OVERVIEW OF MUNICIPAL SOLID WASTE MANAGEMENT IN FINLAND

With practical examples of implementation on regional level

Overview of municipal solid waste management in Finland - with practical examples of implementation on regional level

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Ympäristöministeriö
Miljöministeriet
Ministry of the Environment

Ulkoministeriö
Utrikesministeriet
Ministry for Foreign Affairs of Finland

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Concepts, abbreviations and definitions

The list below of concepts, abbreviations and definitions does not represent the official EU or Finnish approach. It is generic in nature and was developed solely for the purposes of this publication by its authors.

Concept /Name	ABBR	Definition
Association of Finnish Local and Regional Authorities	AFLRA	A powerful advocate for all Finnish municipalities that promotes local self-government and the modernisation of municipal services.
Basic charge		The separate waste fee in some MWMOs, which covers the costs incurred by the municipality for the establishment and maintenance of local reception facilities for recyclable, hazardous and other waste, as well as costs arising from waste advising services, waste management authority activities and other similar tasks related to the organization of waste management.
Battery and Accumulators waste	B&A	One of the waste types under EPR.
Biogas		A gas containing e.g. methane (CH_4), formed when microbes break down organic matter such as biowaste, manure or wastewater sludge in anaerobic conditions.
Biogas production		Generation of gas from organic matter by processing in a reactor. Biogas is mainly utilized as a renewable fuel. In this publication the production of biogas is considered as biowaste treatment and is separated from waste-to-energy.
Biological treatment of waste		Treatment of organic waste by composting or anaerobic digestion that involves biological decomposition of organic matter. Biological treatment is used for e.g. municipal organic waste (biowaste), wastewater sludge and animal manure.
Biowaste		Biowaste (in the EU directives: bio-waste) biodegradable garden and park waste, food and kitchen waste from households, offices, restaurants, wholesale, canteens, caterers and retail premises and comparable waste from food processing plants.
Block collection, block collection points		Shared use of waste collection points, where properties adjacent to each other can make a contract with an MWMO on a voluntary basis to a joint use of waste container.
Carbon capture and storage	CCS	Carbon capture and storage (CCS) is a combination of technologies that capture CO_2 and then safely stored it e.g. underground in suitable geological formations.
Construction and demolition waste	CDW	Construction and demolition waste contains a wide variety of materials such as concrete, bricks, wood, glass, metals and plastic. It includes all the waste produced by the construction and demolition of buildings and infrastructure, as well as road planning and maintenance.
Circular economy		The circular economy is an economic model that switches focus from linear and continuous production towards the extension of the life cycle of products. In the circular economy consumption is based on sharing, leasing, reusing, repairing, refurbishing and recycling existing materials and products for as long as possible.
Composting		Aerobic treatment of biowaste, where microorganisms decompose organic material into humus-like material (compost). The process requires oxygen.
Deposit-based return system for beverage packaging or beverage packaging return system		A voluntary system that enables the collection of a large spectrum of different beverage containers at a high return rate. By joining a deposit system, beverage manufacturers and importers are exempted from the beverage packaging tax (€0.51 per litre in 2021).
Digestion		Anaerobic treatment of biowaste, where microorganisms break down organic matter in the absence of oxygen generating biogas.
Disposal of waste		Depositing the waste at a landfill, incineration without energy recovery, or some other comparable activity that does not constitute recovery
Eco-industrial centre (synonyms: eco-industrial park, industrial symbiosis)		A geographically limited area where waste streams, materials, energy and data circulate between companies. In an ideal situation, the waste of one actor ends up as the raw material of another actor increasing recycling.

Concept /Name	ABBR	Definition
Emptying charge (fee)		Waste fee imposed by a MWMO that covers the costs of property-specific collection, transportation and treatment of MSW, as well as the costs needed for future development of waste management in the area of operation of a MWMO.
Electrical and Electronic Equipment Waste	WEEE	One of the waste types under EPR
ELY Centre	ELY	Centres for Economic Development, Transport and the Environment of Finland
EKHJ or South Karelian Waste Management	EKJH	EKJH (Etelä-Karjalan Jätehuolto) is an MWMO operating in South Karelia. The EKJH service area includes the following municipalities: Cities of Lappeenranta and Imatra as well as the Lemi, Luumäki, Parikkala, Rautjärvi, Ruokolahti, Savitaipale and Taipalsaari municipalities.
Energy recovery	ER	Conversion of non-recyclable waste materials into usable heat, electricity or fuel in waste-to-energy or waste incineration processes.
Environmental Protection Act	EPA	The Finnish Environmental Protection Act is a general law, the purpose of which is to prevent environmental pollution. The Act contains provisions on the protection of soil, air and water.
End-of-life vehicles	ELVs	One of the waste types under EPR
End of waste	EoW	A status that certain recovered waste materials could achieve by fulfilling certain criteria described in Directive 2008/98/EC.
Extended Producer Responsibility	EPR	Extended producer responsibility refers to companies' obligation to handle the waste management of certain products they have imported or manufactured when the products are discarded.
EPR corporation		Same as producer corporation
Finnish Solid Waste Association KIVO Finland	KIVO	Finnish Solid Waste Association KIVO Finland represents 33 municipal waste management organizations.
GDP of Gross Domestic Product	GDP	The most commonly used measure of economic activity that represents the total monetary value of all final goods and services produced and sold on the market within a country during a certain period of time which is typically one year.
Greenhouse gas emissions	GHG emissions	Emissions of carbon dioxide, methane, and water vapour and other gases that contribute to the greenhouse effect and climate change.
Hazardous waste		Waste with chemical or other properties dangerous or harmful to health or the environment and therefore has to be made harmless or recovered according to specific instructions.
HSY or Helsinki Region Environmental Services	HSY	HSY is an MWMO operating in the capital area of Finland. The founding and member municipalities are Espoo, Helsinki, Kauniainen and Vantaa from Uusimaa region.
Household		A household is formed of all those persons who live together and have meals together or otherwise use their income together.
Household waste		Waste originating from the consumption of households.
Industrial waste (out of the focus of this publication)		Waste generated because of a technological process (mechanical and/or chemical).
Kiertokaari		Kiertokaari (previous name Oulun Jätehuolto) is an MWMO in Northern Ostrobothnia that has 9 owner municipalities (Oulu, Hailuoto, Ii, Kempele, Lumijoki, Pudasjärvi, Raahe and Siikajoki; the operational area also includes Simo in Lapland).
Kiertokapula		Kiertokapula is an MWMO the operational area of which covers 13 municipalities: Hattula, Hausjärvi, Hyvinkää, Hämeenlinna, Janakkala, Järvenpää, Kerava, Loppi, Mäntsälä, Riihimäki, Tuusula, Valkeakoski and Nurmijärvi.
Landfill		Permanent site for the final disposal of waste.
Landfill gas		Gas which forms on landfills due to biological processes of decomposition of organic matter. This gas is collected, cleaned and mainly utilized as energy for electricity and heat production.
LHJ or Loimi-Häme waste Management	LHJ	Loimi-Häme waste management (Loimi-Hämeen Jätehuolto - LHJ) is an MWMO operating in 16 municipalities in Kanta-Häme, Satakunta and Pirkanmaa. The owner municipalities are: Forssa, Sastamala, Huittinen, Punkalaidun, Urjala, Akaa, Humppila, Jokioinen, Tammela, Somero, Koski TL, Ypäjä, Loimaa, Oripää, Säkylä, Eura.
Limited Liability Housing Company		A single legal entity, which owns all residential property including apartments in a building or multiple buildings.

Concept /Name	ABBR	Definition
Local collection points		Mixed waste collection points organized by an MWMO mainly for properties located in sparsely populated rural areas, which are not connected to a property-specific waste collection network.
“MARA”decree	MARA	Government Decree (843/2017) on the recovery of certain wastes in earth construction (so called “MARA”-decree) that aims to promote waste utilization in earth construction.
Material recovery, Material recycling		Waste recycling, in which material contained in waste is returned back to production. Recycling of waste does not include reuse of second-hand goods.
Metsäsairila		Metsäsairila is an MWMO owned by the city of Mikkeli in South Savo.
Miscellaneous waste		In this document means: mixture of waste comprised of one or more waste fractions or components.
Mixed waste		Mixed waste is miscellaneous non-recyclable waste, which is left when hazardous waste and all recyclable fractions are sorted out.
Mixed/Dry waste		Synonym for mixed waste applied in this publication. Mixed waste is called “Dry waste” or “Energy waste” in some Finnish municipalities.
Municipal services’ properties		Properties that refer to the public sector, i.e. the municipality and state real estate. State properties include, for example, state administration real estate and businesses. Municipal properties include the schools, health centres, hospitals and business establishments of municipalities and associations of municipalities.
Municipal solid waste	MSW	Waste generated by households, administration and public services of municipalities and other similar waste in terms of quality and quantity. The general common feature of municipal solid waste is that it is generated in the consumption of final products in communities.
Municipal waste management organisation	MWMO	Municipal enterprise or association of municipalities or consortium of municipalities within municipal waste management co-operation.
Municipal waste management authority		The municipal waste management authority takes care of the municipal waste management authority’s tasks, such as deciding on the municipal waste tariff and the waste management system. In practice, the Waste board performs the tasks of the municipal waste management authority (see below).
National Waste Plan		The National Waste Plan presents the objectives for waste management and for preventing the creation of waste and the measures to reach the objectives.
Organic waste		Biodegradable waste or other waste containing organic material (including plastic).
Pirkanmaa Waste Management	PJH	PJH (Pirkanmaan Jätehuolto, official name Tampere Regional Solid Waste Management Ltd.) is an MWMO of the Pirkanmaa region owned by 17 municipalities (Hämeenkyrö, Ikaalinen, Juupajoki, Mänttä-Vilppula, Nokia, Orivesi, Parkano, Pirkkala, Pälkäne, Ruovesi, Sastamala (Mouhijärvi and Suodenniemi), Tampere, Vesilahti, Virrat, Ylöjärvi).
Preparing for reuse		Checking, cleaning or repairing recovery operations, by which products or components of products are prepared so that they can be reused without further pre-processing;
Producer corporation		A producer corporation is a legally competent corporation established to manage the obligations imposed on producers in EPR. Only producers can form a producer corporation and be members of it.
Property		Building or group of buildings of one housing company or one administrative unit of municipal service.
Property holder		Owner or rent right holder of the property.
Property-specific waste collection		Separate collection of waste organized by an MWMO and a housing company or private waste company on the property site.
RDF (Refuse Derived Fuel)	RDF	Refuse derived fuel is fuel produced from combustible components of mixed MSW.
REF (Recovered fuel)	REF	Recovered fuel that is usually made from homogeneous energy waste from trade or industry.
Reuse		Using the product, or a component thereof, for the purpose for which it was originally conceived
RINKI eco take-back point	RINKI eco take-back point	Eco take-back points for household packaging waste under extended producer responsibility organized by the service company RINKI Ltd.
Salpakierto		Salpakierto (formerly Päijät-Häme Waste Management PHJ) is an MWMO owned by 10 municipalities (Asikkala, Heinola, Hollola, Kärkölä, Lahti, Myrskylä, Orimattila, Pukkila, Padasjoki and Sysmä).

Concept /Name	ABBR	Definition
Secondary responsibility of a municipality to organize waste management		The obligation of municipality to organize other than households' and administrative and services' waste management, if the waste holder so requests due to lack of other service provision and the quality and quantity of the waste is suitable for transport or treatment in the municipal waste management system.
Separately collected waste		Waste fractions that are collected separately into specific waste bins on a site of a property or area/group of properties.
SRF (Solid Recovered Fuel)		Solid waste fuel produced from the dry waste of communities, businesses or industry waste. Industry also uses the term recycled fuel, although waste incineration is not recycling.
Standard Industrial Classification TOL 2008	TOL	Data collection and description framework of statistics describing economic activities.
Standardised residential apartment building	IndexBuilding	Concept developed by the Finnish Real Estate Federation for keeping statistics. It means a 10 000 cubic meter residential apartment building located in the grid area of the city centre on its own land plot and with 40 apartments. The energy and water consumption of the house is average, as are the numbers of waste bins and emptying frequencies.
Statistics Finland		Statistics Finland's task is to compile statistics and reports concerning social conditions, collect and maintain data files on society, provide information service and promote the use of statistics, develop statistical methods and conduct studies supporting the development of statistics, develop the national statistical service in cooperation with other Government officials, coordinate the national statistical service, participate in and coordinate Finland's international statistical co-operation.
Value-added tax	VAT	Value added tax (VAT) is a general consumption tax on the consumption of goods and services. VAT is an indirect tax which is to be paid by end-consumers. Collected by businesses liable to tax, VAT is included in sales prices, and the VAT revenue is paid to the state.
Waste		Any substance or object, which the holder discards, or intends or is obliged to discard.
Waste Act	WA	The Finnish Waste Act, the purpose of which is to promote the circular economy and the sustainable use of natural resources, to reduce the amount and harmfulness of waste, to prevent danger and harm to health and the environment from waste and waste management, to ensure efficient waste management and to prevent littering. The current publication is based on the Waste Act that came into force in June 2011. The new Waste Act came into force in July 2021 and the changes it brings are also described in this publication.
Waste Board		A joint body set up by an MWMO to handle administrative duties. Waste board members are selected from the municipalities of the area the MWMO is operating in. The members are mainly elected officials.
Waste carrier (transporter)		Anyone responsible for the transport of waste;
Waste centre		MWMO's centralized facility, where waste is accepted and further processed or transported to recycling companies. Main waste sorting stations of MWMO and landfill sites are usually situated in waste centres.
Waste charge (Waste fee) Note: both terms are used as synonyms		Municipal waste charges cover the costs of waste management under the responsibility of the municipality. These costs include the costs of transporting waste, setting up treatment sites, their maintenance, decommissioning and after-care, maintaining registers and providing waste advice. Part of the fee can also be charged as a separate basic fee. The waste fee is charged from the property owner or other waste holder. The basis for determining the waste fee can be found in the waste tariff approved by the municipality.
Waste collection		Collection of waste at a reception point provided by the property holder, municipality, producer, distributor or other party, for on-site treatment or for the purpose of transportation for treatment, including preliminary sorting and temporary storage of waste.
Waste Decree (The Government Decree on Waste)		The legislative document that clarifies the Waste Act. For example, it sets a minimum level of requirements for waste management like separate collection requirement for properties. The latest Waste Decree came into force on 1.12.2021.
Waste fractions		Each waste group, type or classification is called a fraction (examples: mixed waste, biowaste, plastic, cardboard, metal).
Waste holder		According to the Waste Act, the waste holder, property holder or anyone in possession of waste has the main responsibility for organising waste management.

Concept /Name	ABBR	Definition
Waste management		Organized set of activities for the purpose of sorting, collecting, transporting and storing waste as well as arranging for the recovery and disposal of waste. Activities aimed at the prevention of waste generation are also regarded as waste management.
Waste management register		Register managed by an ELY Centre, which covers professional waste carriers and brokers.
Waste Management Regulations WMR		Municipal waste management regulations are local regulations issued by a municipal waste authority that specify the Waste Act and the Waste Decree. The aim of waste management regulations is to promote the implementation of the Waste Act, taking into account local conditions. Waste management regulations apply to properties covered by municipal waste management.
Waste-to-energy plant	WTE / W2E	A CHP or combined heat and power production plant that produces e.g. heat for district heating and electricity to the power grid from municipal solid waste and other types of waste.
Waste producer		An actor whose activities generate waste or as result of pre-treatment, mixing or other activities change the properties of waste or the composition of waste.
Waste recycling	WR	Use of waste as raw material or other material. Energy recovery is not regarded as recycling even though it involves resource recovery. Reuse of used goods, such as refilling of beverage bottles, is not recycling. However, reuse is part of waste management because it prevents the generation of waste.
Waste sorting station, waste station (e.g. Sortti station in HSY area)		Territory of municipal waste management organization, where it is accepted sorted or mixed waste that cannot be placed in household waste bins in property-specific waste collection.
Waste tariff		A waste tariff is a document that determines the basis for the waste charges for waste management. The municipal waste management authority approves the tariff and based on it imposes waste charges.
Waste tax		The waste tax (or landfill tax) is levied on all waste deposited at landfill sites, provided that i) its utilization is technically feasible and environmentally justifiable, and ii) that by imposing the tax, waste can be made more commercially exploitable.
Waste treatment		Operations of changing the composition, structure or another property of generated waste in order to facilitate activities of energy and material recovery, neutralization and final disposal of waste.
Wastewater and wastewater sludge treatment (out of the focus of this publication)		Wastewater is a polluted form of waste generated from human activities and stormwater. Wastewater sludge is a residual material that is formed in the wastewater treatment process and is composed of organic and inorganic materials contaminated by metals, pollutants, bacteria and other pathogens. Sludge is treated by aerobic and anaerobic processes, sometimes with biowaste, which makes it possible to utilize its high nutrient content as fertilizer and produce biogas.

1 Introduction

The Finnish municipal solid waste (MSW) management system is based on a holistic approach. Sustainable waste management is a combination of legislation, regulatory and financial guidance and controls, segregated waste collection practices and incentives, technology and environmental education. All of these elements complement each other to transform waste into a resource for the circular economy.

Finland has developed an efficient MSW management system that is secure and reliable due to inclusive and transparent legislation, close cooperation between municipalities and private companies and effective supervision mechanisms. Finnish waste legislation is largely based on EU legislation, but in some cases it is even stricter. The leading role of municipalities has formed the basis for municipal solid waste management that ensures the availability of services in all areas and for all citizens under all circumstances.

Finland's waste policy aims to promote the sustainable use of natural resources and to ensure that waste does not endanger human health or harm the environment. Today, only about 0.5 % of MSW is landfilled in Finland. Over 99 % is utilized either as a material or as energy. Technological developments have increased the potential for waste recovery and many profitable business opportunities along the value chain of waste management, first of all in waste treatment, reuse and recycling, have emerged.

The European Union has set strict recycling targets: in 2025, 55% of MSW will be recycled in Finland and in 2035 65% will already be recycled. Still, the share of material recovery of MSW was low: only 42% in 2020. Finland has renewed its waste legislation in 2021 to meet these ambitious targets, but a lot of work is still to be done. Efficient sorting and separate collection are essential to increase the recycling rate.

Today, the transition from the linear to circular economy is one of the policy priorities of Finland and the EU. The circular economy is a new economic model whose main goal is to conserve natural resources and use materials efficiently and sustainably. The transition to a new model will require the development of new forms of cooperation, innovation and a change in attitudes towards waste, and thus will create new models of work and sustainable business.

1.1. What waste is municipal waste?

Finland is an extractive industrial country, which is reflected in the total amount of generated waste. The majority of waste is generated by mining, quarrying, construction and manufacturing (Figure 1). The amount of municipal waste comprises 2 – 3% of the total amount of waste. Although the share of municipal solid waste is rather small of all the waste generated in our societies, it is an important and visible part of the whole waste management system. It contains valuable materials but also harmful substances, it affects our living environment, and citizens themselves can strongly affect its amount and utilization.

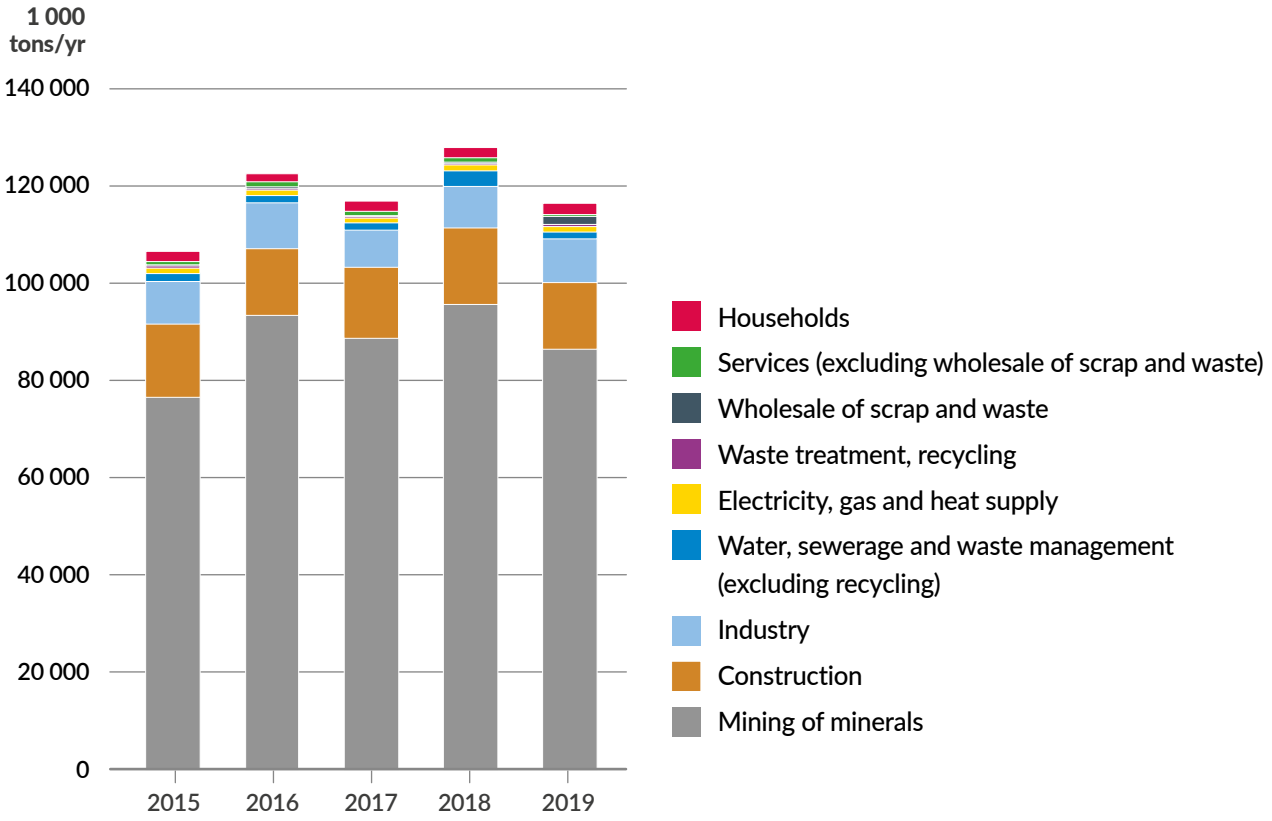


Figure 1. Waste generation in Finland in 2015 – 2019 according to Finnish Environment Institute SYKE and Statistics Finland

The current publication concentrates only on municipal solid waste (MSW). According to the definition of the European Parliament and European Council Directive 2008/98/EC, municipal solid waste includes waste originating from households as well as similar waste from:

- households,
- commerce and trade,
- small businesses,
- office buildings,
- institutions (e.g. schools, hospitals, government buildings),
- enterprises if it is similar in kind and composition to household waste and does not come from production,
- waste from selected municipal services i.e. waste from park and garden maintenance,
- waste from street cleaning services (e.g. street sweepings, the content of litter containers, market cleansing waste).

According to the European Parliament and European Council Directive 2008/98/EC municipal waste means:

(a) mixed waste and separately collected waste from households, including paper and cardboard, glass, metals, plastics, bio-waste, wood, textiles, packaging, waste electrical and electronic equipment, waste batteries and accumulators, and bulky waste, including mattresses and furniture;

(b) mixed waste and separately collected waste from other sources, where such waste is similar in nature and composition to waste from households.

MSW does not include waste from production, agriculture, forestry, fishing, septic tanks and sewage networks and treatment, including wastewater sludge, end-of-life vehicles or construction and demolition waste.

1.2. Municipal solid waste generation and management in Finland

Municipal solid waste in 2020 constituted about 2.8 % of the total waste generated in Finland accounting all in all almost 3.3 million tons (Figure 1). The share of household waste in MSW is estimated to be about 65% and the share of administration, services etc. is about 35%.

Almost 3.3 million tons of MSW or around 596 kg per inhabitant was generated in 2020 in Finland. The amount of MSW continues to increase in relation to the Finnish population. At the beginning of the 2010s, the amount was about 500 kg/capita. Compared to 2019, the total amount of MSW increased by 170,000 tons, or by over five per cent. The long-term aim of Finland has been to get the amount of MSW/capita to decrease but without success as of yet.

In 2020, about 1.5 million tons of MSW components were collected separately to be utilized mainly as material. Paper, cardboard and biowaste have long been the biggest separately collected material items. Still, after separate collection, mixed waste comprised about 1.66 million tons and miscellaneous waste 0.11 million tons of the total amount.

The Finnish Solid Waste Association KIVO (Suomen Kiertovoima ry) represents public waste management and 33 municipal waste management organizations (MWMOs). KIVO has collected a database of the mixed waste composition studies carried by MWMOs, performed by manually separating the mixed waste fractions (mainly from the households). According to the KIVO's statistics, mixed waste generally consists mostly of recyclable fractions like biowaste, plastic, paper and cardboard waste (Figure 2). About 1/3 of mixed waste is biowaste and many other waste fractions are basically recyclables, which people have not separated correctly. Miscellaneous waste comprises in average only 18% of the total amount of mixed waste and consists of miscellaneous packaging (e.g. multi-material packaging), diapers and hygiene products (approx. 8% of everything) and other materials, which cannot be easily utilized.

The total accumulation of property-specific MSW from households consists of the separately collected waste at the property's collection site and the remaining amount of mixed waste. Based on questionnaire research performed by KIVO, the total average accumulation of MSW in a block of flats in 2019 was 237kg, in terraced houses 239kg, in detached

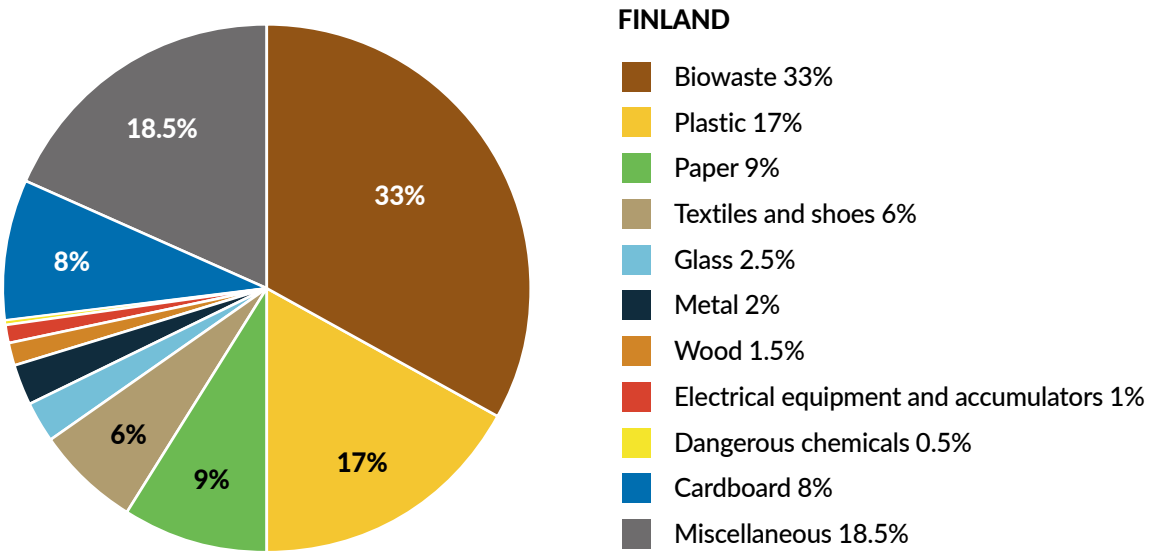


Figure 2. Composition of mixed waste in Finland according to the Finnish Solid Waste Association KIVO's database. Mixed waste is miscellaneous non-recyclable waste, which is left when hazardous waste and all recyclable fractions are sorted out

Accumulation of different types of waste in property-specific collection in different types of housing [kg/inhabitant/yr]

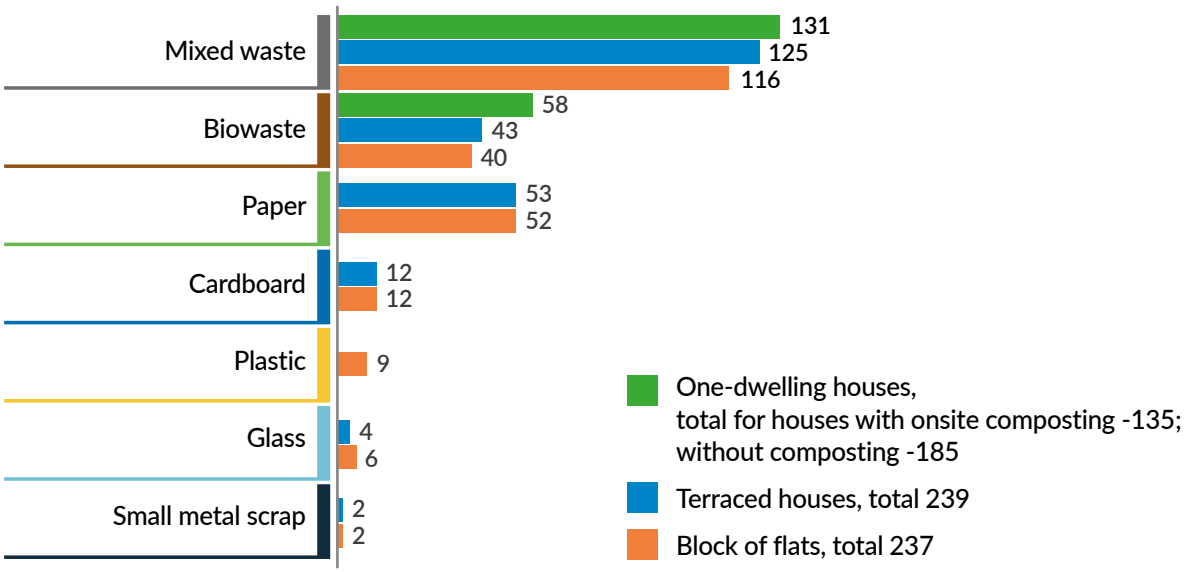


Figure 3. Accumulation of different types of waste in property-specific collection in different types of housing (kg/inhabitant/year) according to the Finnish Solid Waste Association KIVO's database

houses 185kg, and in detached houses with onsite composting 135 kg/inhabitant/year (Figure 3).

