **Possibilities for Turku Region**

Further processing of textile waste seems to be the most potential alternative for Turku region out of examined waste fractions. Textile waste has only limited recycling capacity available in Nordics and Baltic states (also globally) and the available waste material volumes are expected to increase in near future due to separate collection obligation.

Existing textile recycling industry and good logistical connections especially to Baltics can be considered as advantages for the region. Turku area location might not be globally ideal, but for the domestic and neighbouring market (Nordics and Baltic) it can be considered good.



## Annex – Material flow calculations



## Paper and cardboard waste

Import	Amount	Unit
Paper waste, total	9200	t/a
Cardboard waste, total	39000	t/a
Summary, total	48200	t/a
Finland		
Paper waste domestic volume	187 000	t/a
Cardboard waste domestic volume	264 500	t/a
Cardboard and paper waste domestic volume	451 500	t/a
Cardboard recycling capacity		
Existing	389 000	t/a
Planned	389 000	t/a
Paper recycling capacity		-
Existing	158 000	t/a
Planned	158 000	t/a
Paper and cardboard recycling capacity total	547 000	t/a

84000	t/a

$\checkmark$		
Export		
Paper waste, total	84000	t/a
Cardboard waste, total	41000	t/a
Summary, total	125000	t/a
Balance = Paper waste domestic volume+import-		

export	112 200 t/a
Paper waste recycling capacity need (present)	-45 800 t/a
Paper waste recycling capacity need (future)	-45 800 t/a

Balance = Cardboard waste domestic	
volume+import-export	262 500 t/a
Cardboard recycling capacity need (present)	-126 500 t/a
Cardboard recycling capacity need (future)	-126 500 t/a

Balance = Cardboard and paper waste domestic		
volume+import-export	374 700	t/a
Cardboard and paper recycling capacity need		
(present)	-172 300	t/a
Cardboard and paper recycling capacity need		
(future)	-172 300	t/a

Import	Amount	Unit
Paper waste, total	n/a	t/a
Cardboard waste, total	n/a	t/a
Summary, total	82 855	5 t/a

The Baltic		
Paper waste domestic volume	n/a	t/a
Cardboard waste domestic volume	n/a	t/a
Cardboard and paper waste domestic volume	426 691	t/a
Cardboard recycling capacity		
Existing	n/a	t/a
Planned	n/a	t/a
Paper recycling capacity		
Existing	n/a	t/a
Planned	n/a	t/a
Paper and cardboard recycling capacity total	57 000	t/a



Export		
Paper waste, total	n/a	
Cardboard waste, total	n/a	
Summary, total	321373	

Balance = Paper waste production+import-export	n/a	
Paper waste recycling capacity need (present)	n/a	
Paper waste recycling capacity need (future)	n/a	

Balance = Cardboard waste domestic volume+import-export	n/a	
Cardboard recycling capacity need (present)	n/a	
Cardboard recycling capacity need (future)	n/a	

Balance = Cardboard and paper waste domestic		
volume+import-export	188 173	t/a
Cardboard and paper recycling capacity need		
(present)	131 173	t/a
Cardboard and paper recycling capacity need		-
(future)	131 173	t/a

Import	Amount	Unit
Paper waste, total	n/a	t/a
Cardboard waste, total	n/a	t/a
Summary, total	15000	0 t/a



Sweden		
Paper waste domestic volume	149 000	t/a
Cardboard waste domestic volume	618 000	t/a
Cardboard and paper waste domestic volume	767 000	t/a
Cardboard recycling capacity		
Existing	n/a	t/a
Planned	n/a	t/a
Paper recycling capacity		
Existing	280 000	t/a
Planned	n/a	t/a
Paper and cardboard recycling capacity total	900 000	t/a



Export		
Paper waste, total	n/a	t/a
Cardboard waste, total	n/a	t/a
Summary, total	250000	t/a

Balance = Paper waste production+import-export	n/a	t/a
Paper waste recycling capacity need (present)	n/a	t/a
Paper waste recycling capacity need (future)	n/a	t/a