Paper, paperboard and biowaste are the largest separately collected material fractions. In 2020, the share of material recovery of MSW was 42%. Material recovery includes also the recycling of biowaste by composting and anaerobic digestion, which comprises 13.5 percentage units (Figure 4). Anaerobic digestion is considered as material recovery as it generates biogas, which can be utilized as fuel. Also, the recycling rates are high for some separately collected fractions: in 2019 for paperboard packages 116%, glass packages 98% and metal packages 85%. Since 2012 energy recovery (incineration) of waste has been the most significant treatment mode of MSW and in 2020 its share was 58 %. Energy recovery of MSW is mainly based on the combined production of electricity and heat (CHP) that is often utilized in district heating networks.

In 2020, share of landfill disposal of MSW remained low, at around 0.5 % due to restricting legislation. Among the materials still landfilled in Finland are residual waste, which cannot be recovered, such as aggregate, asbestos, ash and non-combustible wastes. As can be seen from Figure 4, the percentage of landfilled MSW has decreased rapidly in the past couple of decades from almost 66 % to below one. Although the amount of landfilled MSW is really low at the moment, the share of material recovery is also still too low. The aim set by the EU for the material recovery of MSW is 55% in 2025, 60% in 2030 and 65% in 2035.

1.3. Transition to a circular economy

Today, Finland is taking steps to increase the share of reusing and recycling and to promote circular economy. In a circular economy, materials are utilized efficiently and sustainably, and they remain in circulation for a long time and safely. Products are also shared, leased, repaired and recycled. Servicification is part of the circular economy, for example, when services replace the ownership of products by paying for their use or results. The circular economy is a new operating method for the economy that produces economic well-being within the limits of the planet's carrying capacity. It utilises digitalisation efficiently and will renew the structures and operating models of society. The circular economy is a means for reducing the use of natural resources.

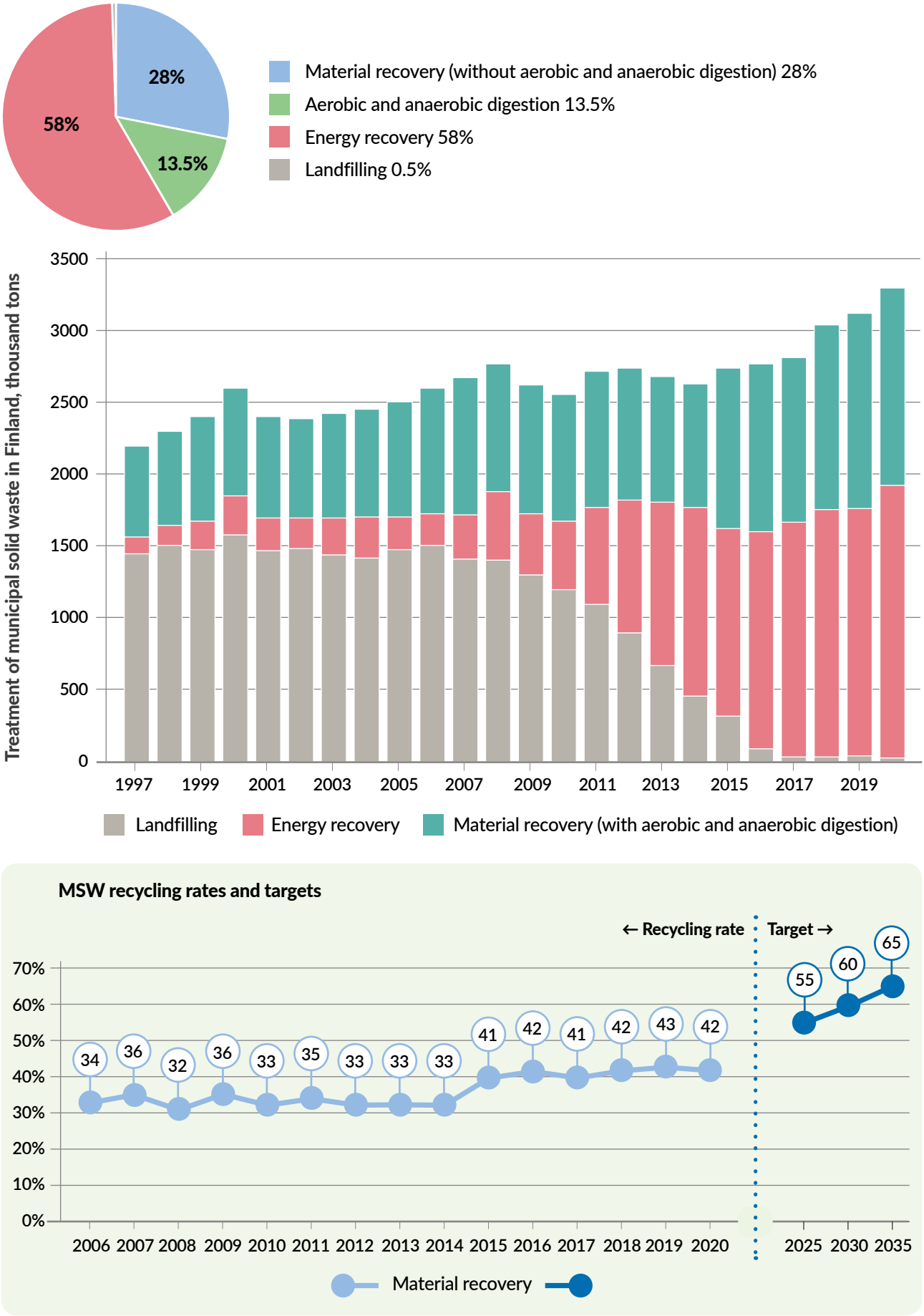


Figure 4. Municipal waste treatment in Finland in 1997–2020 according to Statistics Finland

Finland has many strategies and programs that guide and accelerate the development of the waste sector and the transition to circular economy.

The national waste plan "From recycling to circular economy" is a strategic plan adopted by the Government laying down the objectives and measures for waste management and waste prevention (See INFOBOX 1). The main target is to break the link between economic growth and the environmental impact of waste generation. The program binds the state administration and proposes recommendations to other actors. The current National Waste Plan updated in 2022 and aims for 2027.

INFOBOX 1: The National Waste Plan for 2027: Vision for 2030

- Material-efficient production and consumption save natural resources and mitigate climate change.
- Volumes of waste have decreased from the present. Reuse and recycling have risen to a new level.
- High standard waste management is part of the sustainable circular economy.
- The recycling market works well. Reuse and recycling create new jobs.
- Valuable raw materials present at low levels are also recovered from recycled materials.
- Material cycles are innocuous and less and less hazardous substances are used in the production.
- Cooperation between actors in the field promotes high-quality material cycles.
- Reliable and comprehensive information supports the circular economy. The information can be utilized digitally.
- In the waste sector there is high-quality research and experiments, and competence in waste issues is at a high level.
- The legislation supports the innovations and operating conditions of the circular economy.

Finland was the first country to draw up **a national roadmap to a circular economy**. The roadmap was developed by the Finnish Innovation Fund Sitra in 2016 and it was further updated in 2019. It is a practical tool that combines a vision, goals and the concrete measures needed to achieve the circular economy.

The EU Action Plan for the Circular Economy (2020) is one of the main building blocks of Europe's new agenda for sustainable growth (European Green Deal). It contains 35 legislative and other initiatives that target how products are designed, promotes circular economy processes, encourages sustainable consumption, and aims to ensure that the generation of waste is prevented, and the resources used are kept in the EU economy for as long as possible.

The aim of **Finland's Circular Economy Strategic Program (2021)** is to transform the economy into one that is based on the principles of circular economy by 2035. The programme sets out objectives to minimize the use of primary raw materials and double the use of recycled materials and resource productivity.

The Plastics Roadmap for Finland (2018) is the first national programm with cross-secotral approach that aims at searching for solutions to the plastic challenge and promotes a sustainable circular economy for plastics. It looks for methods to reduce the harm caused by plastic waste, improve the plastics recovery, recycling and product design efficiency, aid consumers deliver plastics to waste management system, ease innovations and investments in the circular economy, and, by increasing bio-based and biodegradable solutions, reduce the dependency on fossil raw materials. The Plastic Roadmap is further updated in 2022 to ensure transition to a circular plastics economy in Finland by 2030. Also, the renewal of the **National chemical program** is underway.

2 Waste management value chain

MSW management is a mandatory and critical service at the state, municipal, organisation and consumer levels. All levels come to contact with waste. The management process has a lot of dimensions and interconnections between economic, environmental and social impacts. The main objective of this chapter is not provide analyses, but to emphasize the better understanding of the direct and indirect economic and environmental aspects of MSW management.

MSW is a part of the economy – the generation of waste creates both expenditures and revenues. It forms revenues for economic activity, whether through reuse, material recycling or energy recovery, as well as expenditures related to economic activity by households, municipal and administration services and businesses. Waste holders, producers and property holders pay for MSW treatment and disposal, and thus these costs constitute revenue for actors operating within the waste sector.

Revenues from reuse refer to sales of used goods and materials for the same purpose. Also, profits can be gathered when upgrading/-cycling used goods and materials for new purposes with higher economic value. Revenues from material recycling refer for example to sales of metal, electronic equipment, paper, or glass wastes to be used as material for the same or a new product. Also, revenues from sales of biomethane as fuel for vehicles, electricity and/or heating energy, residuals as organic fertilizers, which are products from the digestion process and/or composting of organic waste, are considered as revenues of material recovery. Revenues from energy recovery refer for example to sales of electricity and/or heating energy, which are products of the waste incineration process of municipal mixed waste, wood waste and some other waste fractions suitable for incineration.

In addition to the revenues from sales of goods and materials, biomethane fuel, electricity and heating energy, revenues from services form a remarkable part of revenue flows. Examples of services related to the MSW management chain are separate collection and transportation, recycling services and treatment services. There are also indirect revenues, which come for example from the manufacturing of waste collection tools and vehicles, treatment equipment and technology, etc.

In addition to environmental benefits and following the waste hierarchy (See Figure 8), material recovery makes also makes more financial sense than energy recovery, particularly from the perspective of employment, tax revenue and added value because of the longer value chain due to versatile use of recycled material for further processing and using, etc. (See Figure 5).

Expenditures of operational activities of MSW management consist of direct and indirect expenditures, which are the development of technology for different parts of the process, recycling, awareness raising, permissions and other environmental aspects, taking care of health matters, authorities' or governmental duties, statistics and reporting, etc. Various aspects of MSW operational economics include, for example, waste management fees at the municipal level, life-time costs of waste-to-energy solutions, need of land plots in urban areas for waste separate collection, construction of shelters for property-specific collection points, tools and transport vehicles for waste collection, transportation and self-delivering of waste to sorting and treatment facilities, treatment and pre-treatment costs, and land need for final disposal.

Expenditures of waste collection and treatment are direct, but changes in manufacturing processes of goods/materials before the usage phase and investments to facilities for reuse and recycling are indirect costs of waste management. New and innovative, technically and economically viable facility

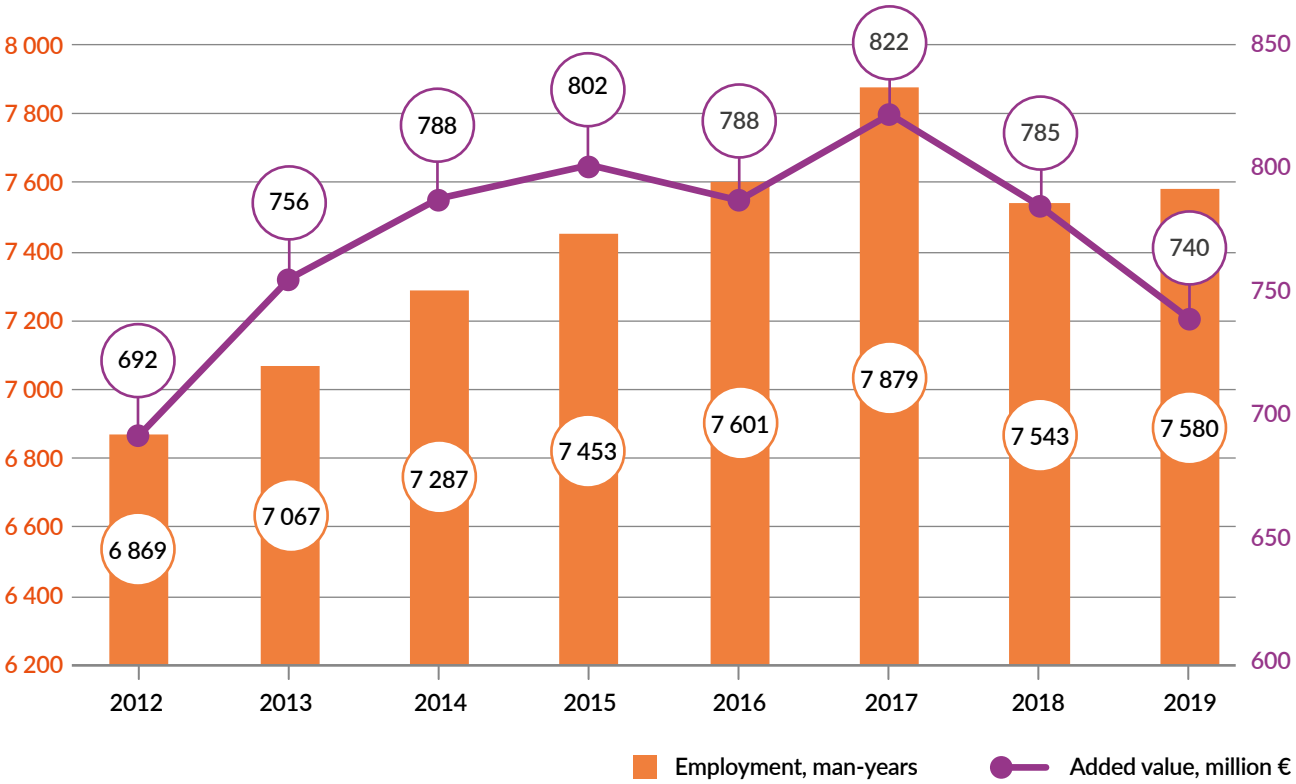


Figure 5. Employment and added value in the environmental business in the waste management, recycling sector and other environmental management according to Statistics Finland

solutions must be introduced in order to increase the safe and high-standard recycling of waste. Expanding and developing sorting possibilities and separate collection networks is essential to obtaining clean waste for recycling. Securing of the appropriate disposal of waste fractions for which cost-effective recycling options have yet to be identified also form costs on one hand. But on the other hand, developing, piloting, demonstrating and taking these into use on an industrial scale also provide business opportunities for enterprises.

Urban planning is also interconnected to MSW management for example in terms of the location of waste treatment facilities and the construction of shelters for property-specific separate waste collection. Adequate areas for economic needs should be reserved sufficiently close to the sites of waste streams origins, but on the other hand, places should be chosen in accordance of environmental safety. Ownership or renting as well as maintenance of the facilities also have their own input into the economics of the process.

Transportation of waste, especially of heavy fractions, have a direct economic impact in terms of expenditures on fuels and an indirect impact in terms of amortization of roads and material costs for vehicle manufacturing. In addition to the economic impact, the transportation of waste has direct environmental impacts in term of noise and emissions (particles and CO_2) and indirect impacts in term of environmental pollution from the process of fuel production and virgin materials used for vehicles manufacturing.

Consumption is a very relevant concept in waste matters – as in terms of usage of natural resources as in nation-wide economics. In Finland, waste management expenditures make up a minimal share of household consumption expenditures. From the value chain perspective, household (and also private business and public sector) consumption expenditures create demand for Finnish Gross Domestic Product (GDP). Also, the growth of waste volumes in Finland reflects economic growth (Figure 6).

Waste collection, transportation and treatment services are on the one hand are part of GDP, providing income or service sales revenues for waste operators and on the other hand expenditures for households, municipal services and businesses.

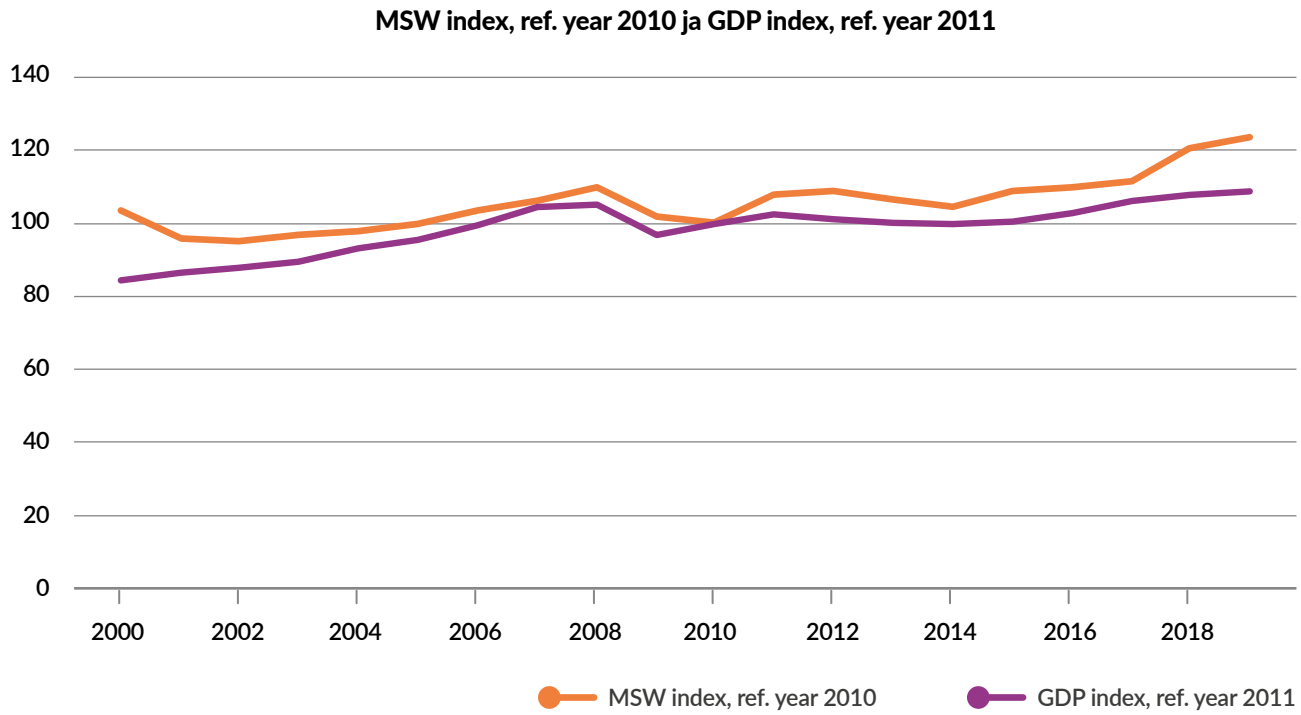


Figure 6. Municipal waste amount and GDP growth in Finland in 2000 – 2018 according to Statistics Finland

The consuming of natural resources is connected to the waste value chain. When you take enough steps back in the production chain, all matter has its origin in nature. This also applies to waste. Prior to waste status, waste fractions have been, among other things, products, packaging or industrial by-products that have arisen at different stages of the production process and consumption. Information on the increase or decrease in the amount of waste does not yet indicate the development of society. The amount of waste can be reduced, even if people consume more, if at the same time the cycle time of materials increases as better design or distribution increases. Nowadays the priorities in the EU and Finland are decreasing waste generation and increasing the share of reusing and recycling. Including circular economy aspects into product and packaging design is an important instrument to extend their life cycle and to reach recycling targets.

The transition to the circular economy requires more utilization of materials and even less virgin raw materials from nature. A higher share of recycled material in total material use means more compensation for the need for virgin raw materials, lower environmental load, more jobs and value added taxes. The lower the waste intensity or the ratio of waste to GDP, the lower the environmental load to produce more products and services. The lower the material consumption relative to GDP, the better the resource efficiency. Jobs in processing chains and substitution for virgin raw material consumption are indirect benefits of recycling. Waste recycling expertise provides growth opportunities for Finnish environmental technology companies and domestic market references would create export potential.

According to the Finnish Innovation Fund Sitra, transition to the circular economy could offer the Finnish economy an annual growth potential of around 3 billion euros by 2030. The waste management sector has significant social benefits. The sector provides jobs, stimulates new innovations and businesses, increases education and training services related to waste management and the circular economy. It has health and wellbeing aspects and is important from the perspective of comfortable living environments as well as from the environmental safety in terms of air, water and soil pollution as well as biodiversity.

3 State level

During the history of Finland, waste management has developed as a co-operation between municipalities, private waste companies and producer corporations. The legislation has played a vital part in the development of a modern, holistic and effective waste management system (Figure 7).

Industrialization and urbanization in the early 20th century increased population density. The intrusions caused health problems and waste management had to be arranged. In 1927, the Health Care Act came into force, making it possible to transfer waste management under municipal responsibility. After World War II, population growth and increased consumption created the need for landfills as well as material recycling. Finland has a long tradition of recycling materials, for example, the separate collection of paper, metal and cardboard began already in the 1940s. In 1950s a deposit system for returning refillable glass bottles was introduced. Since then, the materials and types of packaging included in the return system have steadily increased. Still, more than 90% of these beverage packagings with deposits end up being reused or recycled through a return system.

In 1978, the first Waste Management Act came into force, and it started the waste management services and organized transportation of MSW. The following year hazardous waste management was started, as a company called Suomen Ongelmajäte Ltd. was established in Riihimäki. Currently Fortum Plc.'s plant in Riihimäki handles most of Finland's hazardous waste.

In the 80s, cooperation between municipalities in waste management began. In the 1990s waste legislation evolved due to EU membership. The 1990s were the peak period for the establishment of municipal waste management organizations. The new Waste Act, which entered into force in 1994, accelerated co-operation between municipalities. In the 1990s, the separate collection of bio-waste became more common, and recycling obligations and MSW advising became more efficient.

The Government decision on landfills (1997) and the EUs Landfill Directive (1999) brought landfill construction to the current level, where the environmental impact has been minimized. This also increased the costs associated with the construction of new landfills and led to the closure of old landfills. Later, the restriction of landfilling of organic waste (also called ban of landfilling of organic waste), adopted in 2016, has reduced the landfill of waste, has meant in practice that the landfilling of mixed waste has been stopped.

Starting from the 2000s, the Finnish waste-to-energy field has been developed. In the 2010s, the network of both waste incineration plants and biological treatment plants has expanded strongly. The change in producer responsibility for packaging waste brought a new network for the separate collection of recyclable materials, the RINKI eco take-back points. In 2016, the collection of plastic packages began.

The next Waste Act came into force in 2021. It is based on the revised EU Waste Directive in 2018, which aims to reduce waste and increase reuse and recycling. Due to the new Waste Act, the recycling targets for different waste fractions has tightened and separate collection has intensified. Today, the transition to the circular economy is one of the main priorities in the waste sector in Finland.

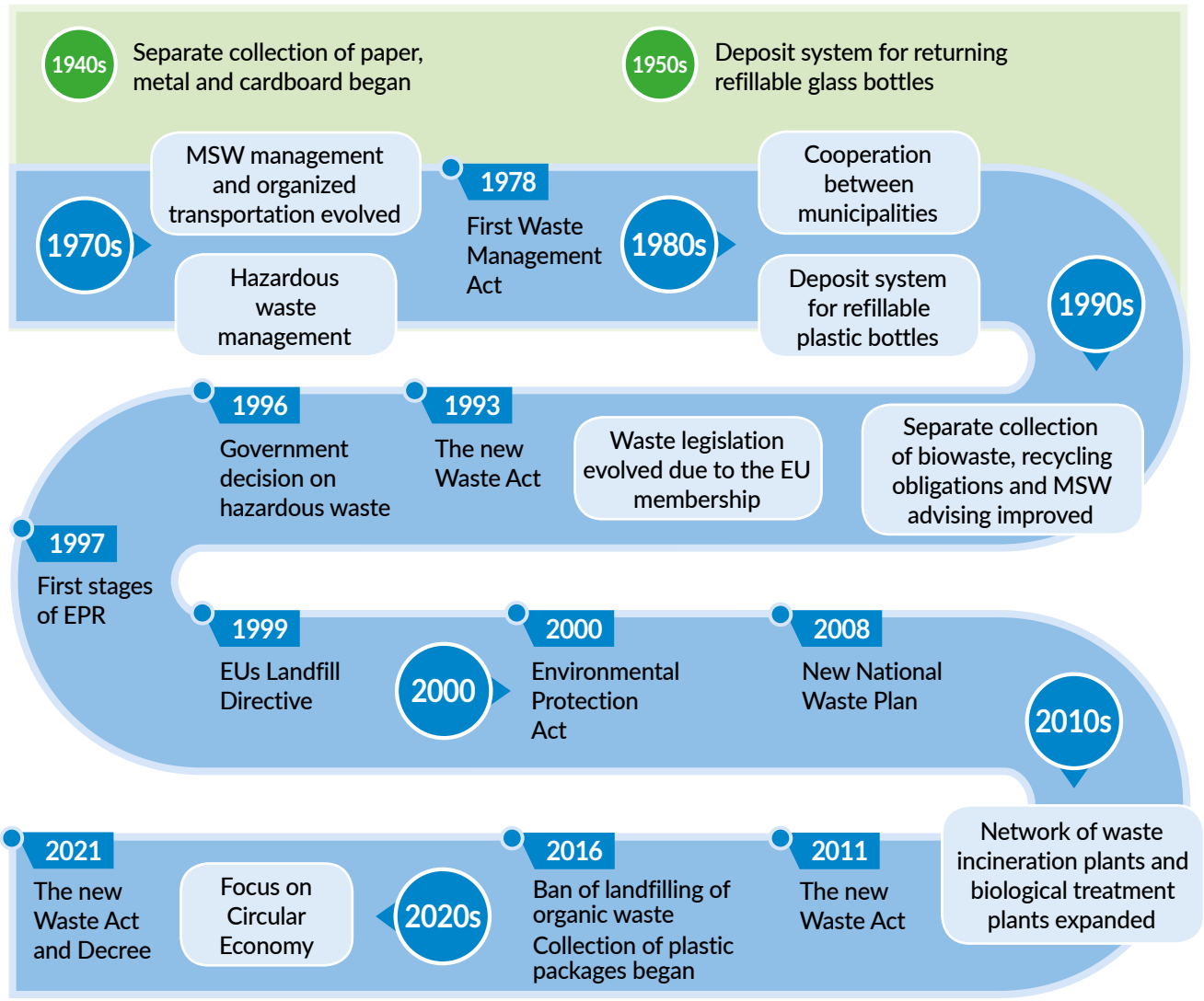


Figure 7. History of waste management development in Finland from 1940s to 2021

3.1 Waste policy - general objectives and principles

The Finnish waste policy aims to promote the sustainable use of natural resources and to ensure that waste poses no harm to the environment or health. The waste policy of Finland is based on the European Union's waste policy. For more information, see INFOBOX 2.

INFOBOX 2: The principles of the EU and Finnish waste policies are:

1. Prevention
   - The production and harmful impact of waste should be prevented and reduced whenever possible.
2. Polluter pays
   - The producer of the waste pays all the waste management costs.
3. Producer responsibility
   - Instead of waste producers, the manufactures, and importers of specific product types bear the responsibility for the waste management of their products when they become waste.
4. Precautionary principle
   - Potential risks caused by waste and waste management should be anticipated.
5. Proximity principle
   - Waste should be treated as close as possible to its source.
6. Self-sufficiency principle
   - The European Community and each of its Member States are self-sufficient in their waste management.

A key principle of waste management in the EU and Finland is the order of priority (Figure 8):

1. The priority is to prevent the production of waste.
2. If the production of waste cannot be prevented, the waste must be prepared for reuse.
3. If the waste cannot be reused, it must primarily be recycled as material and secondarily recovered as energy.
4. Only if its recovery is not technically or economically feasible, waste can be disposed of in landfills.

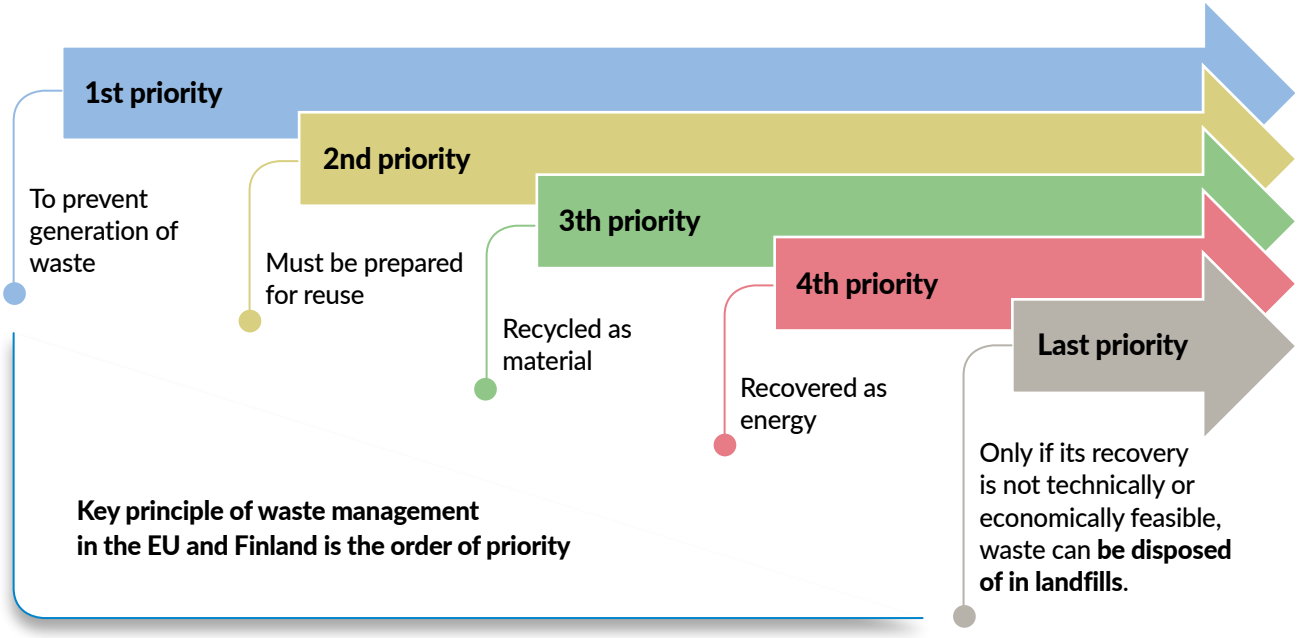


Figure 8. The order of priority as the key principle of waste management in the EU and Finland

3.2 Waste and Environmental Protection Acts

The waste legislation is largely based on EU legislation, but in some cases it is stricter. Finnish waste legislation covers all wastes except certain special types of waste, such as radioactive wastes.

General waste legislation in Finland consists of the **Waste Act** (646/2011) (**WA**) (INFOBOX 3), and the Waste Decree (978/2021). The environmental impacts of wastes are also addressed in the legislation on environmental protection: the **Environmental Protection Act** (**EPA**) (527/2014) (INFOBOX 4), and the Environmental Protection Decree (713/2014). In addition, there are numerous Government Decrees and decisions on specific waste treatment, waste types or activities, and directly applicable EU regulations/ decisions.

INFOBOX 3. Basic ideas of the Waste Act

WASTE ACT

The Purpose:

1. To promote the circular economy and the sustainability of the use of natural resources;
2. To reduce the amount and harmfulness of waste;
3. To prevent danger and harm to health and the environment from waste and waste management;
4. To ensure efficient waste management and to prevent littering.

For the purpose of this Act, "waste" means a substance or object, which the holder has disposed of or intends to dispose of or is required to dispose of.

Does not apply for example for:

- emissions to air;
- CCF, if the total intended storage is less than 100,00 tons and the purpose is research, development or testing of new products and methods;
- wastewaster to the extent provided for elsewhere in law;
- explosives, nuclear and radioactive waste;
- for the disposal of unpolluted dredging material;
- animal by-products (exception: applies to by-products and derived products destined for incineration, landfill or use in a biological treatment plant);
- contaminated soil that cannot be removed from rock or soil;
- substances intended for use as feed materials according to the EU legislation
- to some extent waste generated in agriculture and forestry, which is used for other purposes than for energy production

INFOBOX 4. Basic ideas of the Environmental Protection Act

ENVIRONMENTAL PROTECTION ACT

The Purpose:

1. to prevent pollution of the environment and its danger, to prevent and reduce emissions and to eliminate the nuisances caused by pollution and to combat environmental damage;
2. to ensure a healthy and comfortable environment as well as an environmentally sustainable and diverse environment, to support sustainable development and to combat climate change;
3. to promote the sustainable use of natural resources and to reduce the amount and harmfulness of waste and to prevent the harmful effects of waste;
4. enhance the assessment and consideration of the effects of polluting activities as a whole;
5. improve citizens' opportunities to influence environmental decision-making

"Emission" means the release, introduction or emission, directly or indirectly, of air, water and soil, from one or more points into a substance, energy, noise, vibration, radiation, light, heat or odour caused by human activity.

Applies to:

- industrial and other activities that cause or may cause environmental pollution
- activities in which waste is generated
- waste treatment

3.3 Waste management authorities and their functions

The Waste Act (**WA**) defines state and municipal level authorities and their tasks in waste management. The main authorities are presented in Table 1.

Table 1. Main responsibilities of state and municipal authorities according to legislation

State-level authorities	
Ministry of the Environment	**General control, monitoring and development of activities pursuant to the WA.** The Ministry of the Environment takes part in the preparation of Finnish, European and global waste policies and develops, steers and monitors the application and interpretation of the Waste Act. The legislation in Finland is prepared based on the international agreements and the legislation of the European Union.
The Regional State Administrative Agencies	Give **environmental permits** for major waste treatment facilities, for instance waste incineration plants, large-scale waste recovery and final treatment plants (treat non-hazardous waste), hazardous waste treatment plants, and landfills.
Centres for Economic Development, Transport and the Environment (ELY centre)	The **general supervisory authority** pursuant to the WA. The Centres for Economic Development, Transport and the Environment (ELY) supervise and direct the waste management of municipalities and companies. ELY centres monitor compliance with environmental permits and approve professional waste carriers and brokers for the waste management register. In addition, ELY centres ensure quality assurance of waste data stored in the environmental protection information system; collect and obtain information of the waste and waste management on their operational area; and ensure the organisation of training, advising, information sharing and monitoring on waste and waste management on their operational area.
Finnish Environment Institute (SYKE)	The competent authority referred to in the Waste Shipment Regulation, which is responsible for co-operation with other competent authorities in supervising the international shipment of waste. Also, the contact person in accordance to the Waste Shipment Regulation. In addition, SYKE conduct research and monitoring of the reduction of the amount and harmfulness of waste, and waste management, and organise related training, advice and information sharing; participate in the preparation of the national waste plan, regulations and guidelines on waste issues under the Waste Act, and monitor the implementation of the national waste plan; and contribute to the development of the quality assurance of waste data stored in the environmental protection information system.
ELY Centre for Pirkanmaa region	**A national producer responsibility supervisory authority** that monitors compliance with the provisions on producer responsibility on return systems for beverage containers.
Licensing and Supervision Agency for the Social and Health Sector	Directs the prevention of health-related harm caused by waste in its field.
The Finnish Safety and Chemicals Agency (Tukes); The National Supervisory Authority for Welfare and Health (Valvira)	**Supervisory authorities** that monitor compliance with the requirements concerning certain electrical and electronic equipment (EEE) and their properties and labelling as provided in more detail in a Government Decree. Tukes monitor compliance with the requirements for packaging, vehicles and their materials and parts, batteries and accumulators and electrical and electronic equipment. Valvira monitors compliance with the product requirements of electrical and electronic equipment in health care.
Municipal level authorities	
Municipality	Municipalities are responsible for waste management of housing waste. Many municipalities have transferred the waste management obligations to a municipal waste management company (MWMO) owned by a joint institution of municipalities in the co-operation area or association of municipalities. Municipal waste management companies are non-profit in nature and owned by municipalities. A MWMO handles many of the municipalities' duties e.g. waste guidance, waste transport, incineration plants, composting and biogas plants and landfills.
The municipal waste management authority	The functions of the **waste management authority** belonging to the municipality in accordance with the WA shall be performed by an institution designated by the municipality. The municipal waste management authority has the responsibility for the public administrative duties of the municipality's waste management, such as deciding on the waste treatment system, waste management regulations, principles of waste transportation, and the municipal waste tariff. A municipal waste management company (MWMO)of several municipalities must also set up a joint body to handle the administrative duties (**Waste Board**). Waste Board members are selected from the municipalities of the area the MWMO is operating in. The members are mainly elected officials.
Municipal environmental protection authority	The **general supervisory authority** pursuant to the WA (in addition to ELY centres). Operates in one or more municipalities, grants environmental permits for small-scale waste management activity (e.g. storage of end-of-life vehicles or small storage facilities for hazardous waste), accepts notifications of professional waste carriers in the waste management register, and monitors that private individuals and companies comply with the Waste Act.

3.4 Waste management responsibilities

According to the Waste Act, the waste holder, property holder or anyone in possession of the waste have the main responsibility for organising waste management. As an exception to the general rule, municipalities as well as manufacturers and importers of certain products also have such responsibility.

- **Waste holders** are waste producers, property holders and others, who hold waste.
- **Waste producer** means anyone whose activities produce waste or anyone who carries out pre-processing, mixing or other operations resulting in a change in the nature or composition of such waste
- **Property holders** are owners or rent right holders.

To summarize, the responsibilities for organising MSW management falls into three groups:

1. **Municipal responsibility:** waste generated in households and waste comparable to it in terms of properties, composition and amount (excluding hazardous waste) generated in e.g. municipal administration and services' properties or buildings (See Table 2) as well as in small businesses if their waste is collected in combination with regular household waste. Note that housing properties' owners and renters are waste holders and producers, but the responsibility for organizing waste collection and further treatment belongs to the municipality.
2. **Waste holder responsibility:** for waste produced by business activity, the responsibility for organizing waste management generally belongs to the company that produces the waste, with the exceptions mentioned above.
3. **Producer responsibility**: the responsibility for organizing waste management belongs to the products' manufacturers, importers and packagers under producer responsibility.

The responsibilities for MSW management belongs mainly to municipalities: they are responsible for household waste (46%, Figure 9) and also have 3% share of other municipal waste. Businesses organize 26% of waste management and 25% of MSW is under extended producer responsibility (EPR) (Figure 9).

The responsibilities of each party for organising MSW management is explained in detail in the following chapters (3.4.1. – 3.4.3.)

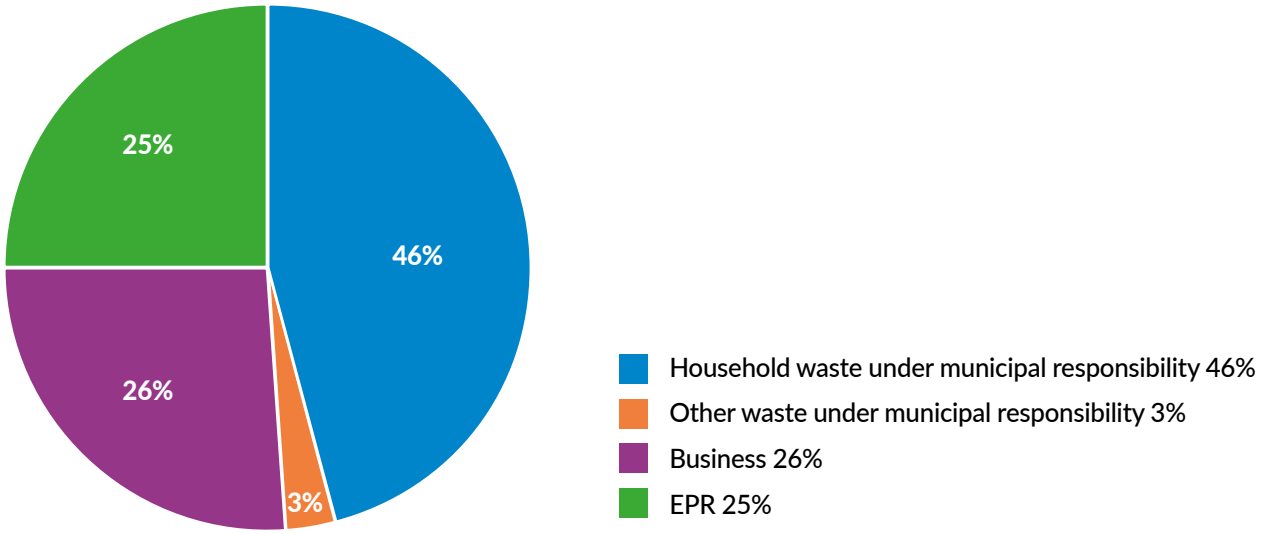


Figure 9. MSW responsibilities of different parties in 2020

3.4.1 Responsibilities of municipalities

Municipalities are responsible for arranging the treatment of waste:

- generated in housing and municipal waste generated in the municipality's administrative and service activities;
- generated in commercial premises if it is collected together with waste from housing or municipal administrative and service activities;
- other municipal waste collected together with the waste mentioned above in regional pipe collection or other similar collection system;
- municipality has to also organize the reception and treatment of hazardous waste generated in housing, the reception and treatment of sedimentation and closed tank sludge generated in housing and in the municipality's administrative and service activities, as well as the reception and treatment of hazardous waste from agriculture and forestry, unless the amount of waste is unreasonable.

According to the secondary responsibility of a municipality to organize waste management, the municipality must organize other than households' and administrative and services' waste management, if the waste holder so requests due to lack of other service provision and the quality and quantity of the waste is suitable for transport or treatment in the municipal waste management system.

Below in the Table 2 are listed municipal administrative and service activities for which municipalities are responsible for organizing waste management. Note: The list is not exhaustive and there may be need for the case-by-case discretion:

Table 2. Waste management responsibilities of municipalities in municipal administrative and service activities according to the Association of Finnish Local and Regional Authorities (AFLRA), 2019

Type of municipal service	Properties of the service
Educational services	municipal day-care centres; municipal open early childhood education and care activities; municipal primary and upper secondary schools; adult education centres and vocational institutes wholly or mainly owned by the municipality or municipalities.
Art and cultural services	municipal theatre or orchestra; municipal public library; municipal museums; municipal youth facilities and workshop service facilities; music schools wholly or mainly owned by the municipality or joint municipal authority.
Sports services	municipal ball game halls; municipal swimming halls; municipal ice rinks; municipal outdoor sports facilities.
Institutional care (Social welfare services)	social and health care services provided at agencies (child and family guidance) or in the homes of private individuals (home services) of municipalities; social care outpatient housing services; institutional care by social services; municipal nursing homes; child welfare institutions, school homes and orphanages wholly or mainly owned by the municipality; institutional care in special care for people with intellectual disabilities, substance abuse rehabilitation centres of municipalities; professional family homes of the municipality.
(Institutional) Health care (medical care and rehabilitation)	municipal health centres and health stations; hospitals of the municipality and joint municipal authorities (hospital districts); municipal dental care units; prehospital care unitas of rescue services; municipal environmental health care units (joint municipal authorities); psychiatric hospital and some of the laboratories of the municipality or joint municipal authority.

Type of municipal service	Properties of the service
Public utility, energy supply, rescue services OR Public utilities and business services	fire or rescue stations of regional rescue; properties and premises managed by the municipal premises centre; municipal waste from municipal water supply service buildings; sanitation of public areas (e.g. parks); ports maintained by the municipality; district heat companies mainly owned by the municipality or municipalities; premises of the municipal or municipal joint waste management organization; municipal business services and development corporations owned by municipalities; premises of joint municipal authorities for public transport.

The municipality is also responsible for environmental awareness-raising and advising services related to the waste management of the waste for which it is responsible.

3.4.2 Responsibility of businesses

Generally, waste produced in business activities is excluded from municipal waste management. Usually, stores, companies, private service activities, and industrial and production plants organize their own waste management and purchase services from service providers. However, municipalities are responsible for waste produced in brick-and-mortar stores, i.e. waste (excluding hazardous waste) produced in business premises located on residential properties that corresponds to household waste (i.e. properties, composition and quantity) and is disposed of in a collection point located on the property.

A company can ask waste management services from the municipality or MWMO if the company is not able to get waste management services from companies offering them. If the value of the waste management service exceeds €2,000 per year, the waste holder must first use the Material Market (*materiaalitori.fi*) to demonstrate the lack of a market-based waste management service. The Material Market is the service provided by the Ministry of the Environment and administered by the Finnish State Sustainable Development company *Motiva* that intended for professional exchange of the waste and production side streams generated by companies and organizations. Through the Material Market, it is also possible to search for and offer services related to them, such as waste management and expert services. Use of the Material Market is free of charge and open to operators in the industry.

In addition, the waste holder is fully responsible for the management of all non-municipal waste, which accounts for more than 97 percent of the total amount of waste generated in Finland.

3.4.3 Extended Producer Responsibility - EPR

Producer responsibility refers to companies' obligation to handle the waste management of products they have imported or manufactured when the products are discarded at their own expense. The authority monitoring the implementation of extended producer responsibility (EPR) is the Centre for Economic Development, Transport and the Environment for Pirkanmaa region (ELY Centre for Pirkanmaa region) (excluding the Åland Islands, where there are separate producer responsibility system). Producer responsibility for waste management applies to 15,000 Finnish manufacturers, importers and packagers, as well as distance sellers.

Producers with producer responsibility are:

1. manufacturers and importers of electrical and electronic equipment (EEE) and vendors selling such equipment under their own brand
2. manufacturers and importers of accumulators and batteries (including importers of vehicles and electrical equipment that contain accumulators and batteries)
3. manufacturers and importers of cars, vans or other comparable vehicles, and operators who import vehicles in the name of a Finnish user
4. importers, manufacturers and re-coaters of tyres, and importers of vehicles and equipment equipped with tyres
5. importers of paper products, and manufacturers and importers of paper used to manufacture paper products
6. packagers and importers of packaged products with turnover is a minimum of €1 million.

There are three options for a company to fulfil its producer responsibility:

1. by joining a producer corporation, when the producer responsibility is transferred to the producer corporation, which fulfils the producer responsibility obligations on behalf of the producer
2. by submitting an application for registration in the producer register to the ELY Centre for Pirkanmaa region and organising the collection, recycling and other waste management of products covered by the company's producer responsibility at its own expense
3. by setting up a producer corporation together with other producers.

The ELY Centre for Pirkanmaa keeps a public list of the companies in the producer register. The list has both producers and producer corporations.

A producer corporation is a legally competent corporation established to manage the obligations imposed on producers. Only producers can form a producer corporation and be members of it. In practice, most producers have joined the corporation due to the fact that arranging collection especially for waste from Business-to-Consumer products is impossible for individual producers due to the large amount of collection points they would have to arrange. The number of collection points is defined in legislation and differ between sectors. Collection points are free-of-charge for end users, and they must cover all municipalities. There can be several producer corporations in the same sector. In that case, they have to cooperate especially in regard to collection networks (See Figure 10).

Producer corporations are approved by the authority. In a producer corporation, obligations must be fairly divided between producers, with consideration given to the nature and extent of operations, and in such a way as to avoid any barriers to business or distortion of competition. Also, only producers can make decisions on the rules and fees in producer corporation. List of producer corporations working in Finland in 2021 is presented in the Table 3.

Once joining the corporation, the producer transfers all the responsibilities to it. It includes:

- organizing waste management (transport, treatment, reuse, recycling etc.);
- arranging collection points that are free of charge for end-users;
- providing information to end-users about the collection points and other issues, which may affect waste management;
- covering the associated costs;
- keeping a record of imported, collected and recycled amounts and submitting the information annually to the authority;
- ensuring that targets for preparing for reuse, recycling and other recovery are fulfilled

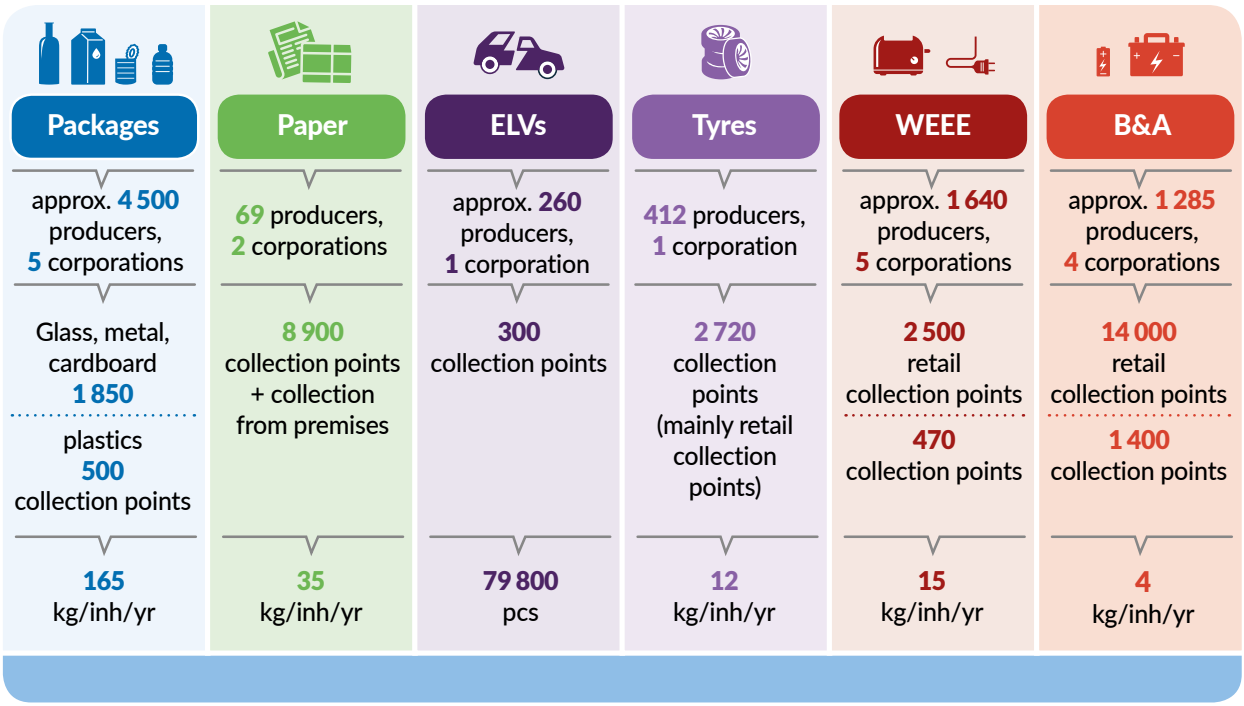


Figure 10. Amount of producer corporations and collection of EPR waste in Finland in 2021

Table 3. List of producer corporations in Finland in 2021

Product	Approved producer corporations
Batteries and accumulators (B&A)	Portable batteries and accumulators ERP Finland Association Portable batteries and accumulators, portable lithium vehicle batteries and industrial batteries and accumulators Recser Ltd. Vehicle and industrial lead acid batteries Akkukierrätys Pb Ltd. Traction batteries for electric and hybrid cars Finnish Car Recycling Ltd.
Paper	Suomen Keräyspaperi Tuottajayhteisö Ltd. Suomen Keräystuote Ltd.
Packages	Common service company that organizes packaging waste collection: Finnish Packaging Recycling RINKI Ltd. Producer corporations: Metal packages: Mepak-Kierrätys Ltd. Wood packages: Puupakkausten Kierrätys PPK Ltd. Glass packages: Suomen Keräyslasiyhdistys Association Fibre packages: Suomen Kuitukierrätys Ltd. Plastic packages: Finnish Plastics Recycling Ltd.
Tyres	Finnish Tyre Recycling Ltd.
End-of-life vehicles (ELVs)	Finnish Car Recycling Ltd.
Electrical and electronic equipment waste (WEEE)	Service company: Elker Ltd. - serves 3 producer corporations: SELT Association, FLIP Association, ICT Producer Co-operative Producer corporations: ERP Finland Association SERTY Association
Beverage packaging return systems	Ekopulloyhdistys Association (refillable deposit glass bottles) Palpa Lasi Ltd. (glass bottles) Suomen Palautuspakkaus Ltd., PALPA (plastic bottles and aluminium cans)

Producers and corporations buy services market-based from waste management companies, either public or private. The producer corporation decides on the annual recycling fee to be paid by the producer, and this is based on the quantity of products placed on the market. This fee covers e.g. the staff costs of producer corporation as well as other general operating costs, costs of organization and maintaining of regional collection points, costs of terminal collection, sorting and recycling costs and other related costs. The producer includes these costs into the product's price paid by consumers. However, so far, the impact of producer responsibility on prices is estimated to be so low that the consumer does not even notice it.

For products subject to producer responsibility, recycling targets have been set for each product group in both EU directives and relevant Government Decrees. The achievement of the targets is monitored annually when producers and producer organizations report collection and recycling volumes to the ELY Centre for Pirkanmaa region, which compiles national statistics on producer responsibility and reports them to the European Commission. The statistics describe the quantities of products placed on the market and the quantities and recovery of waste collected by producers and producer organizations.

A deposit-based return system for beverage packaging provides an effective and positive way to encourage consumers to return beverage containers and provides an option to fulfil producer obligations. The return rates are very high: in 2020 they were 94% for cans, 92% for plastic PET bottles, 87% for recyclable glass bottles and around 97% for reuse glass bottles. (For more information, see INFOBOX 5).

INFOBOX 5: Deposit-based return system for beverage packaging

- Enables the efficient collection of packages for recycling, which yields high volumes of high-quality reusable/recyclable material
- Voluntary system: by joining a deposit system, beverage manufacturers and importers are exempted from the beverage packaging tax (€0.51 per litre), since they are refilled or recovered as raw material
- Covers a large spectrum of different beverage containers: water, lemonades, beer, wine, and liquor
- The Tax Administration takes care of the taxation of beverage containers.
- Companies can make their beverage containers exempt from the tax by joining an approved return system or by arranging their own return system.
- There are three approved return systems in Finland: Palpa Lasi Ltd., Suomen Palautuspakkaus Ltd. and Ekopulloyhdistys Association.
- Each distributor selling beverages with a deposit is obliged to accept empty containers and return the deposit
- For returnable beverage containers the recycling or reuse target is at least 90%.
- In order to reach these targets, a deposit is collected on beverage containers. The minimum deposits are:
  - €0.15 for metal beverage cans
  - €0.20 for plastic containers larger than 0.35 litres but smaller than 1 litre
  - €0.40 for plastic containers at least 1 litre in size
  - €0.10 for other beverage containers.

3.5 Financial guarantee of operation

The purpose of the financial guarantee for waste-related operations under both the Waste Act (WA) and the Environmental Protection Act (EPA) is to ensure proper waste management in a situation where the operator is insolvent or otherwise unable to discharge its obligations. A financial guarantee may become necessary especially in the event of bankruptcy of the operator.

According to the WA, a guarantee is required from:

4. Producers of EEE used in households
5. Waste collectors
6. Waste brokers
7. Transfrontier shipments of waste (excluding so-called green list waste shipments)

According to the EPA, a guarantee is required from waste treatment plants or professional treatment operators, which include

- Waste recovery operators
- Waste disposal operators
- Waste site operators of the extractive waste.

Activities that pose the risk of environmental pollution require an environmental permit in accordance with the EPA. Assessing the need for this financial guarantee and its amount is a part of the environmental permit consideration. For the permit application, the operator must submit a statement of the costs associated with waste management, closure and aftercare. The amount of the financial guarantee shall be sufficient to cover the appropriate waste management, monitoring and supervision costs, as well as costs of actions required in case of cessation[s] of activities and aftercare.

For long-term operations, such as landfill and extractive waste sites, the amount of financial guarantee should be increased according to the environmental permit as the operating areas increase. In this way it is ensured that the financial guarantee corresponds with the actual cost of closing down. The supervisory authority monitors that the operator has a sufficient financial guarantee in accordance with the permit order. All municipal waste management organizations require environmental permits for their operations and financial guarantees.

3.6 Environmental permits or registration

Based on the EPA, all professional waste management activities require an environmental permit or registration.

Brokers, dealers and carriers are subject to a registration procedure, regulated by the Waste Act. Approval for the operations has to be applied in advance from the waste management register.

Still, there are two exemptions from permit requirements: the recovery of certain wastes in earth construction and the use of asphalt waste by an asphalt station. The general rules are specified in the so-called "MARA"-decree (843/2006) (See INFOBOX 6) and the Government Decree on Asphalt stations (846/2012). These operations are subject to a notification procedure to the database of environmental protection.

Enterprises of professional waste collection have the obligation to make a notification to the municipal authority of environmental protection, which should be done in advance of starting operating activities (Figure 11).