Balance = Cardboard waste domestic	n/a	
volume+import-export	nya	t/a
Cardboard recycling capacity need (present)	n/a	t/a
Cardboard recycling capacity need (future)	n/a	t/a

<b>Balance</b> = Cardboard and paper waste domestic		
volume+import-export	667 000	t/a
Cardboard and paper recycling capacity need		
(present)	-233 000	t/a
Cardboard and paper recycling capacity need		
(future)	-233 000	t/a



#### Plastic packaging waste







Plastic packaging waste total	115000	t/a	
Sweden			
Plastic packaging waste domestic volume	220 000	t/a	
Plastic packaging waste recycling capacity			
Existing, sorting	n/a	t/a	
Existing, mechanical & chemical recycling	100 000		
Planned	260000	t/a	

Import

Export		
Plastic packaging waste total	25800	t/a
	•	

Export		
Plastic packaging waste total	70663	t/a

Export		
Plastic packaging waste total	130000	t/a

Balance = Domestic volume+import-export	111 500	t/a
Recycling capacity need, present (balance-		
existing recycling capacity)	93 500	t/a
Recycling capacity need, future (balance-		
planned recycling capacity)	-435 500	t/a

Balance = Domestic volume+import-export	224537	t/a
Recycling capacity need, present (balance-		
existing recycling capacity)	134537	t/a
Recycling capacity need, future (balance-planned		
recycling capacity)	n/a	t/a

Balance = Domestic volume+import-export	205 000	t/a
Recycling capacity need, present (balance-		
existing recycling capacity)	105 000	t/a
Recycling capacity need, future (balance-		
planned recycling capacity)	-55 000	t/a



Amount Unit

Import	Amount	Unit
Textile waste	6	t/a
Reusable textiles	0	t/a
End of life textiles total	6	t/a
End of life textiles total	6	t/a

Import [t/a]	Amount	Unit
Textile waste	89000	t/a
Reusable textiles	59950	t/a
End of life textiles total	89000	t/a



Finland		
End of life textiles annual production	85 000	t/a
Recycling capacity:		
Existing, sorting capacity	11000	t/a
Existing, mechanical & chemical recycling	0	t/a
Planned, sorting capacity	31 900	t/a
Planned, mechanical & chemical recycling	36 500	t/a



The Baltic		
End of life textiles annual production	63506	t/a
Recycling capacity:	0	t/a
Existing, sorting capacity	n/a	
Existing, mechanical & chemical recycling	0	t/a
Planned, sorting capacity	n/a	
Planned, mechanical & chemical recycling	0	t/a



Import	Amount	Unit
Textile waste	n/a	t/a
Reusable textiles	n/a	t/a
End of life textiles total	n/a	t/a



Sweden		
End of life textiles annual production	130000	t/a
Recycling capacity:		
Existing, sorting capacity	25000	t/a
Existing, mechanical & chemical recycling	69000	t/a
Planned, sorting capacity	n/a	
Planned, mechanical & chemical recycling	85 000	t/a



Export		
Textile waste	14	t/a
Reusable textiles	14500	t/a
End of life textiles, total	14514	t/a

Export		
Textile waste	n/a	t/a
Reusable textiles	n/a	t/a
End of life textiles, total	69884	t/a

Export		
Textile waste	n/a	t/a
Reusable textiles	28000	t/a
End of life textiles, total	28000	t/a

Balance = Domestic volume+import-export	70 492	t/a
Recycling capacity deficit, present (balance-		
existing recycling capacity)	52 164	t/a
Recycling capacity deficit, future (balance-		
planned recycling capacity)	15 664	t/a

Balance = Domestic volume+import-export	82622	t/a
Recycling capacity deficit, present (balance-		
existing recycling capacity)	82622	t/a
Recycling capacity deficit, future (balance-		
planned recycling capacity)	82622	t/a

Balance = Domestic volume+import-export	102000	t/a
Recycling capacity deficit, present (balance-		
existing recycling capacity)	33000	t/a
Recycling capacity deficit, future (balance-		
planned recycling capacity)	17 000	t/a