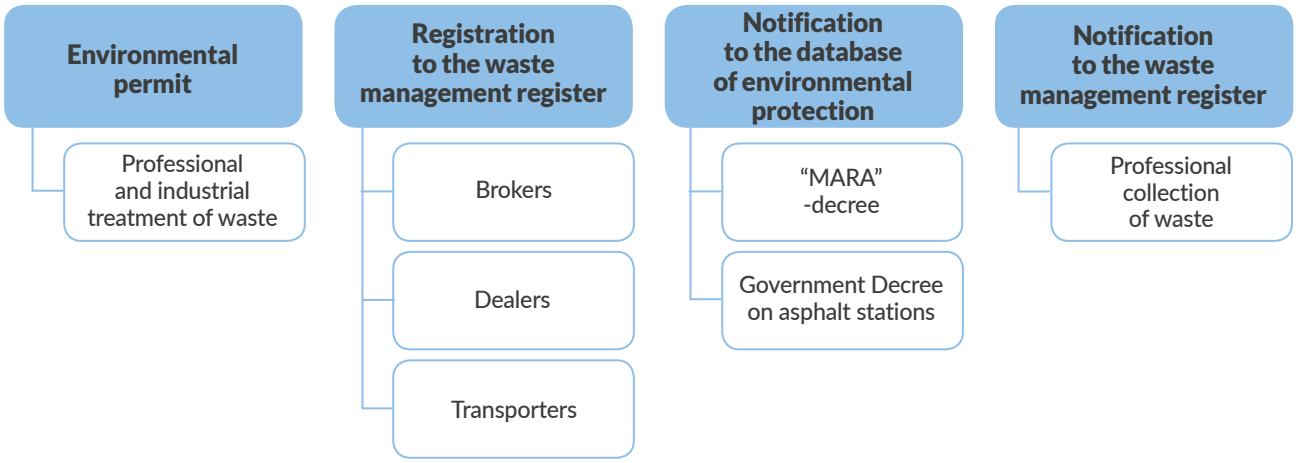


Figure 11. Permits, registrations and notifications needed from different professional waste management operators

INFOBOX 6. "MARA"-decree - Government Decree (843/2017) on recovery of certain wastes in earth construction– definitions and application area.

- The "MARA"-decree aims to promote waste utilization in earth construction. With certain types of wastes, utilization in earth construction does not require environmental permission, but it can be accepted via the notification procedure included in the "MARA"-decree.
- The "MARA"-decree applies to several waste types: concrete chippings, fly ash and bottom-ash from the combustion of coal, peat and wood-based materials, crushed brick, asphalt shippings, treated slag from waste incineration, foundry sand, lime, whole tyres and shredded tyres
- Applicable earth construction destinations:
  - road and bicycle paths, parking areas, sports fields, railway yards and industrial storage fields
  - fairways, fields, ramparts and their structural layers
  - substructures of industrial and warehouse buildings, which means a building
    - » which is used for industrial activities or for the storage of objects or substances
    - » is not used for housing

3.7 Policy instruments promoting recycling

There are multiple instruments in Finland that promote recycling.

- The Waste tax came into force already in 1996. It aims to increase the utilization of waste and reducing the amount of landfilled waste. Currently the amount of tax is €70 per ton of waste sent to a landfill.
  >> More information: See Chapter 4.14.1.1.
- Restriction of landfilling organic waste (also called ban of landfilling of organic waste) came into force in 2016. The restriction applies to cover all biodegradable waste or other waste where the organic matter concentration exceeds 10% determined as the total carbon content or loss of ignition. Organic waste refers to combustible and decaying material such as biowaste, textile, wood waste, newsprint and plastic. The goal of the restriction is to encourage municipalities to collect more biowaste and develop alternative methods of treatment. The restriction has contributed to the development of new businesses as well as reducing landfill emissions into the environment.
  >> More information: See Chapter 4.14.1.1.
- Municipal waste charges (fees) provide incentive to separate collection and recycling. The type, quality and quantity of waste, as well as collection frequency all have an effect on the waste charge. As such, separate collection of recyclable fractions is cheaper, than collection of mixed waste.
  >> More information: See Chapter 4.7.
- Requirements for separate collection of paper, cardboard, glass, metal, plastic, biowaste, wastes falling under the EPR schemes, based on waste legislation and property-specific sorting requirements given by municipal waste management regulations.
  >> More information: See Chapter 3.8., 4.5.
- Extended producer responsibility refers to producers' or importers' obligation to handle the waste management of products they have brought to the market, when the products are discarded, and cover the associated costs.
  >> More information: See Chapter 3.4.3.
- A significant part of the producer responsibility for packaging waste is realized through deposit-based return system for beverage packaging. Beverage packaging deposit-based return systems provide an effective incentive for recycling. As the result, the return rates are very high.
  >> More information: See INFOBOX 5
- Green Deal –agreements are voluntary agreements between the state and the business community or public sector. Green Deal agreements are used to find solutions to curb climate change and promote the circular economy. Agreements can be used to improve or complement the implementation of existing legislation. Agreements can also set stricter targets than the legislation and achieve certain targets without further regulation. Compared to legislation, agreements offer a more flexible approach to finding the most efficient, effective and innovative solution to achieve set goals. Green Deal agreements aim for results that can be achieved relatively quickly, and include the measures to be taken by the Parties of the agreement to achieve the set objectives, as well as follow-up measures. Good examples of Green Deal agreements are Plastic Bag Agreement (See INFOBOX 7), Green Deal on sustainable building demolition, Green deal for sustainable procurement concerning emission-free construction sites, a Green deal on construction plastics.

INFOBOX 7: The Plastic Carrier Bag Agreement

The first Green Deal agreement is the Plastic Carrier Bag Agreement signed between the Ministry of the Environment and the Federation of Finnish Commerce in 2016. EU Packaging Waste Directive was nationally implemented with this voluntary green deal -agreement instead through a legal instrument. The agreement is in force until the end of 2025 and aims to ensure that the reduction targets for the consumption of plastic bags in the EU Packaging Waste Directive are achieved in Finland. The goal is to use a maximum of 40 bags per person per year by the end of 2025.

Based on data reported by companies, the consumption of all plastic bags and sacks (including very light bags for hygiene reasons outside the reduction target) decreased by almost 90 million units from 2017 to 2018.

The consumption of plastic bags covered by the Plastic Carrier Bag Agreement's reduction target was 68 bags per person in 2018. Thus, the plastic bag consumption reduction target for 2019 set by the EU Packaging Waste Directive of a maximum of 90 bags per capita per year has already been achieved in Finland.

Despite the increase in customer visits, the disconnection between the number of visits and the consumption of plastic bags took place in about a year after the signing of the Plastic Carrier Bag Agreement. As a result of awareness-rising measures on plastics, consumers have rapidly changed their consumption behaviour. Much work still remains to be done to reach the 2025 target of 40 bags per person.

3.8 New Waste Act

Wide-ranging reform came into force through the Waste Act on July 19, 2021. The reform will boost recycling and the circular economy. The Waste Act obliges waste operators to separate collection and to recycle waste more efficiently than currently. In addition, there will be new accounting, monitoring and reporting obligations for operators.

In 2025, 55% of municipal waste will be recycled in Finland and in 2035 65% will already be recycled. Efficient separate collection is essential to increase the recycling rate. Precise requirements for the waste management of households, businesses and other operators have been laid down later by the Government Decrees. Separate collection obligations are intended to take effect gradually between July 2022 and July 2024.

What changes?

Municipalities will organize the transport of separate collectable wastes from housing, namely biowaste, small metal waste, and packaging waste from properties after a transitional period. The transport system will change in the municipalities where the transport of waste has been transferred to the responsibility of the holder of the residential property at the moment. The municipality may continue to decide, if the conditions laid down in the law are fulfilled, that the holder of the residential property arranges the transport of mixed municipal waste by agreeing directly with the transport company. Municipalities and packaging producers will organize separate collection of housing packaging waste from real estate in a joint operation. Producers will pay compensation to municipalities for collection. In addition, packaging producers will still have a duty to maintain regional reception sites for packaging waste.

Producers responsible for the waste management of packaging materials will be merged into a "super producer corporation", which will be responsible for the obligations of producers relating to all packaging materials. Producers, i.e. entities of manufacturers and importers of products, will be obliged to arrange for the disposal of the products they place on the market at their expense when the products are withdrawn. In all product categories, producer responsibility will be extended to international remote trade. Producers outside of Finland may fulfil their obligations through an authorised representative in Finland or by accession to the producer corporation. Producer liability charges levied by producer entities on producers will be staggered to favour recyclability, fixability, upgradeability and reusability of products. The producer corporation will receive the funds necessary for the recycling and waste management of its products under producer responsibility from producer liability fees paid by consumers at the price of the product. These funds will provide the required producer liability for recycling and waste management services.

The monitoring of waste flows will be intensified and the digitalization of the sector will progress. There will be tightening in the accountancy and disclosure obligations of operators. In monitoring the flow of hazardous and certain other wastes, electronic transfer documents will be used. The procedures to be followed in applying for municipal secondary waste management services will be amended for public procurement entities.

New Government Decrees will regulate which waste fractions should be collected on properties, but municipalities can tighten or reduce separate collection requirements in their waste management regulations. (For more information see INFOBOX 8).

INFOBOX 8: New separate collection obligations regulated by Governmental Decrees

- Separate collection of biowaste will start in all agglomerations in properties of at least five apartments by July 2022 at the latest and separate collection of small metal and packaging waste by July 2023.
  - equivalent requirements for non-residential properties concerning biowaste, small metal waste and packaging waste from July 2022.
- In addition, separate collection of biowaste will be extended to all properties in agglomerations of more than 10,000 inhabitants by July 2024 at the latest
- The municipality can expand or reduce separate collection with waste management regulations.
- Regional reception of textile waste will start in 2023 at the latest.
- There will be at least 1000 regional reception points for household packaging waste and sufficient amount of terminals throughout the country for the collection of non-household packaging waste and packaging waste collected from properties.

3.9 Sanctions and fines

More attention has been paid to environmental crimes over the past decades. The types of acts and neglects which are considered to be punishable environmental crimes are stated in environmental legislation (e.g. the Environmental Protection Act, the Waste Act, the Nature Conservation Act, the Land Extraction Act) and criminal acts. Punishment types especially suitable for environmental crimes include fine and imprisonment. The most serious environmental crimes which can be sanctioned with imprisonment are governed by chapter 48 of the Penal Code. Environmental crimes are divided by criminal titles for example as follows: impairment of the environment, aggravated impairment of the environment, environmental infraction, negligent impairment of the environment, nature conservation offence, building protection offence and environmental offence committed by a foreign vessel within the economic zone.

In Finland, the typical type of sanctions for violations is a fine. An offence under the criminal law may also be subject to a corporate fine. The importance of the corporate fine should be noted from the perspective of companies. A corporate fine is a penalty for unlawful conduct incurred by a legal person, in most cases a company, in its activities. The fine is €850 at a minimum and €850 000 at a maximum. The Waste Act also includes the default fee, where the payment is €500 - 500 000. For very small infractions, a fixed fine can also be issued, e.g. for acts against the Waste Act's littering ban. Only in extremely few environmental criminal cases have conditional or unconditional sentences of imprisonment been given.

Also other alternative sanctions might be possible, but are not practically in use in Finland. Finnish law also regulates the legal responsibility of officials. The issue could be, for example, neglect of the supervisory authority or exceeding of authority in the authorization procedure. These cases may be connected to environmental offences as well. In the most severe cases a dismissal from office could be used as a sanction. The procedure would have to show that the official is also unfit to carry out his/her duties.

If a company bears producer responsibility for several areas of producer responsibility, the company has to fulfil its producer responsibility separately for each area. If the producer fails to fulfil its producer responsibility, the ELY Centre for Pirkanmaa region can impose a penalty payment for negligence. The penalty payment is 1% of the company's turnover for the previous year but no less than €500 and no more than €500,000.

4 Municipal level

The task of the municipality is to produce and organize waste management services for its residents cost-effectively. This part of the publication concentrates on the organization of waste management on the regional and municipal level, providing detailed examples.

4.1 Population distribution and types of residential properties

By the end of 2021, the population of Finland was 5,549,807. The average population density was 18.2 inhabitants/km^2 but the average density varies strongly depending on the region of Finland (e.g. from less than 2 inhabitants/km^2 in the north, Lapland, to 187 inhabitants/km^2 in the region of Southern Finland). The median area of municipalities is 760 km^2, the smallest municipality being 6 km^2 and the largest 17,334 km^2.

The share of the population was the following:

- in urban areas 72.1% (in the inner urban area 37.4%, in the outer urban area 23.9%, in the peri-urban area 10%),
- in rural areas 26.7% (in local centres in rural areas 5.5%, in rural areas close to urban areas 7.1%, in rural heartland areas 9.3%, in sparsely populated rural areas 4.8%).

As of 2021, Finland has 19 regions and 309 municipalities, 293 of which are in mainland Finland and 16 in Åland:

- Nine cities with a population exceeding 100,000 (the country's capital Helsinki with a population of about 656 000 followed by Espoo, Tampere, Vantaa, Oulu, Turku, Jyväskylä, Lahti and Kuopio), account for 1 % of Finland's area, 30 % of the country's population and 40 % of all jobs.
- Half of the municipalities have fewer than 6,000 residents. These small municipalities account for about 50% of the land area, 15 % of the population, and about 10 % of all jobs. The smallest municipalities have fewer than 200 residents.

The most significant part of residential properties in Finland are one- and two-dwelling houses or detached and semi-detached houses – in 2020, the share was 89% counting 1,169,903 properties. Blocks of flats take a share of 5% and account for 65,479 properties. One-person households comprise 1,254,300 properties, covering 45% of the population, and two-person households cover 33% of the population. About 60% of one-person households or 804,732 people live in blocks of flats. Over four-person households comprised 338,853 properties taking a 12% share from the total number of households, from which 228,785 or about 68% are detached and semi-detached houses (Figure 12).

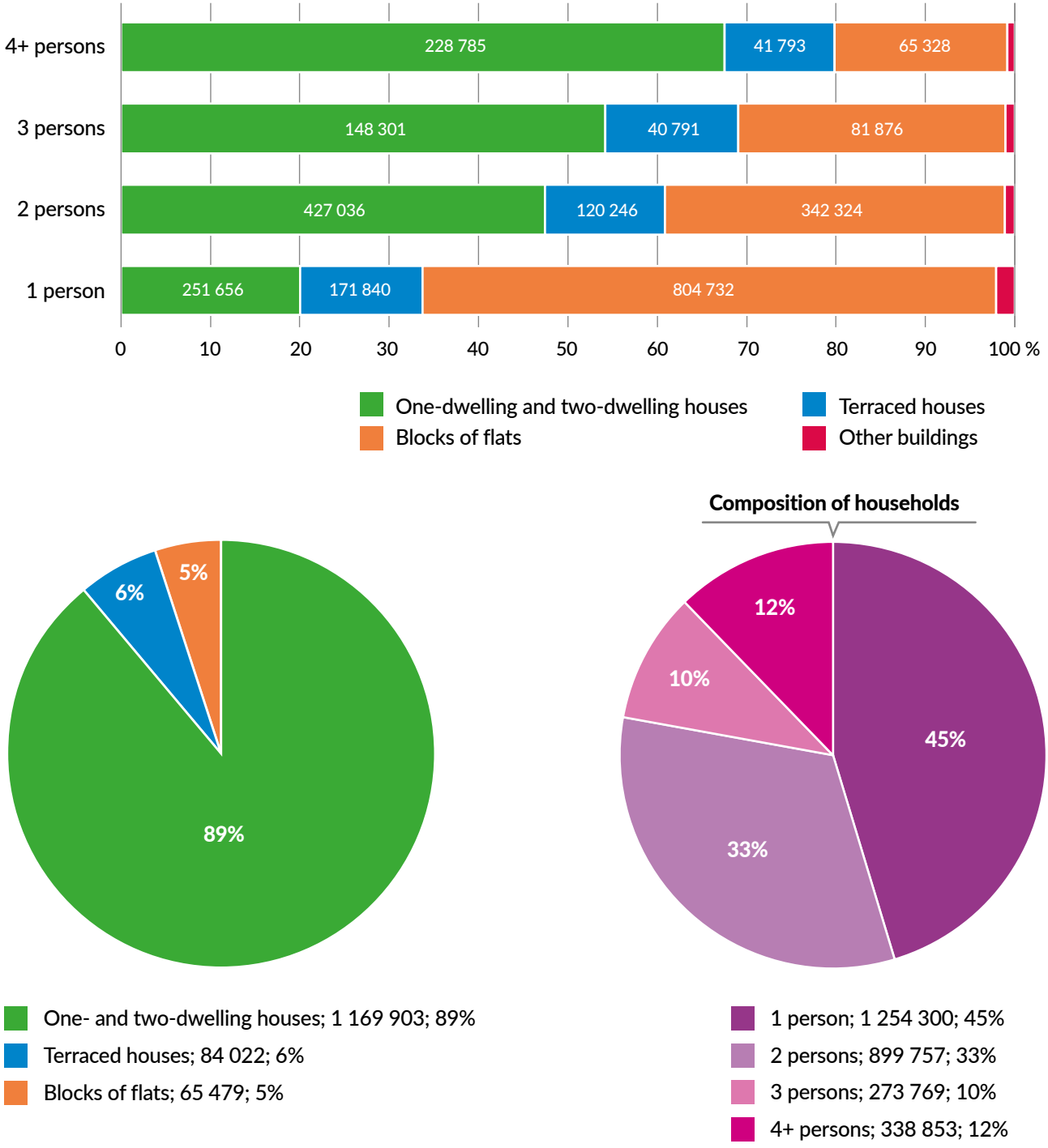


Figure 12. Composition of Finnish residential properties

4.2. Co-operation of municipalities on MSW management

In 2021 in mainland Finland was about 264 Finnish municipalities out of 293 arrange municipal waste management in cooperation, providing services for 5.3 million, 95 % inhabitants. Only about 29 municipalities organize waste management alone, which rely mainly on the services of a municipal enterprise or business entity, either through contracts or tenders.

There are several options for co-operation:

1. Establishment of a **municipal enterprise** together with co-operation municipalities.
   Private ownership is not allowed, so the enterprise should be municipally owned. A municipal enterprise can operate on market terms only at a small extent. The average volume

of market-based operations of such an enterprise cannot exceed 10 % of turnover.

2. Establishment of an **association of municipalities** with other municipalities or **agreement on the joint production of the service** with another municipality or association of municipalities. According to the Municipal Act (410/2015), waste management companies operating as an association of municipalities cannot have market-based activities, so they only accept waste on the basis of municipal responsibility stated in the Waste Act.
3. Municipalities can also agree on the **joint purchasing of the service with another municipality or association of municipalities**. In case of purchasing services from a private service provider, the services should be tendered out in accordance with Finnish procurement legislation. However, organizational responsibility always belongs to the municipality.

At the time of writing of this publication, there were in operation in Finland 25 municipal enterprises, 4 associations of municipalities, 1 business entity and 2 balance units as well as one joint purchase service from a private company, organized by four municipalities.

In this text we concentrate only on municipal enterprises and associations of municipalities, further called **Municipal Waste Management Organizations (MWMOs**) that present the most common way to organize waste management in Finland. The number of founding member-municipalities and the operational area of the MWMOs vary across a broad spectrum (See 8 examples of those in the Chapter 4.4.).

The centralizing of MSW management in larger units started in the 1990s and improved the quality of waste management and enabled waste treatment investments as well as the development of circular economy infrastructure. Many MWMOs contribute to the development of eco-industrial parks or industrial symbioses, providing a platform for companies to work in collaboration by utilizing the resources, side-streams and waste streams of each other.

4.3 MWMO economic baseline and waste management value chain

Municipal enterprises and associations of municipalities are public entities. However, they are registered in the register of companies and establishments. MWMOs operate on business principles but do not have the pursuit of profit as their goal. According to the Waste Act, the pursuit of a reasonable profit is acceptable, but this profit should be used to cover the activities of waste management and possible investments.

Only municipal enterprise can provide limited market-based services (a maximum of 10 % of turnover), most of which are related to the reception of contaminated and surplus soils as well as construction and demolition waste **(**which are not MSW**)**. The waste producer, like private enterprise or state office, usually tenders out the treatment, whereas the municipal enterprise can offer service on market terms.

MWMOs do not usually distribute any dividends. Some of municipal enterprise MWMOs have also achieved the status of social enterprise that produces social well-being.

An MWMO manages the whole value chain of waste management, including health and environmental protection, material flow management, tendering and partnerships. An MWMO deals with all the waste under municipal responsibility and may arrange property-specific separate waste collection, waste sorting stations, local collection points for sparsely populated areas, sufficient number of reception points for hazardous waste, as well as takes care of waste treatment and landfilling. An MWMO also provides information and advising on separate waste collection and is responsible for environmental awareness raising, the goal of which is minimizing waste generation and increasing recycling rate.

Figure 13 shows the whole spectrum of organization of waste management in Finland, covering waste generated in housing properties, municipal services' properties, as well by business services covering all enterprises producing MSW. The responsibility of businesses is described in the Chapter 3.4.2. The content of Figure 13 will be opened in more detail in the following chapters.

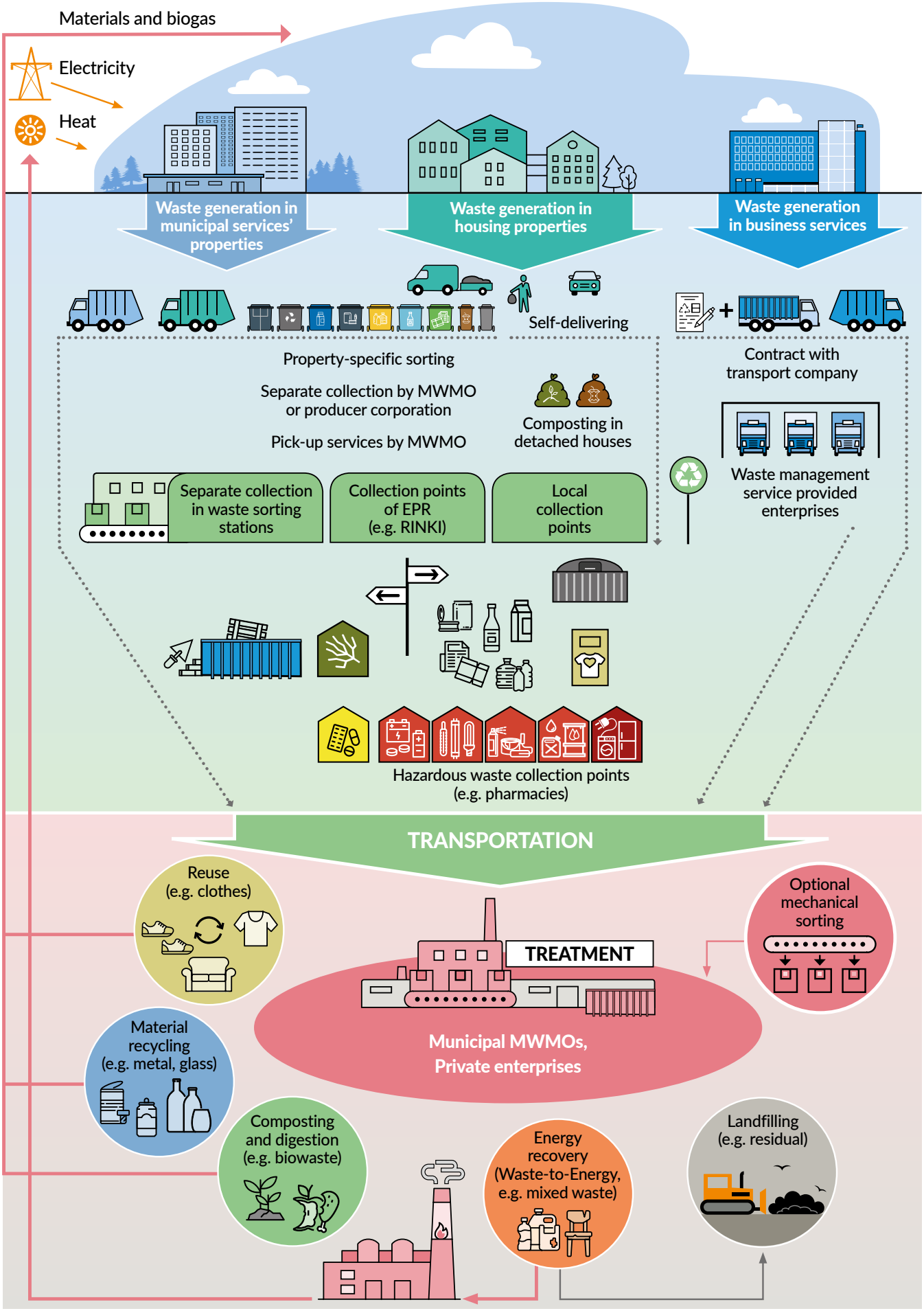


Figure 13. Value chain of MSW management in Finland

Usually, MWMOs purchase the required services from private companies through public procurement. Such services are transportation services, and a large part of the waste treatment services. Also in the case of outsourcing of tasks, organizational responsibility always belongs to municipality. In this way it is possible to avoid situations where a private operator goes bankrupt and is not able to provide needed services. Under certain conditions, transportation can be also organized by mutual agreement between the property holder and the waste carrier. Competitive bidding organized by municipalities is usually more effective and lowers the costs of the waste transportation.

On the other hand, most of Finland's waste-to-energy plant capacity is under municipal control (More information: Chapter 4.13.). Also biowaste treatment is often organized by an MWMO or together with subcontractors and partners (More information: Chapter 4.11.).

An MWMO covers all the costs of organizing waste management. The operational activities of MWMOs are financed by:

- Waste charges collected from properties' holders or owners
  - Emptying charge (More information: Chapter 4.7.1.)
  - Basic charge (More information: Chapter 4.7.2.)
  - Fees paid by customers of waste stations (More information: Chapter 4.7.4.)
  - Charges of other types of collection (More information: Chapter 4.7.3.)
- Revenues from the reception of business waste (including e.g. construction and demolition waste and waste under secondary responsibility)
- Other (for example fees paid by producer corporations for the organization of collection points at the waste stations of an MWMO)
- Revenue from the sales of waste raw materials or waste-derived fuel

The main expenditures of MWMOs include e.g. waste treatment costs (including mechanical separation, recycling, biogas production and composting, incineration and landfilling), landfill aftercare cost, waste tax to the state (€70/ton), costs related to service maintenance (e.g. separate waste collection), awareness-rising and advising activities, and

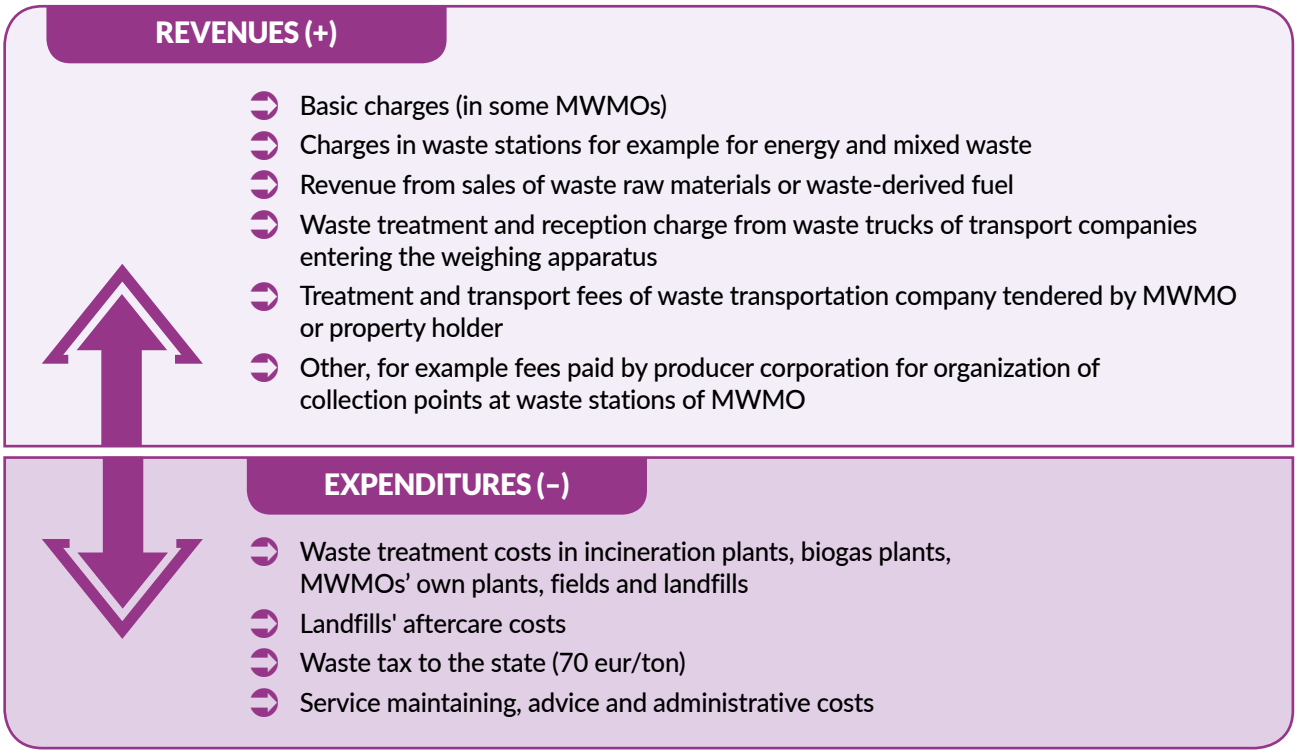


Figure 14. Revenues and expenditures of MWMOs

administrative costs. The revenues and expenditures of MWMOs are presented in the Figure 14.

The MWMO (in case it organizes waste transportation by itself) or waste transport company charges the property an emptying fee when emptying the property's waste bins. In the later case, the MWMO then charges transport companies that bring waste to their management facilities. Waste loads can be priced according to volume (e.g. the volume of the waste bins in the property affect emptying charge), quality (e.g. mixed waste is more expensive than recyclables) and weight (e.g. when taken to the waste station with truck) of the waste. Heavy traffic and corporate customers drive through a weighing apparatus. There may be also reception fee per truck.

4.4. Case examples of Finnish MWMOs

One of the main objectives of this publication is to describe variations between some aspects of the operational and business models of some municipal waste management organizations (MWMO). From the broad spectrum of waste management services of MWMOs, this publication will focus on three of them:

1. Separate waste collection from household properties or the emptying of property-specific waste bins
2. Reception of self-delivered waste at sorting stations
3. Eco-industrial/waste centres

In the following chapters, we will describe different aspects of operation of MWMOs providing examples of MWMOs. The case examples for this publication are selected based on existing collaboration of the projects prepared this publication and knowledge about the operational activities of the selected organizations collected in the framework of these projects. The selection of MWMOs covers different types of administration and operating environments adding a holistic perspective to the publication despite the small number of case examples.

The amount and density of population and types of housing properties are factors, which influence the waste management value chain and its management in addition to Waste Act, relevant Government Decrees and Waste Management Regulations (WMR). For example, how many waste sorting stations, waste centres or eco-industrial centres are feasible to establish and operate, how many waste local collection points are achievable, what kind of collaboration is feasible for organizing transportation and treatment etc.

Table 4 presents a summary of the eight case examples. The locations or municipalities mentioned in this publication are visualized on the map of Finland in the Figure 15.

Table 4. Summary of the operational area of eight MWMO case examples

Abbreviation of MWMO and province	The original name of the MWMO in Finnish	Covering area (cities and municipalities)	Number of municipalities within the operational area	The approximate number of inhabitants
HSY (Helsinki-Uusimaa)	*Helsingin seudun ympäristöpalvelut -kuntayhtymä*	Helsinki, Espoo, Vantaa, Kirkkonummi and Kauniainen	5	1,180,000
Metsäsairila (South Savo)	*Metsäsairila*	Mikkeli	1	55,000
EKJH (South Karelia)	*Etelä-Karjalan Jätehuolto*	Lappeenranta, Imatra, Parikkala, Rautjärvi, Ruokolahti, Lemi, Luumäki, Savitaipale and Taipalsaari	9	127,000
PJH (Pirkanmaa),	*Pirkanmaan Jätehuolto (official name in English: Tampere Regional Solid Waste Management Ltd.)*	Tampere, Nokia, Pirkkala, Lempäälä, Kangasala, Orivesi, Vesilahti, Sastamala, Pälkäne, Juupajoki, Ylöjärvi, Hämeenkyrö, Ruovesi, Ikaalinen, Parkano, Mänttä-Vilppula and Virrat	17	447,000
Kiertokapula	*Kiertokapula*	Hämeenlinna, Riihimäki, Hattula, Hausjärvi, Hyvinkää, Janakkala, Järvenpää, Kerava, Loppi, Mäntsälä, Tuusula, Valkeakoski and Nurmijärvi	13	390,000

Abbreviation of MWMO and province	The original name of the MWMO in Finnish	Covering area (cities and municipalities)	Number of municipalities within the operational area	The approximate number of inhabitants
Salpakierto (Päijät-Häme)	*Salpakierto*	Lahti, Asikkala, Heinola, Hollola, Kärkölä, Myrskylä, Orimattila, Pukkila, Padasjoki and Sysmä	10	200,000
Kiertokaari (Northern Ostrobothnia, and a small part of Lapland)	*Kiertokaari*	Oulu, Hailuoto, Ii, Kempele, Lumijoki, Pudasjärvi, Raahe, Siikajoki and Simo	9	260,000
LHJ (Kanta-Häme, Satakunta, Pirkanmaa)	*Loimi-Hämeen Jätehuolto*	Forssa, Loimaa, Säkylä, Akaa, Eura, Huittinen, Oripää, Punkalaidun, Koski, Somero, Tammela, Sastamala, Ypäjä, Humppila, Jokioinen, Urjala	16	135,000

1. HSY (Helsinki-Uusimaa)
2. Metsäsairila (South Savo)
3. EKJH (South Karelia)
4. Kiertokaari (Northern Ostrobothnia)
5. PJH (Pirkanmaa)
6. Salpakierto (Päijät-Häme)
7. LHJ (Kanta-Häme, Satakunta, Pirkanmaa)
8. Kiertokapula

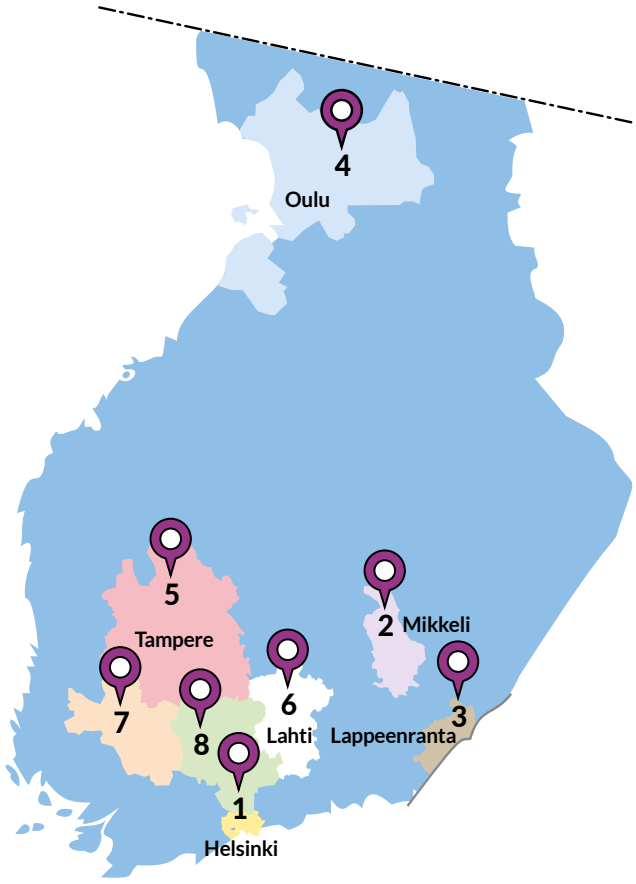


Figure 15. Eight Finnish MWMOs considered in the current publication

The majority of Finnish municipalities are joining resources for arranging MSW management. This publication presents case examples of MWMOs representing two types of organizations – **associations of municipalities** (HSY case) and **municipal enterprises** (Metsäsairila, EKJH, PJH, Kiertokapula, Salpakierto, LHJ and Kiertokaari). The number of municipalities within one MWMO in this paper varies from 1 (in the Metsäsairila case) to 17 (in the PJH case) (Table 4).

In further descriptions of MWMOs in this publication, abbreviations will be **derived from the original names of organizations in Finnish, e.g. HSY, EKJH and PJH**. There are no abbreviations but only original names in Finnish in some cases. Full original names will be used in such case examples**, e.g. Kiertokapula and Metsäsairila.**

To help to recognize/understand Finnish names in this publication:

- "Kierto" is referring to "circular" (e.g. Kiertokaari, Kiertokapula, Salpakierto)
- "Jätehuolto" is "Waste Management" (e.g. EKJH, PJH, LHJ)
- "J" in an abbreviation refers to "Jäte" or "Waste"
- "H" in an abbreviation refers to "Huolto" or "Management"

A brief introduction of each MWMO is found below, which includes statistics on the population in the municipalities within the operational area of particular MWMOs and also on the living environment, e.g. shares of population in urban and rural areas, distribution of population in different types of housing properties, e.g. one- and two-dwelling houses/detached and semi-detached houses, terraced houses and blocks of flats. Also main waste management services, provided by MWMOs are presented, including amount of waste sorting stations and eco-industrial parks/eco-industrial centres. It should be noted that separate waste collection and waste management services in each municipality are much broader, including e.g. collection of hazardous and medical waste, and waste fractions that fall under EPR system. MWMOs also provide environmental raise-awareness services and often come up with other innovative ways to increase separate collection of waste and involve residents in recycling efforts. Introduction of case examples of different MWMOs are presented below.

4.4.1. Brief introductions of case example MWMOs

1 Helsinki, Uusimaa – HSY

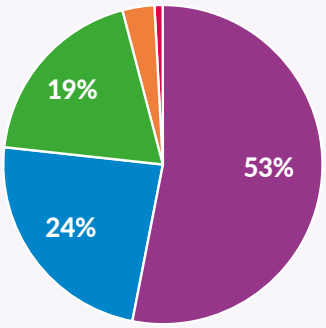
Helsinki Region Environmental Services (*Helsingin seudun ympäristöpalvelut* HSY*)* is an association of municipalities, the founding and member municipalities of which are Espoo, Helsinki, Kauniainen and Vantaa. HSY provides municipal water supply and waste management services, environmental education, training and information services.

HSY operates e.g.:

- 5 sorting stations (See description of operational model in the Chapter 4.6.2.1. and information of charges in the Chapter 4.7.6.1.)
- Ämmässuo Eco-industrial Centre (See Chapter 4.12.1.)

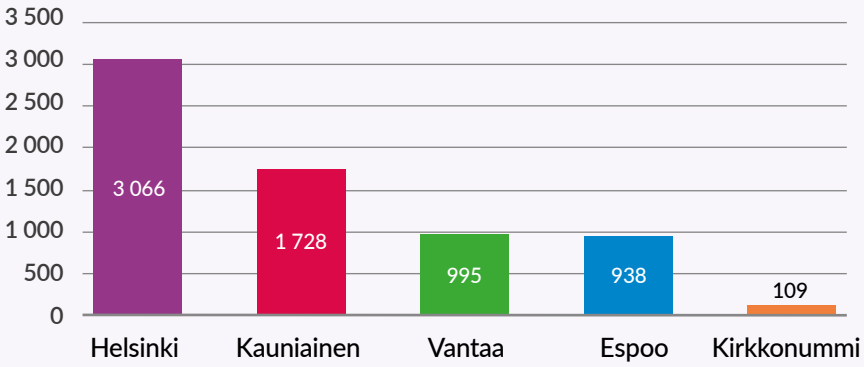
The waste management regulations (WMR) of the HSY apply to all residents of Helsinki, Espoo, Kauniainen and Vantaa, as well as Kirkkonummi and other actors covered by waste management organized by HSY. The municipalities under HSY's waste management operations differ in terms of density of population and types living areas. In 2020, in the HSY area there were about 1,180,000 inhabitants, of which 53% in Helsinki, 24% in Espoo, 19% in Vantaa, 3% in Kirkkonummi and 1% Kauniainen. The density of population varies from 3,066 inhabitants per square kilometre in Helsinki to 109 in Kirkkonummi (Figure 16). Most of population lives in urban areas. There are overall 111,099 housing properties in HSY's service area, 80,760 of which are one- and two-dwelling (synonyms: detached and semi-detached houses).

Population in December 2020



Helsinki; 656 920; 53%
Espoo; 292 796; 24%
Vantaa; 23 7231; 19%
Kirkkonummi; 40 082; 3%
Kauniainen; 10 178; 1%

Population density, [inhabitants/km²]



	Espoo	Helsinki	Kauniainen	Kirkkonummi	Vantaa
Population 31 Dec 2020	**292 796**	**656 920**	**10 178**	**40 082**	**237 231**
Land area, km²	**312.33**	**214.29**	**5.89**	**366.23**	**238.37**
Population density	**937.5**	**3 065.6**	**1 728.0**	**109.4**	**995.2**
Share of persons in urban areas, %	**98.5**	**98.1**	**98.8**	**91.2**	**98.3**
In inner urban area, %	73.7	95.6	97.3	0.0	68.3
In outer urban area, %	22.8	2.3	1.5	54.7	28.4
In peri-urban area, %	2.1	0.3	0.0	36.4	1.6
Share of persons in rural areas, %	**0.1**	**0.0**	**0.0**	**7.4**	**0.0**
In rural areas close to urban areas, %	0.1	0.0	0.0	7.4	0.0

Figure 16. Population in the operational area of HSY

HSY provides waste services for properties, operates Sortti-waste sorting stations, the Ämmässuo eco-industrial centre and Ekomo – a resource-efficient circular economy cluster. HSY works at increasing recycling rate and promoting the circular economy by improving internal processes, but also by providing regional data and by taking part in Finnish and international projects and research, development and innovation.

In 2020 HSY:

- Emptied waste bins almost nine million times
- Processed a total of 769,000 tons of solid materials
- Was left with more than 500,000 tons of material, some of which was utilized in the eco-industrial park of Ämmässuo in the landfill structures of the waste centre, and some of which remained in the centre to await later recovery
- Only 0.8 % of all received waste was landfilled

2 South Savo, Mikkeli - Metsäsairila

Metsäsairila is an MWMO (municipal enterprise) owned by the city of Mikkeli in South Savo. The main task is providing waste management services for the city. The company operates a sorting and recycling centre (waste centre) and small waste stations, organises the recycling of recyclable waste, maintains and develops a network of waste stations in rural areas, and provides hazardous waste management, treatment of separately collected biowaste, and waste transportation. The company's tasks also include the planning, development and co-ordination of waste management, as well as providing advice and information to the public.

Metsäsairila's area of operations is home to about 53,000 residents and is characterised by a large number of holiday homes, some 10,300 in total. The biggest part of population of the city of Mikkeli lives in the so called outer urban area of the city of Mikkeli (over 40%) followed by the inner urban areas (over 26%). In the rural areas close to the urban areas live 13.5% and in the peri-urban areas about 11% of the population. About 7% are live in sparsely populated areas. Per each km^2 of land area there are 21 persons. (Table 5).

Table 5. Population in the Metsäsairila operational area

Population 31 Dec 2020	52,583
Population density, [inhabitants/km^2]	20.6
Share of persons in urban areas, %	78.6
In inner urban area, %	26.7
In outer urban area, %	40.8
In peri-urban area, %	11.1
Share of persons in rural areas, %	20.7
In local centres in rural areas, %	0.0
In rural areas close to urban areas, %	13.5
In rural heartland areas, %	0.0
In sparsely populated rural areas, %	7.2

Metsäsairila operates e.g.:

- 3 small waste stations in Haukivuori, Ristiina and Suomenniemi.
- sorting and recycling centre (waste centre) KIEPPI

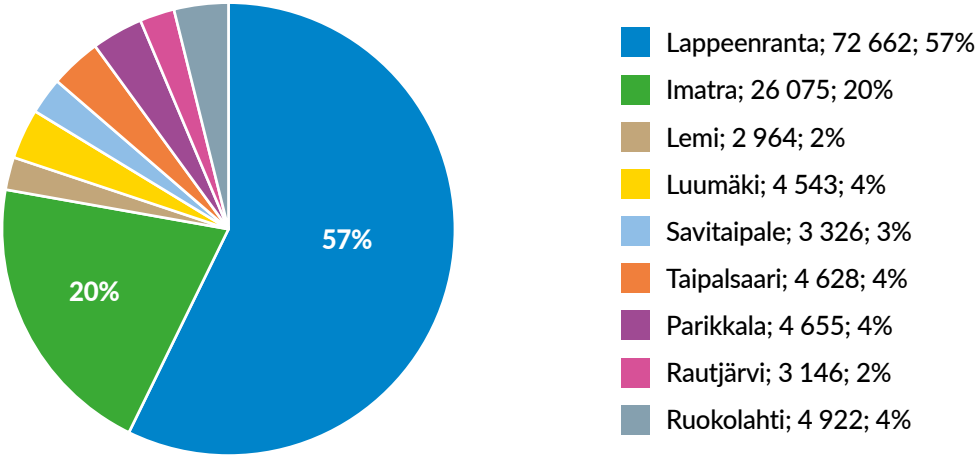
3 South Karelia – EKJH

The South Karelian Waste Management Centre, or EKJH MWMO (*Etelä-Karjalan Jätehuolto – **EKJH***) serves the whole South Karelia area. The EKJH service area includes the following municipalities: Cities of Lappeenranta and Imatra as well as the Lemi, Luumäki, Parikkala, Rautjärvi, Ruokolahti, Savitaipale and Taipalsaari municipalities, which have 126,921 inhabitants altogether. The city of Lappeenranta has 72,662 inhabitants or comprising 57% of the population and while Imatra comprises 20% (Figure 17).

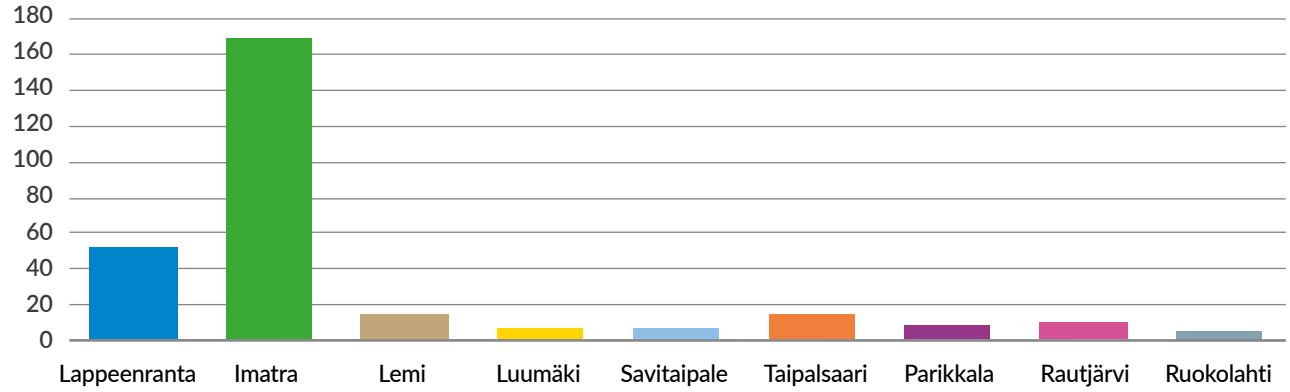
EKJH operates e.g.:

- 9 For use (sorting) stations
- Kukkuroinmäki treatment (eco-industrial) centre (See Chapter 4.11.1.).)

Population in EKJH operational area in December 2020



Population density, [inhabitants/km^2]



Shares of population in urban and rural areas in EKJH operational area

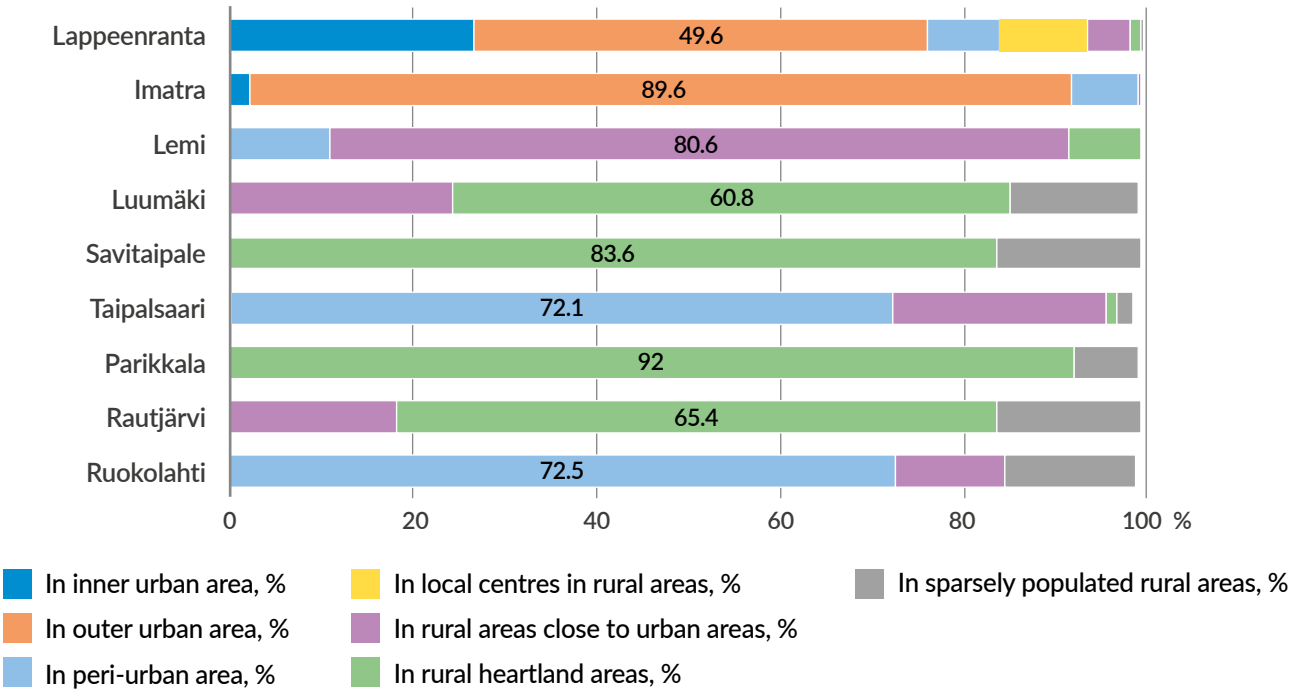


Figure 17. Population in the EKJH operational area

4 Pirkanmaa - PJH

Pirkanmaa Waste Management (*Pirkanmaan Jätehuolto* – PJH, official name Tampere Regional Solid Waste Management Ltd.) is an MWMO of the Pirkanmaa region established in 1994 and owned by 17 municipalities (Hämeenkyrö, Ikaalinen, Juupajoki, Mänttä-Vilppula, Nokia, Orivesi, Parkano, Pirkkala, Pälkäne, Ruovesi, Sastamala (Mouhijärvi and Suodenniemi), Tampere, Vesilahti, Virrat, Ylöjärvi). It has 454,000 residents and clients in its operational area (Figure 18) and 98 employees. The company has won numerous international awards for their operating model in the environmental and social responsibility categories. The turnover off the MWMO is around 44 million euros.

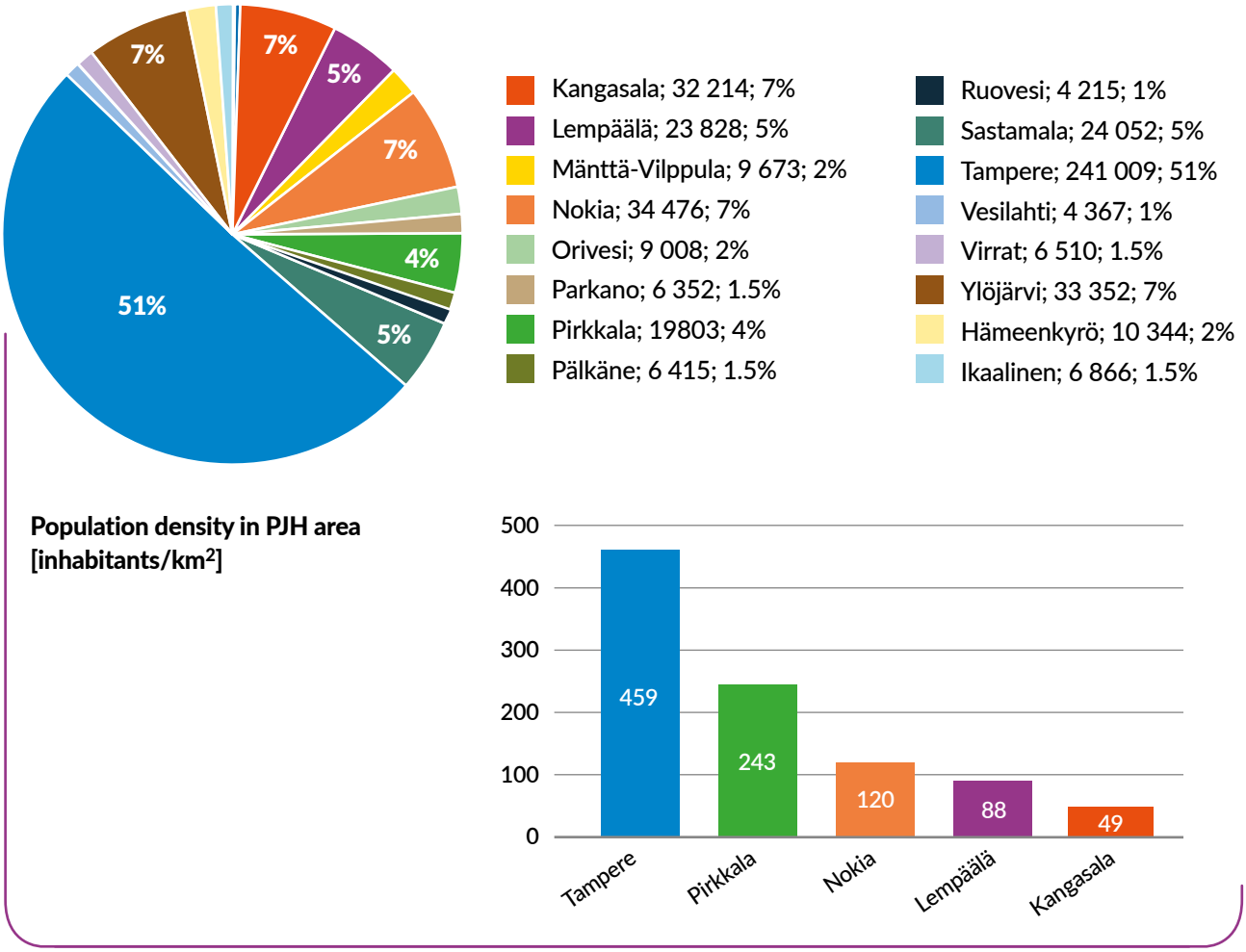


Figure 18. Population in the PJH operational area in December 2020

PJH operates e.g.:

- 21 waste sorting stations covering around 160,000 clients
- 2 full-service waste recycling centres receiving 463,000 tons of waste yearly

It has 25 transport contractors and 14,000 waste bin emptyings per day. Also, it has 487 local waste collection points in sparsely populated areas.

5 Northern Ostrobothnia - Kiertokaari

Kiertokaari is the country's 4th largest MWMO (in waste volumes). It was established in 1995 and has 9 owner municipalities (Oulu, Hailuoto, Ii, Kempele, Lumijoki, Pudasjärvi, Raahe and Siikajoki; the operational area also includes Simo in Lapland), with a total population of 275,000 (more information of population distribution in Kiertokaari operational area in the Figure 19). The turnover of Kiertokaari is 15.2 million euros and it has 26 employees.

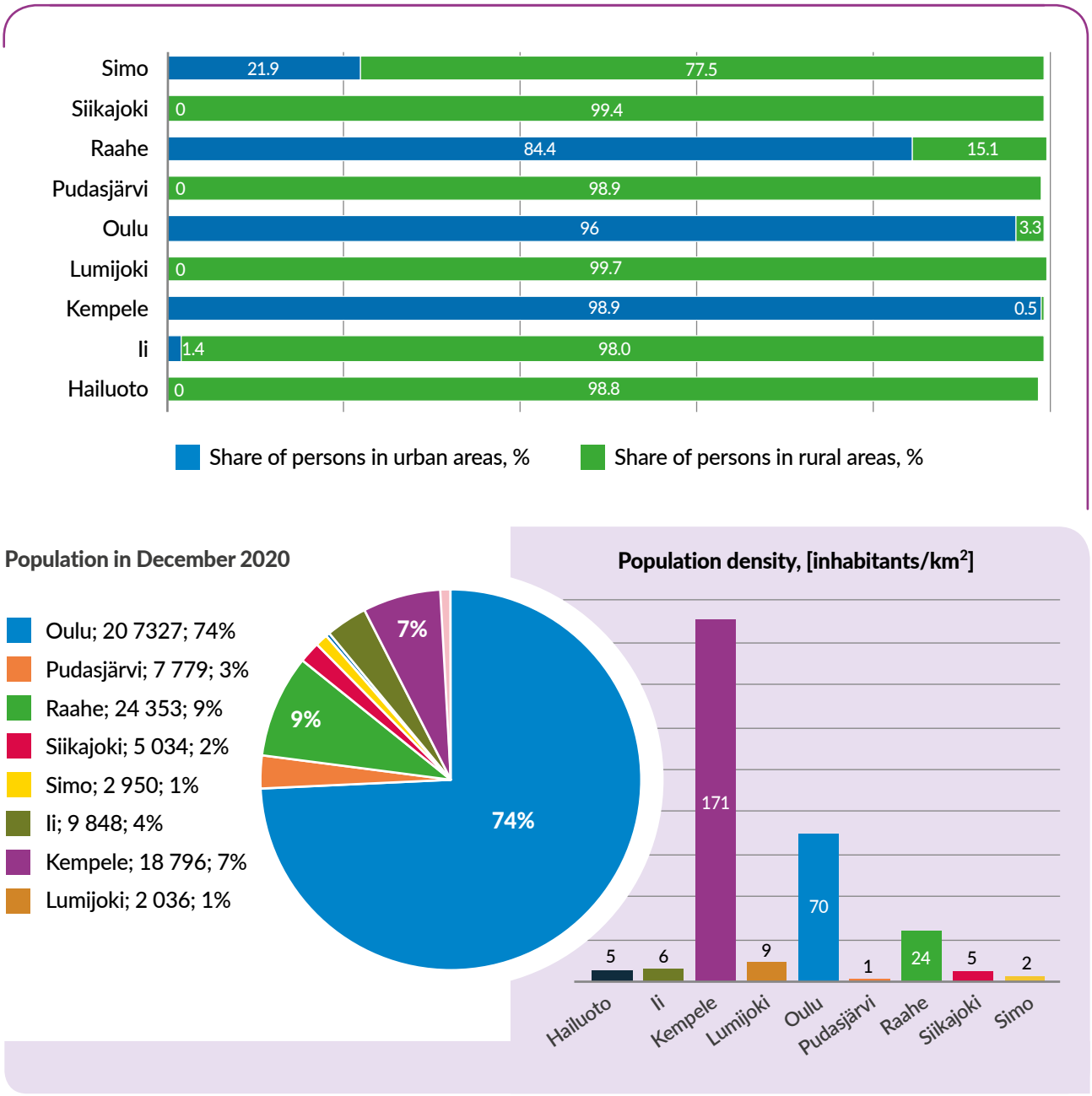


Figure 19. Population in the Kiertokaari operational area

In 2020 Kiertokaari received 174,852 tons of waste, 115,159 tons of this amount being municipal waste. It utilized 99.94 percent of all municipal waste received at their sites as material and energy.

Kiertokaari operates e.g.:

- 8 waste drop-off (sorting) stations
- the Rusko waste centre in Oulu

Since 1997, Kiertokaari has been developing the biogas ecosystem in the Oulu region (More information in the Chapter 4.11.2.).

6 Päijät-Häme – Salpakierto

Salpakierto is an MWMO owned by 10 municipalities. The shareholder municipalities are Asikkala, Heinola, Hollola, Kärkölä, Lahti, Myrskylä, Orimattila, Pukkila, Padasjoki and Sysmä. It was established in 1993 and provides waste management services for 200,000 inhabitants. Its turnover is approximately 19.5 million euros and it has 50 employees. Salpakierto also has two subsidiary companies: Salpamaa Ltd. (reception and processing of earth and stone materials) and LABIO Ltd. (reception and treatment of biowaste).

Salpakierto operates e.g.:

- the Kujala Waste Centre in Lahti (the main site and the only location where it processes waste). The Kujala Waste Centre takes in waste from communities and production facilities for interim storage, handling, reclamation, transfer and final disposal (See Chapter 4.12.5.).
- 7 waste sorting stations

7 Kanta-Häme, Satakunta, Pirkanmaa - LHJ

Loimi-Häme waste management (Loimi-Hämeen Jätehuolto - LHJ) was founded in 1995. The owners are 16 municipalities from Kanta-Häme, Satakunta and Pirkanmaa: Forssa, Sastamala, Huittinen, Punkalaidun, Urjala, Akaa, Humppila, Jokioinen, Tammela, Somero, Koski TL, Ypäjä, Loimaa, Oripää, Säkylä and Eura. It has a turnover of 12.9 million euros and 52 employees. It organizes waste management services for 135,000 residents and 66,000 properties.

LHJ operates:

- 2 waste centres (Kiimassuo in Forssa, Hallavaara in Säkylä)
- 7 waste stations (in Akaa, Huittinen, Loimaa, Punkalaidun, Sastamala, Somero, Urjala)

In addition to its main activities as an MWMO, LHJ has established several subsidiary companies that form the LHJ Group (See Chapter 4.12.4.). The LHJ Group provides services to the business community, public administration and producer corporations in the treatment of electronic waste, contaminated land and special waste, as well as data protection materials. The whole LHJ Group concern processes 500,000 tons of waste annually.

8 Kiertokapula

Kiertokapula's operational area covering 13 municipalities serves the following municipalities: Hattula, Hausjärvi, Hyvinkää, Hämeenlinna, Janakkala, Järvenpää, Kerava, Loppi, Mäntsälä, Riihimäki, Tuusula, Valkeakoski and Nurmijärvi.

Kiertokapula operates e.g.:

- five waste treatment sites (waste centres): Kapula in Hyvinkää, Karanoja in Hämeenlinna, Lumikorpi in Valkeakoski, Metsä-Tuomela in Nurmijärvi and Puolmatka in Järvenpää. Kiertokapula's waste treatment sites accept and treat a wide range of waste, and the entire process up to recovery or final disposal is handled using the latest expertise. The recovery rate of the waste accepted by Kiertokapula is almost 100%, meaning that most of the waste continues its journey towards utilisation.
- four depots (waste stations) operated jointly by municipalities and Kiertokapula: Hausjärvi Municipal central warehouse, and Municipal depots in Loppi, Mäntsälä and Riihimäki. These depots accept household hazardous waste, electric waste and electronic equipment and scrap metal free of charge.

4.5. Waste Management Regulations

Municipal waste management regulations (WMR) are local regulations given by the municipal waste management authority e.g. Waste Board (See Table 1 in the Chapter 3.3.).

WMR are regulations (not recommendations) that specify legislation, the Waste Act and the Waste Decrees, taking into account local conditions. The aim of WMRs is to prevent harm or hazards to health or the environment caused by waste or waste management, and to promote compliance with priority principle management (described in the Figure 8 in the Chapter 3.1.). As such, WMRs play an important role in the practical implementation of waste management in the municipality and provide guidance on types of waste to be collected separately in different kinds of properties, provide information on waste stations and local collection points, collection equipment, emptying frequencies, and requirements for waste transportation, utilization and disposal, as well as prevention of littering. Most municipalities have imposed obligation limits on the property-specific collection of different types of waste in their waste management regulations. In addition, municipalities have taken other steps to increase the separate collection and recycling of waste.

WMRs apply to properties covered by municipal waste management under the responsibility of municipalities, such as housing properties and municipal service facilities. WMRs apply to enterprises' waste if such is collected and treated in the municipal waste management system at the request of the business operator based on the supplementary obligation of a municipality to organize secondary waste management. Thus, all municipal actors, owners and inhabitants of residential and public property, and, where applicable, other actors, must comply with WMRs. WMRs are binding to all inhabitants of an area of application or area of operation of an MWMO.

WMRs contain a general part and an actual regulatory part. The general part describes the obligations under the Waste Act and other legislation and provides information on the waste management system. The actual regulatory part includes binding provisions.

Notice that the case examples of MWMO operation and applied WMRs described in the following chapters are based on the older Waste Act, which came into force in 2012. The requirements of the new Waste Act that came into force in July 2021 were not yet implemented in WMRs at the date of this publication. Also, the new Waste Decree have some new specific obligations. It is expected that MWMOs will update their WMRs and operational models starting from 2022 until 2024. See more information about the new Waste Act in the Chapter 3.8.

4.6. Separate Waste Collection

Property owners, other waste holders and housing companies are obliged to organize waste collection points and containers for household waste, and waste producers (residents) should take their waste to these collection points. Different types of wastes are separately collected to make handling and utilization easier. In addition, it is reasonable to collect waste which still has market value, such as metal and paper.

Basically, in blocks of flats separate collection from properties of paper, cardboard, glass, plastic packages, metal, and biowaste should be organized. Inhabitants of detached houses usually collect only mixed waste, but many properties often also have their own composter. The situation is currently changing due to the new waste legislation, and in the future also the detached houses need to separate their biowaste in densely populated areas. Other waste types can be self-delivered by inhabitants (especially of detached houses) to waste sorting stations or collection points organized by producers via EPR corporations. Hazardous waste produced by households should be accepted free of charge at collection points organized by MWMOs. Medical waste, needles and syringes generated in households should be delivered to pharmacies.

Detached houses, mainly in rural sparsely populated areas (incl. summer cottages) not connected to waste collection networks, have to join local waste collection networks for mixed waste organized by MWMOs. In some cases, this takes place also in urban areas, for example in the Helsinki Metropolitan Area. Pre-sorted waste can be returned to regional collection points for packaging waste and paper of EPR corporations (For more information see Chapter 4.6.3.).

In addition, glass and plastic bottles and metal beverage cans with deposits can be returned to shops selling beverage bottles.

The most common way to organize separate collection of waste is property-specific waste collection organized jointly by MWMO (or private waste company) and real estate properties. (See descriptions of three examples in an operational model perspective in the

Chapter 4.6.1.; examples of charges/fees in a business model perspective in the Chapter 4.7.6.; management and ownership of housing or residential real estate properties is described in the INFOBOX 9).

Other types of separate collection options can be divided into the following types (Figure 20):

1. Local collection points (See more information in the Chapter 4.6.5.)
2. Joint waste containers, also called block collection (See more information in the Chapter 4.6.4.)
3. Collection network organized by EPR corporations (See more information in the Chapter 4.6.3.)
4. Self-delivery to waste sorting stations (See description of example in the Chapter 4.6.2. and business models in the Chapter the 4.7.6.)

Additional options to organize separate collection of waste are described in the Chapters 4.6.6. and 4.6.7.

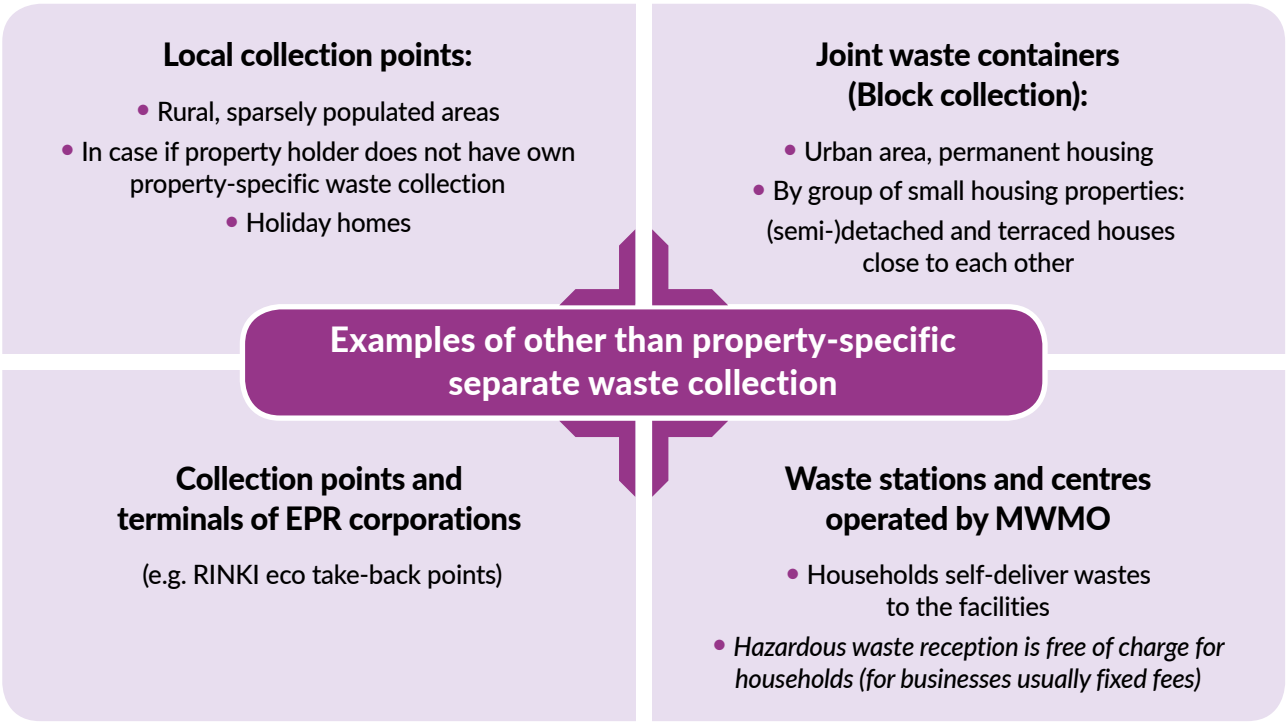


Figure 20. Examples of other than property-specific separate waste collection

INFOBOX 9: Management and ownership of housing or residential real estate properties

Management and ownership of housing or residential real estate properties in Finland has a few models.

One of them is ownership by shareholders model, which is visualised in the Figure 21. In the core of this model is *limited liability housing company (further is the text – housing company)*, which is single legal body, which owns the whole property/building; it also owns the apartments themselves. In Finland is approximately 88,000 of housing companies. As a general rule, costs in the housing company are distributed on a consideration basis in accordance with the Housing Companies Act (1599/2009). This means that the costs are distributed among the shareholders in accordance with the basis for payment per square meter or per share.

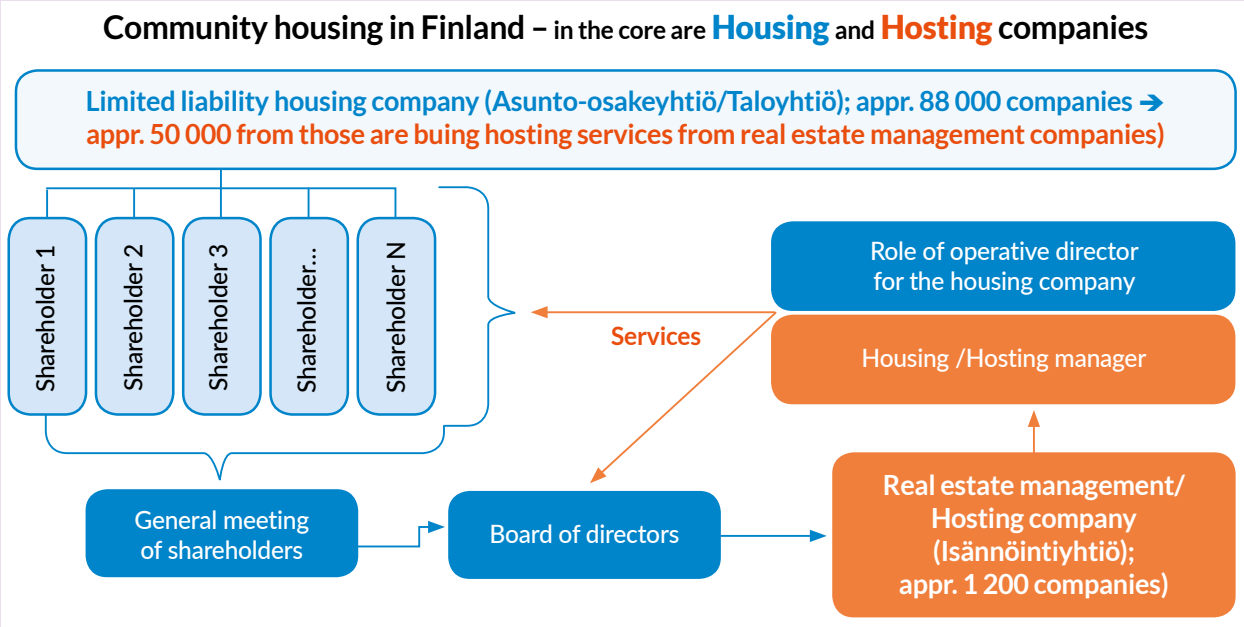


Figure 21. Management of community housing in Finland.

So called articles of association is an internal law of the housing company and must be held by every housing company in accordance with the Housing Companies Act (1599/2009). The articles of an association are approved by the annual general meeting and should be registered.

The articles of association define the basis on which the shareholders pay remuneration and on which premises the shareholder's shares give the right to manage the company. It is also possible to find out from the articles of association how maintenance responsibilities are divided between the shareholder and the housing company.

The Finnish Real Estate Management Federation indirectly affects the lives of about 2.7 million Finns living in block of flats buildings and terraced houses. The Federation includes more than 500 member companies and 21 associations, through which about 3/4 of the housing management industry in Finland belongs to the Federation.

4.6.1 Property-specific waste collection

In this chapter case examples are presented of the property-specific waste collection of the following MWMOs: HSY, Metsäsairila and EKJH. General information of MWMOs is presented earlier in the Chapter 4.4.

4.6.1.1 Case Helsinki metropolitan area – HSY

For property-specific waste collection, the WMR of the HSY defines which waste of properties have to be sorted and collected. HSY's waste management regulations are valid in the Helsinki metropolitan area (Helsinki, Vantaa, Espoo, Kauniainen) and Kirkkonummi. There were 122,335 properties in HSY operational area in 2020, of which 111,099 were housing or residential properties. Most housing properties were one- and two-dwelling houses accounting for 80 760 properties. Blocks of flats numbered 17,551 in 2020 (See Figure 22 and Table 6).

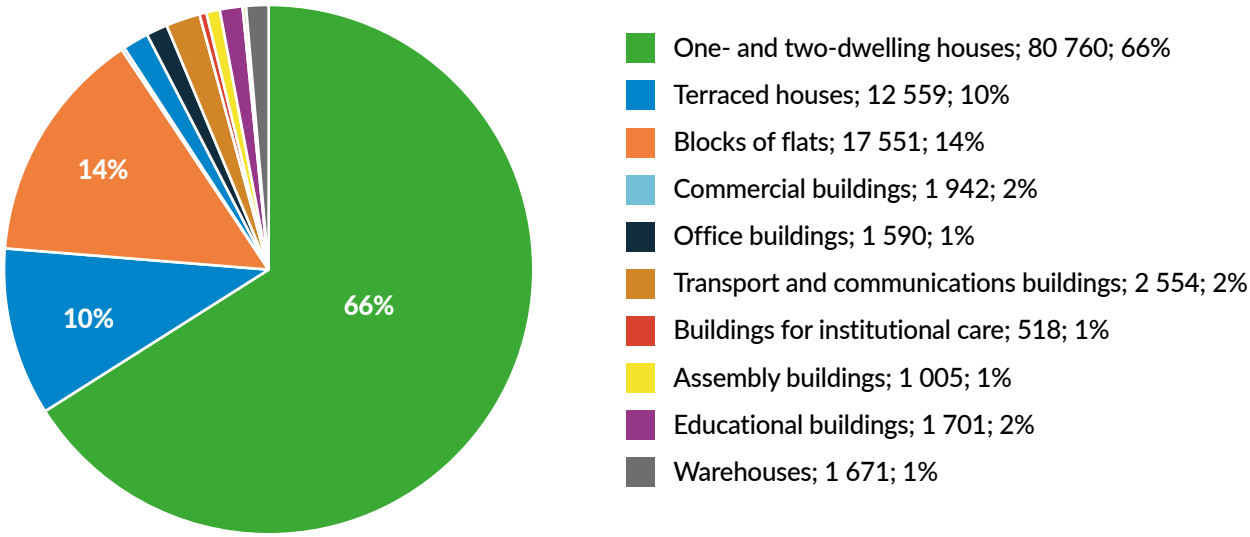


Figure 22. Composition of properties in the HSY operational area in 2020.

Waste sorting obligations in housing properties are defined by the number of apartments and, in other properties, the amount of generated waste. Usually, the more inhabitants, the more waste types are recommended to be collected property-specifically. Effective waste sorting by inhabitants reduces the amount of mixed waste. Waste sorting obligations in the HSY operational area are presented in the Table 6.

Table 6. Waste sorting obligations in the HSY operational area in 2021

Waste	Residental property	Other property
Mixed waste	always	always
Biowaste	5 apartments	25 kg/week
Carton packages and cardboard	5 apartments	25 kg/week
Glass packages	5 apartments	25 kg/week
Small metal items	5 apartments	25 kg/week
Plastic packages	5 apartments	15 kg/week
Paper	in accordance with the Waste Act	in accordance with the Waste Act

The minimum requirement is to collect mixed waste in residential properties with less than five apartments as well as detached houses. However, all properties can acquire more bins for separate collection, which is quite a general practice and helps to keep waste management costs lower. Mixed waste does not include the following waste fractions, which have to be delivered to waste sorting stations or/and other collection points organized by the MWMO as well as EPR collection networks:

- Hazardous waste
- WEEE - Electric and electronic equipment waste
- (Large) metal items
- Large amounts of non-combustible waste or large non-combustible items > deliver to a Sortti Station
- Recyclable materials with their own separate collection, such as
  - biowaste
  - carton and cardboard packaging
  - glass bottles and jars
  - metal
  - plastic packaging
  - paper

Starting from 2021, all properties with at least five apartments should separately collect biowaste, plastic, glass, cardboard packaging and small metal. Property-specific separate plastic packaging waste collection started already in 2016 on a voluntary basis and became obligatory in the Helsinki Metropolitan area since 1.1.2021.

Waste collection should be arranged with waste collection equipment approved in the WMR. Waste collection may be arranged using:

- 140–660-litre manually movable waste bins suitable for mechanical loading (carton may also be collected in 790-litre containers, the HSY does not use roller cages for the collection of carton packages)
- For the collection of biowaste, waste bins with lids and a maximum capacity of 240 litres suitable for mechanical emptying may be used (bins of up to 140 litres may be used for the collection of biowaste generated in facilities).
- Waste containers with lids suitable for front, end or crane loading
- The sizes of deep collection containers range from a few hundred litres up to five cubic metres
- Waste press containers

Table 7 shows the standard dimensions of the most common waste bins.

Table 7. Standard dimensions (mm) of the most common waste containers

Note! The dimensions vary somewhat depending on the manufacturer of the container.

Nominal size	Width	Depth	Height
140 l	510	560	1,080
240 l	600	720	1,100
360–370 l	700	850	1,100
660 l	1,250	850	1,250

Residential properties with less than five apartments as well as detached houses can order smaller than 660 l mixed waste bins:

- 140–240 litres only for detached or semi-detached houses.
- 300–360 litres can only be ordered for properties with fewer than 5 households.

For small apartment properties – from five to nine apartments – HSY has since spring 2021 been delivering 660 l multi-compartment waste containers (INFOBOX 10). The composition of the four compartments is the following: two separate bigger parts for plastic packaging and cardboard and two smaller separate parts for glass packaging and small metal objects. It is not mandatory to use the HSY's multi-compartment container, and households can use regular bins of 660 l for plastic packaging and cardboard or e.g. 240 l for glass and metal. HSY empties the multi-compartment waste bin and the biowaste bin once a week or every other week according to the amount of waste accumulated in the housing company.

Properties of 10 or more apartments should have separate bins for each waste fraction. Table 8 and Figure 23 show the waste bins for separate collection provided by HSY and related emptying frequencies.

Case HSY – property-specific waste sorting

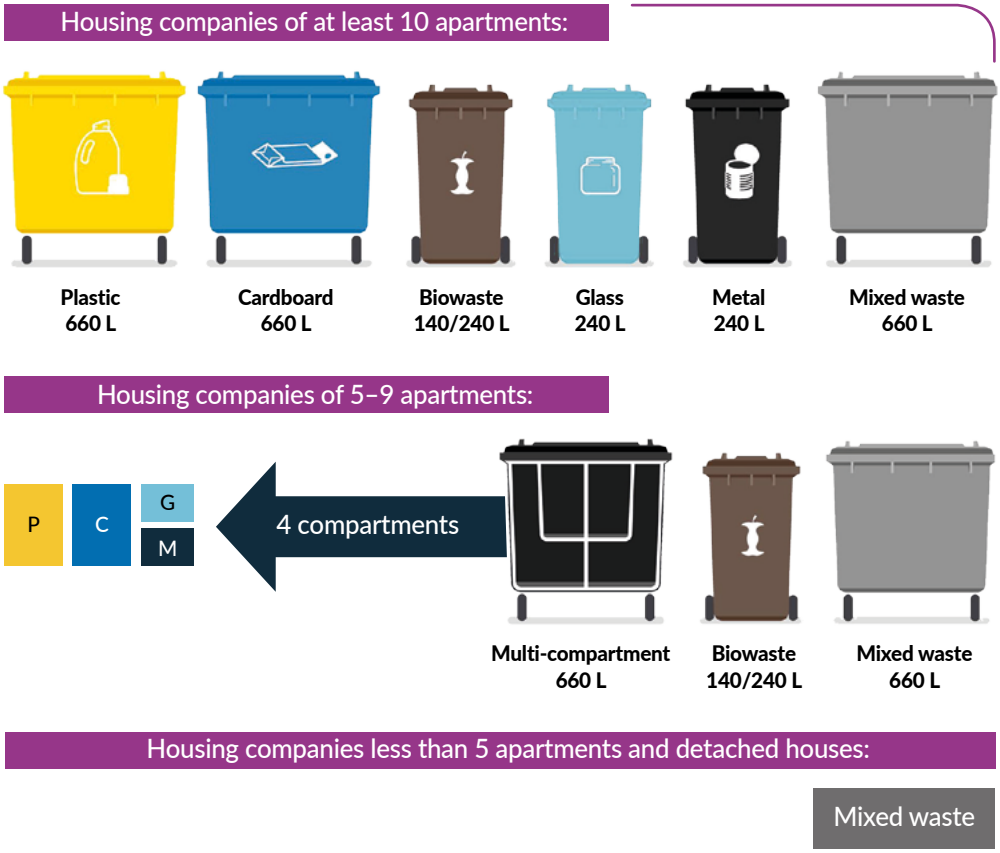


Figure 23. Composition of waste bins provided by HSY for different housing properties

Table 8. Waste bins for separate collection provided by HSY and related emptying frequencies in 2021

	Biowaste	Small metal	Glass	Cardboard	Plastic packaging	Mixed waste
5-9 apart.	140 or 240 l, once a week or every other week	**660 l multi (four)-compartment container**: two larger compartments (one for plastic packaging, one for cardboard + two small compartments (one for small metal, one for glass); once a week or every other week				660 l
10-19 apart.	140 or 240 l,	240 l, emptying every 8 weeks	240 l, emptying every 8 weeks	660 l,	660 l, emptying once a week or every other week	660 l
At least 20 apart.	140 or 240 l,	240 l,	240 l,	660 l,	660 l, emptying once a week	660 l, emptying from 4+ in a week to once a week

In 2019 HSY collected 179,213 tons mixed waste, 42,058 tons of biowaste, 10,581 tons of carton, 4237 tons of glass, 2259 tons of plastic packaging, and 1744 tons of metal scrap (Figure 24).

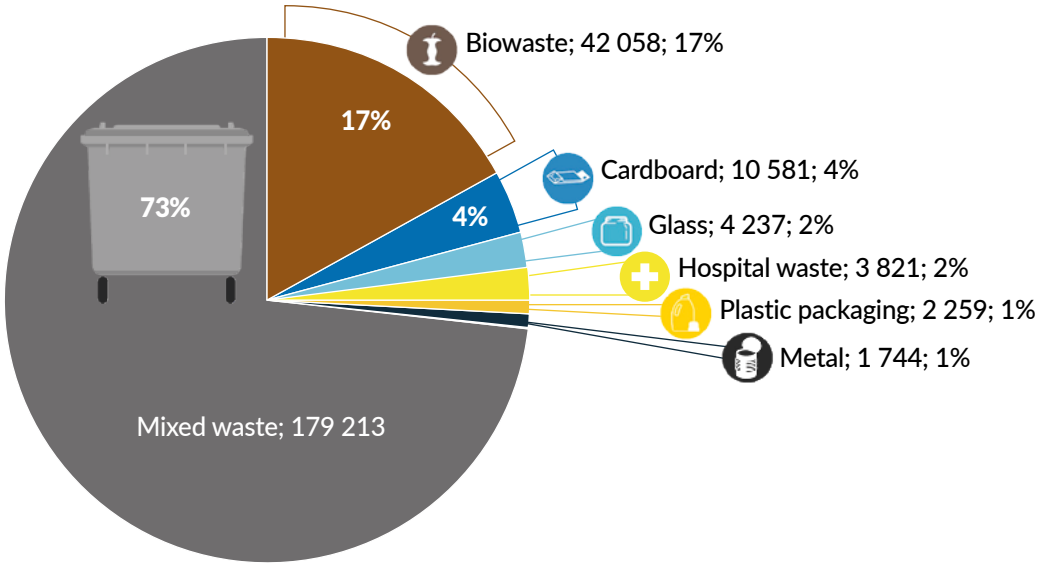


Figure 24. Waste collected by HSY from properties in 2019, [tons]

In 2019 in HSY area mixed waste bins were emptied 5,621,318 times, biowaste bins 1,597,609 times, carton bins 910,854 times, bins for plastic packaging 511,062 times, bins for metal scrap 108,175 times, bins for glass 105,201 times, multi-compartment bins 18,284 times, and bins for cardboard packaging 8,085 times (Figure 25).

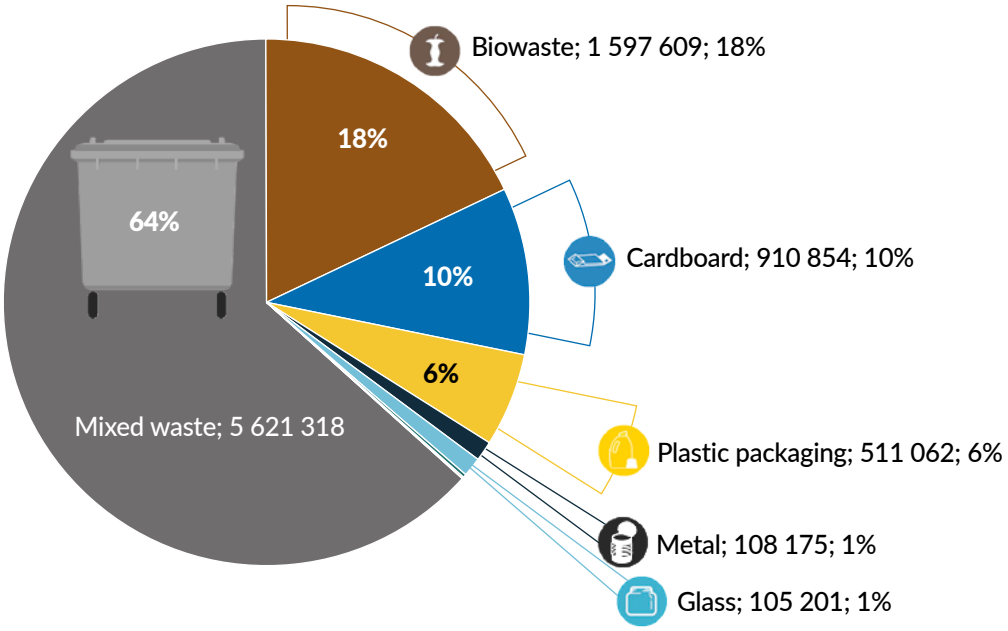


Figure 25. Emptying times of HSY by waste fraction/waste bin type in 2019

More information about the costs associated with bin emptying is provided in the Chapters 4.7.6. and 4.7.7. An example of waste separate collecting point is presented in the Figure 26.

Figure 26: Example of waste separate collecting point in Helsinki. Photo: Evelina Lufti

INFOBOX 10: **Multi-compartment waste bin collection**

Many households currently recycle different fractions so that they take glass, metal and other packages and recyclables to the regional collection point of EPR corporations, which has large separate containers for all the fractions.

A multi-compartment container partly replaces the traditional mixed waste container and functions like a small recycling point (Figure 27). Multi-compartment waste collection facilitates sorting and saves space, time and effort by bringing a completely new type of recycling service right to the resident’s doorstep. With multi-compartment waste collection, people can reduce the amount of mixed waste and improve the recycling rate easily.

Figure 27. Multi-compartment waste bin.

The main benefits of multi-compartment collection are the reduction of transportations costs and increase of separate collection. In multi-compartment collection, the property's collection containers can have their own compartments for plastic, cardboard, glass, metal, biowaste and mixed waste, or alternatively for some other waste fractions. All the compartments in the multi-compartment waste container are emptied at the same time into the corresponding compartments in a specially designed multi-compartment waste truck. This allows the different types of waste to be kept separate and raw materials to be obtained for recycling. As the multi-compartment waste truck picks up several waste frations on one visit, and not just one fraction at a time as usual, it this allows to reduce transportation costs.

HSY is attempting to improve the recycling rate of waste in smaller properties and reduce mixed waste amounts by multi-compartment collection. In detached houses and small terraced houses under 5 apartments multi-compartment waste collection is not organized at a regular basis. HSY tested multi-compartment waste collection in a pilot area starting from May 2019 until Spring 2022. About a thousand detached houses and a few terraced houses from Helsinki, Vantaa, Espoo and Kauniainen took part in the pilot, in which the traditional mixed waste bin was replaced by four-sectioned bin including the separate part for plastic packaging, biowaste and metal. HSY selected areas with many detached and semi-detached houses for the pilot. The pilot area was set up so that the collection could be done in the most cost-efficient and environmentally friendly way.

All multi-compartment collection is best suited for single-family homes and semi-detached houses. It may not be suitable for a block of flats as such, because the accumulating waste amounts are so large that it is more sensible to arrange a separate container for each material. It is important to note that multi-compartment collection is already in permanent use in terraced houses in the capital region, where number of apartments is greater than five.

Please see Chapters 4.7.6., 4.7.7. and 4.9. for more information regarding fees and transportation regarding multi-compartment collection.

One specific option to organize property-specific separate waste collection is an automatic waste pipeline network conveying system, which is situated underground. The underground system allows to plan a property area more effectively due to no need to build extra waste collection rooms. Pneumatic systems also contribute to overall comfort, as there are no unpleasant odours or overfilled waste bins on the territory. Furthermore, waste is transported automatically to a terminal underground, which eliminates the need to arrange waste transportation thus saving the associated costs. In Finland pneumatic waste collection is organized e.g. in the cities of Helsinki, Vantaa and Tampere.

There are also other factors that have an effect on the organizing of property-specific waste collection in addition to WMR, such as building order regulations (For more information see INFOBOX 11). Moreover, responsibilities in the maintenance and cleaning of public areas are divided between the municipality and property or land plot owners. INFOBOX 12 presents how it works in the case of the city of Helsinki.

INFOBOX 11: Connection of Building order regulations to waste containers shelters – case city of Helsinki

According to the Land Use and Building Act (132/1999), the municipality is obligated to have building order regulations, but those may differ in different areas of the municipality. The building order regulations set out the provisions necessary for planned and appropriate construction, the consideration of cultural and natural values, and the realization and preservation of a good living environment due to local conditions. The provisions of the building order regulations may concern the construction site, the size and location of the building, the adaptation of the building to the environment, the construction method, plantings, fences and other structures, the management of the built environment, the organization of water supply, the definition of the planning needs area and other similar local construction issues. The provisions of the building order regulations must not be unreasonable for the landowner or other e.g. renter. The municipal council approves the regulations.

Guidelines of the city of Helsinki on waste containers shelters.

The city of Helsinki has published a guide which describes the principles of the construction of waste shelters in different urban environments as well defines when a permit that must be applied for a waste shelter, based on the Building order regulations of the city of Helsinki.

- The shelter is a subject of building regulations. Adequate facilities for the collection and sorting of waste and other arrangements for waste management, proportionate to the size and use must be available.
- If waste collection equipment is placed in the yard of the plot, a protective waste shelter, canopy or fence must be built, or they must be landscaped with plantings. According to the building regulations, a maximum of 30 square meter construction of a fence, canopy or shelter for waste collection is exempted from applying for an operating permit. In protected buildings the requirements arising from building protection must be taken into account.
- Waste shelters should be placed at a distance away from the neighbour's border or other structure, or shall be located at the boundary of a neighbouring plot at least so that when drawing a line at an angle of 45 degrees from the boundary of the plot, the structure must remain completely under it. Placing the structure closer to this requires the neighbouring plot's owner's or holder's consent. If the location of waste management facilities is intended to be relocated and has an impact on the neighbour's interests, it is worth for the builder to consult the neighbours. The structures should also be placed at a distance away from the street side boundary of the plot.
- Waste management facilities may not be located in the yard if the town plan prohibits it. Waste shelters should also not be placed along the street on a part of the plot designated for planting in the town plan. In construction it has to be ensured that waste shields do not pose a health or safety risk.

Health and safety aspects of organising a shelter for property-specific waste collection

- Ventilation. Exhaust air should lead at least 8 meters away from adjacent air intakes and opening windows in buildings. When locating a waste room in the building space, exhaust air is removed above the water roof (the regulations appear in the Finnish Building Code).
- Inspections. For example, in the case of an odour nuisance, municipal environmental services conduct inspections at the request of the housing company.
- Property waste collection must be carried out in such a way that HSY Waste Management transport and persons have access to the waste bins (or to deep collection containers).
- The containers can be placed in the waste room in the building or in a waste fence or canopy in the yard. Also, joint collection of waste (block collection) by a group of properties may be considered.
- In the inner urban area of Helsinki (districts 1-27) and in a new block of flats, waste management premises should, as a general rule, be located on the ground floor of the building and not in the yard. It is also possible to use different deep collection or suction collection systems, whereby the above-ground parts are smaller in size. In the city of Helsinki, the placement of deep collection containers does not require permission (according to the construction regulations of the city) if the containers are model-approved and surrounded by a fence, wall or plantation, and placed in the yard so that they are not directly related to the street space.

INFOBOX 12: Share of responsibilities between the municipality and property or land plot owners in the maintenance and cleaning of public areas – case city of Helsinki.

The obligation to maintain and clean the streets, squares, street squares, parks, plantations and other comparable public areas in the town plan area belongs partly to the municipality, partly to the owner of the plot or other area. The division of tasks is based on the Act on the maintenance and cleaning of the street and certain public areas (669/1978). The obligation enters into force when the municipality allows the area to be taken into use as indicated by the town plan. According to this Act, a street handed over or considered to be handed over to the public must be kept in good condition and clean.

Division of responsibilities in the city of Helsinki on street maintenance

The city and property owners are together responsible for the street maintenance. In the suburban areas, the city keeps the streets clean, while in the city centre the responsibility lies mainly on the properties.

According to division of responsibilities for example:

- in the city centre, the property is responsible for:
  - emptying the waste bin at the bus or tram stop if the stop is on the sidewalk at the property
  - street cleaning, i.e. removing dirt, debris and loose objects from the street
  - keep the pavement and carriageway clean up to the centre line of the street, but not more than 15 meters wide or 24 meters wide if there is a planting lane in the street area
- the city is responsible for:
  - keeping the street planting lanes and squares clean
  - cleaning the sidewalks and walking and cycling routes at their own properties and parks, as well as emptying waste bins in these areas
  - cleaning of stops situated on separate platforms in the middle of the street
- in the suburban area
  - the owner of the land plot or the property handler is responsible for the maintenance of the land plot. The city charges the property owners a fee to pay for maintenance.
  - the city is responsible for the cleaning of the entire street, i.e. the carriageways and sidewalks. The exceptions are private roads and state-owned roads.

Maintenance services provide Helsinki City Construction Services Stara - public enterprise owned by the city of Helsinki.

4.6.1.2. Case Mikkeli region – Metsäsairila

In the Mikkeli region the city of Mikkeli and other municipalities have a separate WMR. According to the latest WMR from 2016, all properties in the city of Mikkeli are required to either opt for the municipal waste transport service or self-deliver their waste to a local collection point.

Recyclable waste generated by households should be sorted in property-specific waste bins according to the WMR requirements presented in the Table 9.

Table 9. Waste sorting requirements in the city of Mikkeli

	Categories of waste to be sorted and collected separately				
Number of households on the property	**Biowaste**	**Cardboard**	**Metal**	**Glass**	**Paper**
Up to 4	X				The property owner must arrange a reception area for the collection of paper products. However, the obligation does not apply to detached houses or other similar properties or to properties located in sparsely populated areas.
5 or more	X	X	X	X	

Properties where biowaste is composted are not required to sort biowaste for separate collection. Recyclable plastic packaging waste generated by households must be separately collected on the property or self-delivered to the RINKI eco take-back points of EPR corporations for recycling in accordance with the producers' instructions. Non-recyclable plastic waste must be sorted on the property as mixed waste.

Also other waste should be collected separately, e.g.:

- Waste under the EPR (such as WEEE and B&A) must be collected separately and self-delivered to a collection point organized by the EPR corporation.
- Brushwood and untreated wood waste that is not disposed on the property in accordance with these WMRs must be delivered to a designated reception point.
- Various types of hazardous waste must be sorted and collected separately. Hazardous waste collected and stored on the property must be delivered to a designated collection point at least once a year.

Property waste bins should be emptied with sufficient frequency to ensure that the waste does not cause an odour nuisance or other harm to waste transport. The emptying frequency for mixed waste bins depends on the number of subscribed households and the capacity of the waste bins. The minimum capacity is 20 litres per person per week. The maximum emptying frequency of mixed and biowaste bins in the summer (weeks 18 to 40) – once in 2 weeks and in winter (weeks 41 to 17) – once in 4 weeks. In case of cardboard packages, metal scrap and glass, the maximum emptying frequency in summer is once in 8 weeks and in winter once in 16 weeks.

4.6.1.3 Case South Karelia - EKJH

According to the MWR of South Karelian municipalities, separate collection of biowaste is mandatory in all permanent living properties and holiday homes. Residents can order either a collection service for biowaste or it can be composted in property-specific composter. In residential houses there must be a waste bin and collection service for so called dry waste, which is equivalent to the mixed waste concept used in the other MWMO example cases. In sparsely populated areas, residents can deliver dry waste to local collection points. Properties that are located close to each other can use joint waste bins thus implementing so called block collection.

Organizing sorting of cardboard is compulsory for all housing properties of at least 10 apartments. Organizing sorting of glass packaging and metal is compulsory for all housing properties of at least 20 apartments as well as sorting of plastic packaging starting from 31.12.2021.

4.6.2 Self-delivering of waste to sorting stations and waste centres

Waste that is not suitable or cannot fit in the property's own waste containers should be taken to waste sorting stations and waste centres operated by the MWMO. Waste sorting station is a place, where waste fractions are collected into separate containers, whereas waste centres are larger facilities, where waste is accepted and also further processed, or transported to recycling companies. Main waste sorting stations of MWMO are usually situated in waste centres. Self-delivered waste includes, for example, bulky waste, renovation and garden waste, hazardous waste and large quantities of mixed waste. Waste sorting stations do not charge a fee for separately sorted waste under ERP or household hazardous waste. However, the customer should pay for other waste fractions including mixed waste.

4.6.2.1 Case HSY

In the Helsinki metropolitan area, there are five waste sorting stations (*Sorttiasema or* Sortti Station), which are operated by MWMO HSY. The stations are located close to bigger roads and so are easily reachable by customers. Two of the stations located on the territory of the city of Helsinki (in the Kivikko and Konala districts), two on the territory of the city of Espoo (in the Ämmässuo and Jorvas districts) and one in the city of Vantaa (in the Ruskeasanta district) (Figure 28).

Figure 28. Example of HSY's waste sorting station in Ruskeasanta

A wide range of waste fractions can be brought to the Sortti Station (See Figure 29). HSY provides general instructions via the organisation's web-site on how to use the services at the Sortti Stations.

A total of 581,867 customers visited HSY's Sortti stations in 2020, 510,103 customers in 2019 and 473,132 customers in 2018 (Figure 30). It should be noted that the HSY stations in Vantaa and Espoo are used not only by inhabitants within the municipality borders of the operational area of HSY. For example, the Ruskeasanta station is also used by inhabitants from Tuusula due to that fact that there is only about 1 km from the Ruskeasanta site to the border of Tuusula municipality.

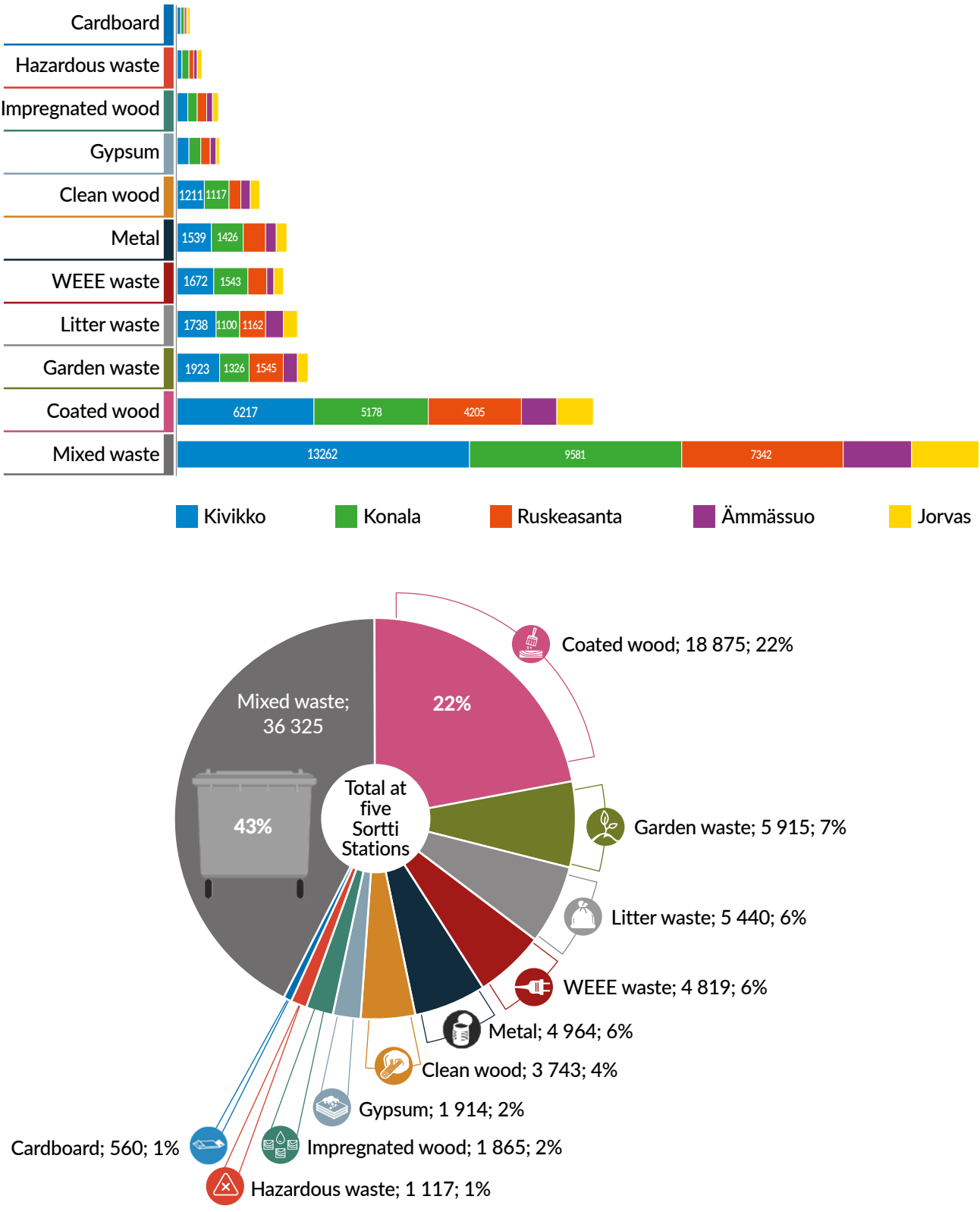


Figure 29. Waste fractions received at HSY Sortti Stations in 2019

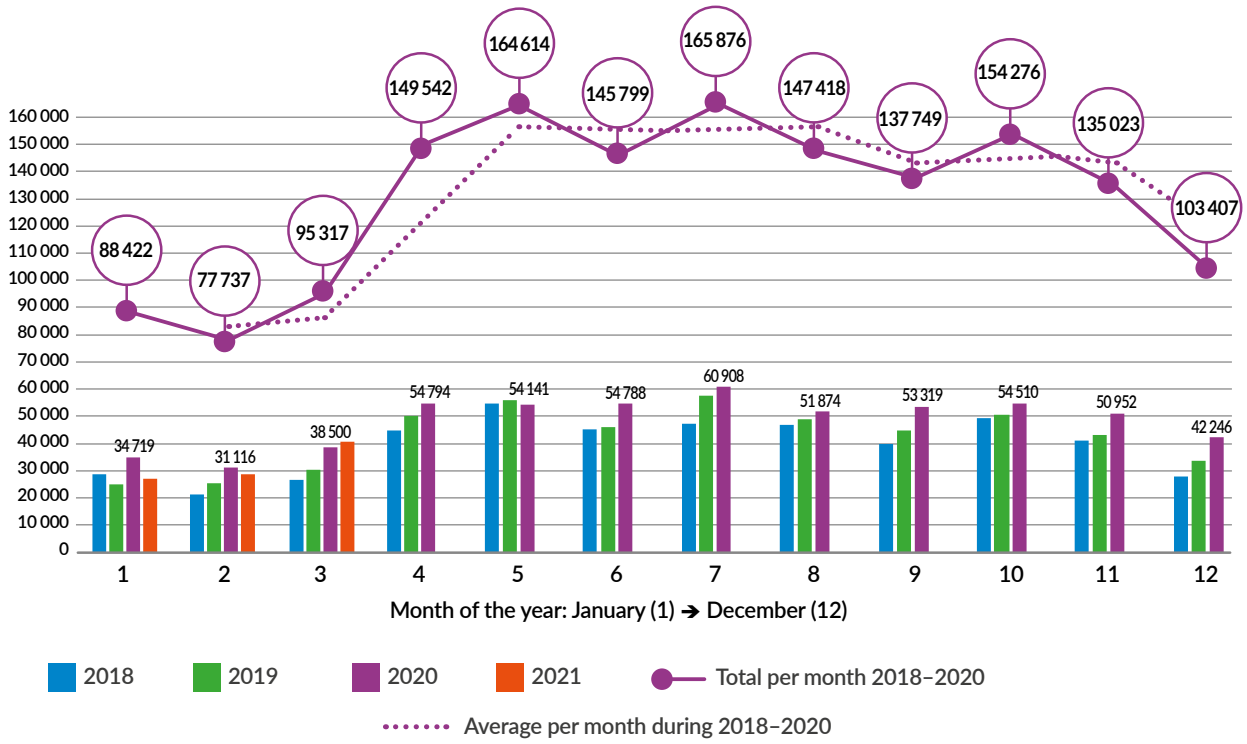


Figure 30. Numbers of customers visiting HSY Sortti Stations during the years 2018-2020/2021

HSY collaborates with Helsinki Metropolitan Area Reuse Centre within Sortti Stations (INFOBOX 13). At all HSY Sortti Stations there are Reuse Centre's collecting points for small reusable household items. HSY then directs such items delivered by customers straight to the Reuse Centre's own reception points. Acceptance on such household items can be seen as an additional service at the Sortti Stations. However, customers are not recommended to come to the Sortti Stations only to bring such items – in this case, it is better to deliver them directly to the reception points of the Reuse centre.

INFOBOX 13: Collaboration of HSY with the Reuse Centre within Sortti Stations

Accepted for Reuse Centre collection:

- usable and intact small household furniture and storage units
- clean carpets
- small items, such as books, CDs and vinyl records, tableware, clothing, shoes
- sports and hobby equipment
- bicycles in any condition
- flat-screen televisions, including defective ones as long as the screen is intact (repaired or used as spare parts)

Not accepted for collection

- large furniture items
- electric and electronic equipment
- bicycle, motorcycle, ski and riding helmets
- child seats for cars and bicycles
- climbing safety gear (climbing harness and additional equipment)

4.6.2.2 Case EKJH: For use –stations in South Karelia

In every municipality of South Karelia there is at least one so called *For use* station. In the city of Lappeenranta there are three *For use* stations: at the Toikansuo and Kukkuroinmäki waste management centres and at the Ylämaa small *For use* station, which is open once a month. *For use* stations receive the same type of waste as Sortti stations in the Helsinki region. *For use* stations are very popular, and for example in 2020 more than 12,000 customers visited the Toikansuo *For use* station.

EKJH has its own collection points or eco points for packaging that supplement the collection network of RINKI eco take-back points. Cardboard and glass packaging is collected in all collection points (eco points) and *For use* stations, and plastic packaging waste at the most of them. For example, in the city of Lappeenranta there are 19 RINKI eco take-back points provided by EPR corporations and the 11 eco points of the MWMO. In addition, the MWMO has organized the collection of plastic packaging at three RINKI eco take-back points, where there is no container for plastic collection.

4.6.2.3 Case PJH: self-service station Vuores

The modern waste sorting station "Vuores" is situated in the city of Tampere (See Figure 31). It is one of 21 waste sorting stations operated by PJH. It is an automated station that operates on a self-service basis outside the opening hours. The waste station is open on weekdays from 8 am to 8 pm, and staff is on site from 12 to 3 pm.

The customer must register as a user with a mobile application, which allows the opening of the gates and doors during self-service hours. If customer also adds a car registration number, the camera detects the car at the gate and open the door automatically without the need to press a button. The station produces all the energy it needs from a solar power plant. The waste sorting station is surrounded by a wooden fence, inside of which is a roundabout, around which all the waste pallets and waste points are situated.

Large garbage trucks do not come to the same yard as the customers, but the garbage pallets are emptied from the edges.

Most of the waste is free of charge, but payment for delivering of other fractions can be handled by mobile application.

Figure 31. Waste sorting station "Vuores"

Free of charge waste fractions:

- Hazardous household waste, aside from waste oil and other liquid in batches of over 200 litres
- Sorted recyclable waste (metal scrap, paper, cardboard and glass packaging)
- Household electrical equipment
- Portable batteries and accumulators
- Lamps

Paid waste fractions

- Wood and mixed waste

Customers that are in the area of a pipe collection system can take a maximum of 240 liters of mixed waste to the waste station free of charge, so that they can put waste in a mixed waste container that is not suitable for a pipe collection system (such as large textiles, buckets and flowerpots). Other waste and larger items are charged according to the price list.

4.6.3 Self-delivering to collection points of producer corporations (waste under EPR)

Waste fractions under producer responsibility (See Chapter 3.4.3.) should be delivered to the collection points organized by producers. Despite packaging waste belonging to EPR, the new Waste Act requires that municipalities together with EPR corporations organize a geographically comprehensive collection network, which includes also property-specific separate collection of packaging waste (See Chapter 3.8.). Many municipalities have arranged a supplemental collection point network of packaging waste already before this obligation, by tightening separate collection requirements through WMRs.

Producer corporations should pay compensations for municipalities that covers at least 80 % of the costs incurred from planning and implementing supplementary collection on property-specific basis or in waste stations. Packaging waste collected by municipalities is delivered to the producer, which is responsible for the treatment and recycling.

4.6.3.1 Packages

Service company Finnish Packaging Recycling RINKI Ltd. arranges eco take-back points for the collection of household packaging. Eco take-back points serve primarily the inhabitants of detached and terraced houses, as well inhabitants of block of flats, where separate collection of packaging waste is not arranged.

RINKI eco take-back points are usually situated in connection to supermarkets (See Figure 32). In 2021 there are 1,855 eco take-back points for cardboard package, glass package, metal package, and 658 take-back points for plastic package. All agglomerations of more than 500 inhabitants must have an eco take-back point for cardboard packaging, glass packaging, and metal packaging. All agglomerations of more than 10,000 inhabitants must have an eco take-back point also for plastic packaging. The new waste legislation would affect eco take-back network e.g. concerning the number of the points.

RINKI delivers collected packages to the terminals, from where those are transported to recycling facilities (More information in the INFOBOX 14).

Figure 32. RINKI eco take-back point in Malminkartano (Helsinki), close to supermarket (25.9.2021)

INFOBOX 14: **Terminals for packaging waste.**

The recycling charge invoiced by Finnish Packaging Recycling RINKI Ltd. from producers covers the terminal network for receiving packaging waste (accepted free of charge) as well as the transport of material from the terminal to the processing plant and recycling into new products or raw materials for new products. The transportation charge from the property is a separate expense and is not included in the recycling fees invoiced by RINKI.

The producer corporations responsible for the fibre, metal, plastic and wood packaging share information about their own reception terminals, receiving of packaging waste and the sorting instructions for commercial and industrial packaging.

- Commercial and industrial fibre packaging waste is collected for recycling directly from the premises when the trader has an agreement with an authorized company to collect recyclable waste. In Finland, there are nearly 40 terminals for fibre packaging.
- Metal packaging waste is received at the reception terminals from producer-responsible companies and also from the eco take-back points and property-specific collections. Some reception terminals receive metal packaging waste transported from both companies and consumers. In such cases, drivers shall inform the terminal reception of the origin of the metal packaging waste they have supplied. In Finland, there are about 55 terminals for metal packaging.
- The EPR corporation Finnish Plastics Recycling Ltd. receives plastic packaging waste from companies in its authorised terminals. Some terminals also act as a contractual partner. Plastic reception terminals for company packaging do not automatically receive consumer collection plastic packaging. There are over 60 terminals for trade and industry packaging waste and 45 for household packaging waste collected from the properties (curb side collection) in Finland.
- The producer corporation has reception points for wooden packaging waste in different parts of Finland. Before delivering a batch, there is a request to contact the receiving point and check with the recipient the size and delivery time of the batch. In Finland, there are about 70 terminals for wooden packaging waste.
- In addition to these, Suomen Keräyslasiyhdistys Association has authorised Finnish Packaging Recycling RINKI Ltd. to arrange reception terminals for non-deposit glass packaging waste. The terminals receive only glass packaging waste collected and sorted according to the national sorting instructions from the municipal and private waste transportation companies. There are almost 40 terminals for glass packaging waste in Finland.

In 2019, 71 % of packages brought to the market was recycled. INFOBOX 15 presents more details on packaging recycling practices in Finland.

INFOBOX 15: Recycling of packaging waste

Plastic
Consumer plastic packaging waste collected via RINKI eco take-back points and via housing companies' property-specific collecting go to the plastic refinery of Fortum Plc. in Riihimäki, where it is processed to produce recycled plastic granulate as a raw material for the manufacturing industry or used as fuel in the waste-to-energy plant on the same site (See Chapter 4.10. for more information).

Cardboard
After arriving at the EPR terminal, cardboard packages are baled and sorted. In the treatment process different fractions such as metals and plastics are sorted out and send for recycling or energy production. From the fibre laminate paper, special carton types, and other recycled papers and cardboards is produced.

Metal
Metal scrap is sorted at the terminals and delivered to the crushing plant. The crushed metal waste is delivered to smelters, where scrap metal is made into new raw materials for use in the metal industry. New metal products are made from recycled raw materials for household and business use. Over time, these products may also be recycled.

Glass
Glass can be recycled unlimitedly for the manufacture of new packaging without lower quality or cleanliness. From RINKI eco take-back points, glass packaging waste is transported to terminals. Glass waste from terminals is delivered to glass processing plants in Forssa and Estonia. In plants, glass packaging waste is processed. Impurities are sorted out of glass packaging waste, cleaned and sorted in colour. After processing and crushing, it is raw material for glass packaging factories where new glass bottles and jars are made of the material.

Almost all glass waste is recycled. The use of recycled glass as a raw material for new packaging is environmentally friendly and reduces the need to use virgin raw materials. Careful sorting according to RINKI's instructions is important. Only glass bottles and jars should be returned to the glass collection container, as they are suitable for recycling. For example, drinking glasses, oven pans, crystal or porcelain are not suitable for recycling as they have quality properties that prevent or hinder recycling.

Glass packaging waste is made into:

- mainly new glass packaging, i.e. glass bottles and jars
- some glass packaging waste is also made into construction products, such as foam glass and glass wool

4.6.3.2 Paper

Paper is collected separately from each property (if they are e.g. blocks of flats and terraced houses or properties with offices or services) when the property is located in the densely populated area. The organization of a collection point and bin for paper collection are part of properties' obligations. The property covers the associated costs, while the producer corporation pays for the management of the wastepaper from there onwards. As such, properties may not be charged a fee for emptying the collection container or transporting the wastepaper.

If properties are located in residential areas with detached houses or dispersed settlements, producer corporations have to arrange paper collection at their regional reception points. In this case, the property can enter into an agreement with a waste carrier for a fee.

From the recycled fibre are produced e.g. raw materials for corrugated boards, packing cardboard, special papers, laminated paper, many types of fibre drums.

4.6.3.3 Other fractions

Based on the Waste Act, the seller, or the product distributor, must accept discarded accumulators, batteries, WEEE, and tyres at the seller's point of sale free of charge. The seller is also obligated to share information about the fact that it accepts discarded products. The costs from accepting discarded products are covered by the seller, while the producers (i.e. manufacturers and importers) will bear any costs after they have been accepted, i.e. transport and handling costs.

Products accepted without the obligation to purchase a new product are:

- Portable accumulators and batteries, including button cell batteries, AA and AAA batteries, and accumulators and batteries used in laptops, mobile phones, cordless tools, toys, and electric toothbrushes and shavers.
- Small (less than 25 cm) household WEEE, such as mobile phones and their chargers, energy-saving lamps, electric toothbrushes, toys, hair dryers and power tools. The obligation to accept discarded products is for convenience stores which have a sales floor area of more than 1,000 square metres or other stores that sell EEE with sales floor area of more than 200 square metres. A reception point may also be arranged in the immediate vicinity of the point of sale. The seller must accept products also from other places than households if they are correspondent to household equipment in quality and quantity.

The seller must accept the following products when a new corresponding product is purchased as a replacement:

- Large household WEEE, i.e. the seller must accept, free of charge, the equipment when the customer purchases a new corresponding product as a replacement. A reception point may also be arranged in the immediate vicinity of the point of sale. The seller must also accept products from other places than households if they are correspondent to household equipment in quality and quantity.
- Vehicle tyres, i.e. the seller must accept them free of charge when the customer buys the same number of tyres of the same type as replacements. This obligation only applies to tyres without rims.

Automotive batteries i.e. discarded starter batteries from consumers are considered to be products accepted voluntarily. If a store that sells starter batteries to consumers accepts discarded starter batteries from the consumer, it must take them free of charge without obligation to buy a new product.

Information on reception points arranged by the seller for discarded products must be provided to customers for example through the store's marketing or on signboards at points of sale. The seller bears the costs caused by the provision of information. The discarded products accepted by the seller may only be delivered to handlers or carriers who have an agreement with the producer (manufacturer or importer). Based on the Waste Act, it is forbidden to deliver such products to other parties. After the products leave the store, the producers are responsible for the waste management of them, and they pay the costs of this waste management themselves.

Accumulators, WEEE, batteries, and tyres discarded by consumers can also be taken to reception points organised by the producers and producer corporations free of charge.

4.6.4 Joint waste containers (Block collection)

Properties adjacent to each other can make a contract with an MWMO on a voluntary basis to use a jointly owned waste container. This concept is so called *block collection (kortteli-/kimppakeräys).* Block collection can be organized for properties in a particular housing area, where mixed waste and recyclable waste are collected.

Block collection is recommended if the amount of waste is low or transport connections to the property are difficult for a heavy waste truck. In this case, the waste container is used by several properties, in which case the emptying costs are also divided between them. Also, a contact person must be designated to manage the system. The annual cost of waste management consists of a basic fee and the emptying fees of the collection container. The basic fee is invoiced to each member of the group once a year. The invoice for the emptying is addressed either to the contact person of the group or distributed directly to each member of the group (More information about waste charges in the Chapter 4.7.).

Block collection is organized, for example, in the Helsinki metropolitan area. All the properties that are parties to the contract concerning block collection use the jointly owned waste container in the defined location. The contract on joint use must have a main contracting party, which acts as contact person to HSY for container emptying and maintains the contact information on the waste container users, i.e. the joint owners in the contract.

If the waste container needs to be placed outside the property boundary, the placement of the container should be agreed with the landowner. Note that the National Land Survey of Finland manages a register of landowners.

Holiday home owners can also agree on the use of a jointly owned waste container with their closest neighbours, the road maintenance association, or

another organisation. It is a good option, for example, in situations where there is no road to the holiday home.

4.6.5 Local collection points

IIn sparsely populated and remote areas an MWMO may arrange waste collection by organizing local collection points that are regional sites for mixed household waste collection. A local collection point is recommended if the use of an own waste container or block collection container is not suitable for the property, e.g. when the area is not connected to an MWMO waste transportation network. This is usual practice in case of summer cottages.

The property owners take the waste themselves to the local collection point. The right to use it can be obtained by paying the local collection point fee. Joining a local collection point and taking mixed waste there is one way to take care of the property's waste management obligations.

The annual cost of waste management consists of a basic fee and a local collection point fee (summer or full year access).

4.6.6 Other ways to organize waste collection

Circulating waste collection points (cars) for e.g. WEEE, hazardous waste, large scrap metal

In addition to permanent collection sites, hazardous waste, WEEE and metal are collected in many localities by mobile collection trucks. The waste fractions in question are transported for proper treatment after collection.

For example, in the operational area of the MWMO PJH there are Repe & Romu trucks that collect hazardous household waste, scrap metal and electrical equipment free of charge. The Repe & Romu route has in total 377 stops. The MWMO Salpakierto organizes so called Roinaralli, which is a circulating waste collection of hazardous waste, scrap metal and electrical equipment in all municipalities. In the MWMO Kiertokaari customers can also request a hazardous waste collection truck to visit their area. Also other MWMOs organize circulating waste collection points.

Waste management in the archipelago

The Keep the Archipelago Tidy Association does environmental maintenance works in the archipelago, on beaches and lakes. The association e.g. builds and maintains waste points, dry toilets, as well as arranges separate collections of scrap and hazardous waste. The association operates nearly 200 Roope service points across the country. Roope services are services provided and maintained by the association for the boaters in the sea areas and in Lake Finland. They also include dry toilets, 30 floating toilet waste suction discharge stations and separate collection sites (e.g. collection of metal, WEEE and hazardous waste with local operators such as municipalities or waste management companies). Roope services benefit all boaters and the services are funded by the association's membership fees.

In some areas locked common containers are available to the inhabitants of the archipelago. The key to the locked container can be accessed by having a contract with a local waste company and paying an annual fee. The container is intended only for residual waste from the households, i.e. waste remaining when recyclable waste and hazardous waste are sorted separately.

In some parts of the archipelago, hazardous household waste, WEEE and scrap metal, even end-of-life vehicles, are accepted free of charge by a mobile waste collection system. Inhabitants can also bring construction and cleaning waste to the collection for a fee. Construction and cleaning waste is packed in the waste management company's large waste bags.

Pick-up services

Individual large waste objects that cannot fit in the property's own waste container due to their size can be picked up from the properties. Such items include mattresses, fridges, washing machines, bookshelves, bicycles and large flat-screen TVs. Electrical equipment can be included but they must be packed and portable. The items must be portable by two persons and ready for transfer. Demolition waste, garden waste, hazardous waste or other similar waste will not be collected.

Temporary waste reception points

An MWMO can also organize temporary waste reception points during big events. Salpakierto organizes the SERRISTOPPI waste reception point at Lahti Market Square in April-October in connection with the monthly market, which is held on the first Wednesday of the month.

At the reception point, households can bring fluorescent tubes, energy saving lamps, small electrical appliances, batteries, cosmetic products classified as hazardous waste, such as perfumes, aftershaves, hair sprays, nail polishes, hair dyes and similar free of charge.

Accepting recyclable goods

Nowadays many MWMOs also cooperate with recycling centres and accept items for further re-use and recycling. For example, the MWMO Salpakierto accepts recyclable goods at waste sorting stations and organizes delivering for reuse and recycling together with cooperation partners, for example the Padasjoki Recycling centre.

4.6.7 Collection of hazardous and other types of waste

Hazardous waste

Hazardous waste from households includes:

- energy-saving lamps and other fluorescent tubes, accumulators, batteries
- medications, needles and syringes; thermometers containing mercury.
- waste oil, oil filters and other oily equipment; solvents such as turpentine, paint thinner, acetone, petrol, fuel oil and solvent-based detergents
- wet paint, adhesives and varnishes; water used to wash painting tools
- pressurised containers, such as aerosol cans (sloshes around or fizzles); fire extinguishers and gas bottles
- pressure impregnated wood (reception subject to a charge); wood preservatives and impregnating agent
- asbestos (reception subject to a charge)
- alkaline detergents and washing agents; pesticides and disinfectants
- strong acids such as sulphuric acid
- New Year's tin (the EU forbade the sale of tin in consumer products as of 1 March 2018)

Hazardous waste needs to be collected separately based on its type, kept separate from each other and other waste and stored appropriately. If it is possible and safe to do, hazardous waste must be packaged in its original packaging. Hazardous waste from households must be delivered to collection points arranged by MWMOs free of charge, while hazardous waste under producer responsibility (e.g. batteries and accumulators; WEEE) can also be delivered to reception points organized by producers. Medical waste, needles and syringes from households must be delivered to pharmacies.

Hazardous waste from companies needs to be packaged and marked, and all necessary information about it needs to be provided in all stages of the waste management chain so that the properties and transfers of hazardous waste can be monitored from the source till the waste's recovery and final treatment. Hazardous waste produced in places other than households and businesses need to be delivered to a consignee entitled to receive it.

For example, the MWMO PJH has five "Vartti" containers for hazardous household waste as well as separate Varma – a hazardous waste station "Varma" that receives waste from households and businesses. In the operational area of the MWMO LHJ hazardous waste is accepted at five so called "eco-act points", in addition to waste stations. LHJ organizes annually an "eco-action" campaign in all LHJ's owner municipalities. During the campaign, hazardous waste from households, agriculture and forestry is accepted free of charge. Alternative ways of hazardous waste collection are presented in the Chapter 4.6.7.

Special waste

Special waste is not the same than hazardous waste, examples of special waste include human waste or biological waste (special health care waste). Special waste must be kept separate and packaged in securely closed, sturdy containers, and the type and potential harm of the waste and its measures must be marked on the container. Special waste is waste that requires special measures during treatment or transport.

Textiles

The separate collection of waste disposal textiles by MWMOs is expected to develop significantly in the coming years. Finland is adopting the EU directive on separate textile collection (aiming to start in 2025) two years earlier than the other EU members in 2023. This separate collection is organized by MSMOs nationwide.

Nowadays, textiles are collected from the textile collection points organized by private companies. Collection points are often situated next to the RINKI eco take-back points or straight in the city, for example, on streets or in supermarkets or supermarket yards. Also, some stores selling textiles accept used clothes and other textiles from the customers.

4.7 Waste tariffs and charges

Waste holders must pay for the costs of the waste management organized by municipalities. Municipal waste charges cover all the costs of municipal waste management, so no tax money is used.

The costs of municipal waste management covered by waste charges include:

- Organization of separate waste collection, including emptying, washing and rental of collection containers (bins) as well as the organization and maintenance of waste sorting stations
- Waste transportation
- Waste treatment and final disposal (including establishment, maintenance, decommissioning and after-care of treatment facilities and landfills)
- Development of waste management
- Preparation for future investments
- Information and advising (incl. environmental awareness-rising)
- Waste tax
- Other costs, for example costs related to the work of waste management authorities
- Value added tax

Waste charges are determined by local **waste tariffs**. The waste tariff is a document that determines the basis for the waste charges for waste management. The municipal waste management authority approves the tariff based on the costs presented by MWMOs, and imposes waste charges. Information on the waste tariff and waste charges is published in open access on the websites of MWMOs. Each MWMO updates information of waste tariffs annually. Charging principles and categories vary between MWMOs. Furthermore, the waste charges of different municipalities in MWMO operational areas can also vary despite the single tariff, as they are based on regional tenders of waste transportation. The following chapters present examples from several MWMOs.

Waste charges are paid by the property owner or other waste holder directly to the MWMOs if they are organizing the collection. If a transportation company is arranging the waste collection instead of an MWMO (i.e. property has ordered waste collection from it), the waste charge may vary. Depending on the waste collection system of the municipality, the information of waste charges is published in open access on the websites of the MWMOs or waste transportation companies, or residents can ask the price from the waste transportation companies directly themselves.

Municipal waste charges (fees) consist of **emptying charges (fees)** that are based on the type, quality and quantity of waste, the volume of the waste bin and collection frequency, and in major municipalities also of **basic charges (fees)**. Both are described in detail below. Waste centres charge per ton of delivered waste.

4.7.1 Emptying charges (fees)

Emptying fees cover the costs of property-specific collection, transportation and treatment, as well as the costs needed for the future development of waste management in the area. The collection equipment can be acquired either by the property itself (purchased by or rented), or the cost of acquiring the collection containers or bins may be included in the emptying fee charged from the property. Municipal waste management regulations generally require regular washing of collection equipment of some waste types. Washing costs are either included in the emptying fees or the property pays the washing costs separately, as for example in the case of Kiertokapula.

The emptying fees of MSW are not based on the floor area of the apartment or real estate property, not either on the number of persons in households. The type, quality and quantity of waste, size (i.e. volume) and type of container (e.g. surface waste bin, deep collection container, pallet) as well as emptying frequency all influence on the waste charges paid by waste holders. It is the task of property manager to determine an optimal number of bins/containers and the emptying frequency so that waste and recyclable materials can fit in the containers and that they follow WMR.

In accordance with the Waste Act, the waste charges must correspond to the level of service provided by the municipality and where possible, should encourage the reduction of the amount and harmfulness of waste as well as contribute to waste management according to the priority principle. In practice, emptying waste bins for different recyclable fractions - plastic, metal, cardboard, glass and biowaste - is often cheaper than the emptying of mixed waste bins. In this way, waste fees motivate residents and other waste holders to sort more of their useful waste fractions for recycling. Hence, properties can influence the amount of their waste charges the most efficiently by sorting, but also by adjusting the number, size and emptying interval of the waste bins.

See INFOBOX 16 more more detailed information about waste management costs.

INFOBOX 16. Waste management costs breakdown

Finnish Solid Waste Association KIVO has gathered the latest waste information pertaining to 2019 on emptying fees, eco charges and total costs from MWMOs. There were 12 MWMO responders to the KIVOs questionnaire.

Emptying fees and the number of collection times vary depending on the waste type, property type and size as well type of collection container (bin). Average numbers are presented in Tables 10–13.

Table 10. Collection times and emptying fees (incl. VAT) for waste types collected at blocks of flats per type of collection container

Waste type	Collection container	Times collected (times/year)	Emptying fee (€/emptying/container)
Mixed waste	Container 600/660 l	60	12.06
Mixed waste	Surface container 8 m^3	24	68.45
Biowaste	Container 240 l	49	8.65
Paper	Container 600/660 l	28	0
Paperboard	Container 1,000 l	52	5.73
Paperboard	Container 600/660 l	40	6.16
Glass (recyclable glass)	Container 240 l	7	3.28
Metal (small metal objects)	Container 240 l	8	2.68
Metal (small metal objects)	Container 600/660 l	12	7.30
Plastic	Container 600/660 l	51	8.57

Table 11. Collection times and emptying fees (incl. VAT) for waste types collected at terraced house properties per type of collection container

Waste type	Collection container	Times collected (times/year)	Emptying fee (€/emptying/container)
Mixed waste	Container 600/660 l	52	12.44
Biowaste	Container 240 l	38	7.21
Biowaste	Container 140 l	52	5.54
Paper	Container 600/660 l	17	0
Paperboard	Container 600/660 l	14	5.52
Glass (recyclable glass)	Container 240 l	5	2.84
Metal (small metal objects)	Container 240 l	10	2.69
Metal (small metal objects)	Container 600/660 l	7	8.03

Table 12. Collection times and emptying fees (incl. VAT) for waste types collected at detached house properties (that do not have composting) per type of collection container

Waste type	Collection container	Times collected (times/year)	Emptying fee (€/emptying/container)
Mixed waste	Container 240 l	25	7.17
Biowaste	Container 240 l	19	8.48

Table 13. Collection times and emptying fees (incl. VAT) for waste types collected at detached house properties (**that have composting**) per type of collection container

Waste type	Collection container	Times collected (times/year)	Emptying fee (€/emptying/container)
Mixed waste	Container 240 l	20	7.06

The prices of surface containers ranged from €50–110 for smaller (0.14–0.4 m^3) containers to €175–320 for larger (0.6–1 m^3) containers. Very large (2–8 m^3) surface containers cost €1,250–2,600. Deep collection containers (0.6–8 m^3) cost €1,390–2,860. The default value of a waste container's washing cost was €18 for a surface container and €120 (incl. VAT) for a deep collection container.

4.7.2 Basic charges (fees)

Part of the municipal waste charge may be collected as a basic charge (fee). The basic fees collected separately from households in some areas are used to cover the costs of waste recycling services such as establishment and maintenance of sorting stations (48 % of the basic fee), waste guidance (12 %), operation of waste boards and development of waste management (12 %), as well as organization of free-of-charge collection of hazardous waste (10 %), among other things. In 2019, basic fees were in use in 79% of the municipalities located within the operating areas of KIVO's member MWMOs. In other municipalities, the costs of these services are covered by emptying fees for mixed waste or possibly also some by other sources.

The amount of the basic charge is based on the number of persons or apartments on the property, the use of the property or other similar grounds. For detached house properties, the average basic fee, including value-added tax (VAT), was €30.04/year in 2019 (Table 14).

Table 14. Annual costs of basic charges per property type (incl. VAT) according to the Finnish Solid Waste Association KIVO's database (2019); [€]

Property type	€/household/year	€/inhabitant/year
Apartment building	23.47	12.52
Terraced house	26.88	13.44
Detached house	31.96	10.65
Detached house with composting	28.08	9.36

4.7.3 Charges for local collection of waste

The only exemption, where the number of inhabitants is taken into account is regional collection charges that are in use in sparsely populated areas, where detached houses or holiday houses do not have their own waste bin. In this case, the MWMO may provide an alternative opportunity for properties to join the local collection of mixed waste (See more in the Chapter 4.6.5.). The basis for payment for a permanent residential property is often the number of inhabitants. The charge for a holiday house is lower than the price of a permanent home and a person living alone also gets the service cheaper. In addition, the payment for both a permanent and a leisure property can be lower if the houses have home composting.

A property used for permanent residential use by one person pays on average about €110 per year for regional collection, and less than €140 if there are three inhabitants. The average fee for a leisure property is just over €70. See Table 15 for more information.

Table 15. Annual charges for regional collection of mixed waste per property (incl. VAT) according to the Finnish Solid Waste Association KIVO's database (2019); [€]

Property	€/property/year (incl. VAT)
Permanent dwelling, one inhabitant	112.73
Permanent dwelling, three inhabitants	138.43
Holiday home	72.59
Holiday home (with composting)	70.09

4.7.4 Charges of waste sorting stations and waste centres

Waste sorting stations and waste centres charge waste holders that deliver large amounts of waste with a truck, for example, in this case, the waste should be weighed. Table 16 shows the average reception prices charged by waste centres for different waste types.

Table 16. Reception prices (incl. additional weighing fee), additional weighing fees, weighing charges and load weights per waste type (VAT 0%) according to the Finnish Solid Waste Association KIVO's database (2019)

Waste type	Reception price (€/t)	Additional weighing fee (€/t)	Weighing charge (€/load)	Load weight (t/load)
Mixed waste	146.32	2.47	9.47	4.60
Biowaste	95.35	2.42	9.07	4.05
Energy waste	103.80	5.10	11.22	2.28
Raking and brushwood waste	23.72	4.48	6.57	1.42
Sand interceptor waste	72.89	2.38	10.00	4.41
Grease interceptor waste	98.00	2.30	9.59	4.34

4.7.5 Municipal waste charges from the inhabitants' point of view

Municipal waste charges remain affordable for the inhabitant, despite the large number of types of waste collected. The cost level has even fallen in blocks of flats over the past five years. Waste management per inhabitant is the most affordable in blocks of flats properties, even though they collect the highest number of different waste fractions. The price may be explained by collection efficiency and high number of inhabitants per waste collection point. Waste management cost (calculated per inhabitant) is the most expensive in detached houses without a compost for biowaste on the property site. When a one-dwelling house property composts biowaste, it reduces the waste management costs close to the cost per inhabitant in a block of flats (Figure 33).

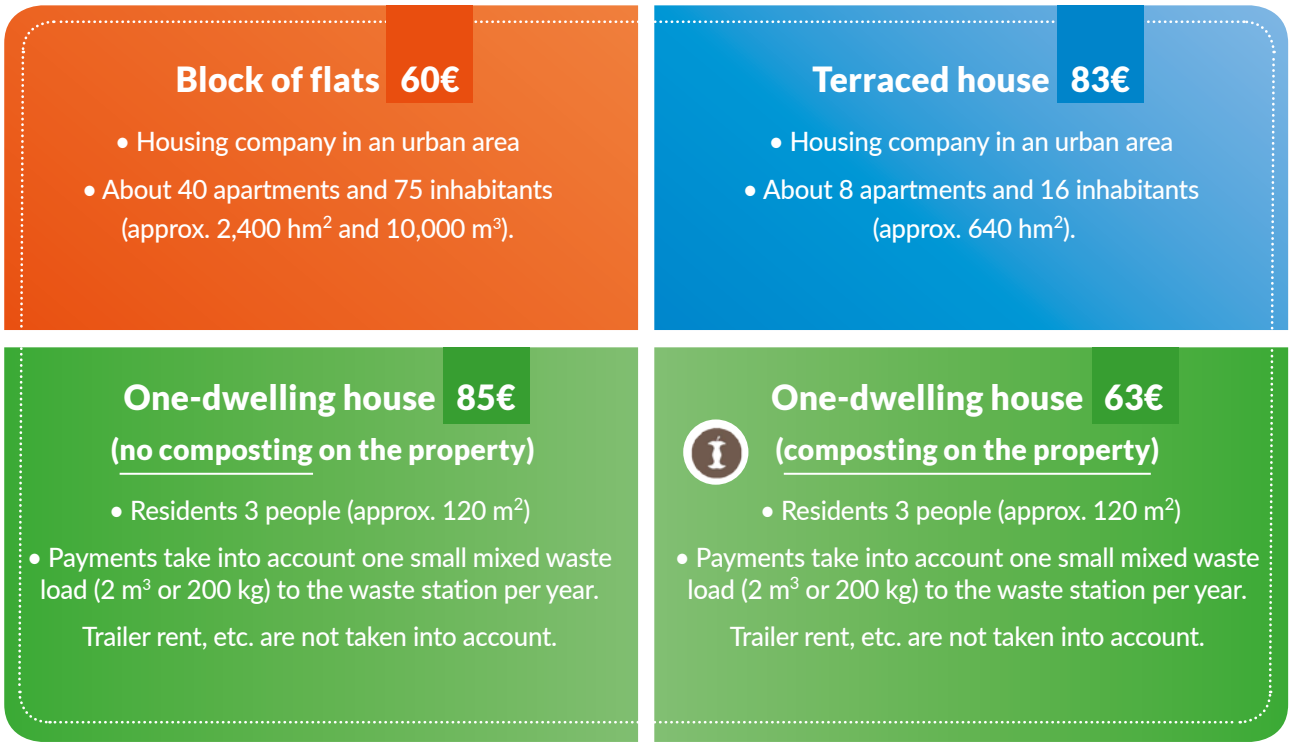


Figure 33. Costs of waste management per inhabitant per year in different types of housing properties; [€]

Since 2001 The Finnish Real Estate Federation has annually compared property taxes, waste management costs and other housing costs (such as real estate electricity, district heat, water and wastewater charges) of the so-called standard-type house/standardized building ("index building"). The reports cover the largest Finnish cities and are based on current prices and grounds for payment.

According to the latest report, in 2021 waste management costs in the municipalities selected for the report were €0.13 - 0.27 per square meter per month. The average monthly waste management cost is €0.19/square meter, corresponding to 6.8% of the total housing cost. Total housing costs consists of total property taxes on buildings and plots, waste management, district heating, electricity for buildings, , and water and wastewater charges. For more details, see Figure 34.

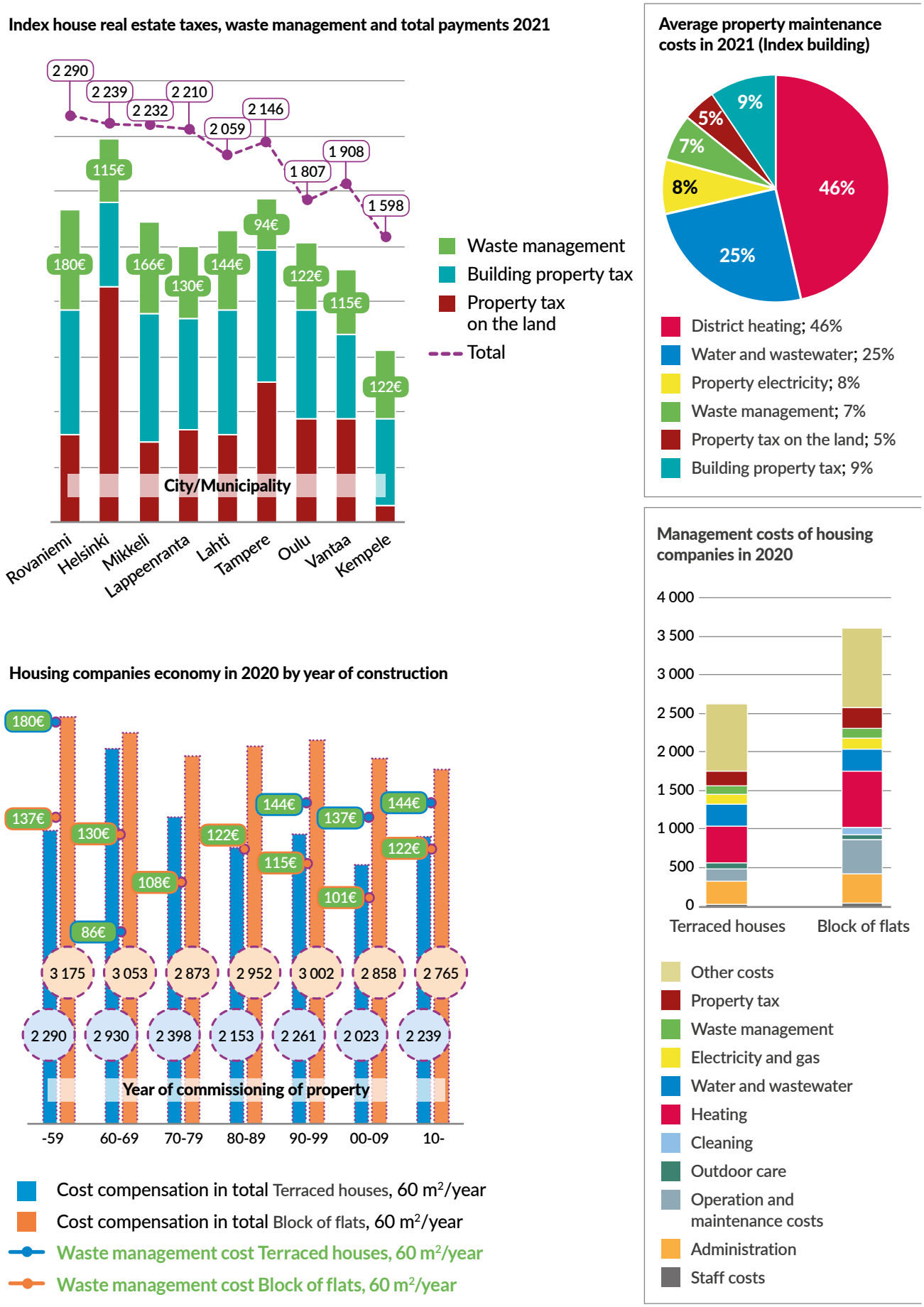


Figure 34. Waste management and other costs in housing companies' economy by example of a 60 m² apartment; [€]

4.7.6 Examples of charges of MWMOs

This chapter is dedicated to the economic part of the operational activities presented in the previous chapters. For descriptions of fees some waste fractions collected in case regions are selected. In the end of this chapter a comparison of emptying charge for several fractions – e.g. mixed waste, biowaste and plastic – in five regions, which are Helsinki Metropolitan area, Pirkanmaa Region, South Karelia, Mikkeli and the operational area of MWMO Kiertokapula (Figures 45 and 46) is presented.

Waste management costs differ in the regions. For example, the city of Tampere and adjacent municipalities has the lowest waste charge in the whole country, if comparing blocks of flats.

4.7.6.1 Case HSY

Property-specific waste collection

In the operational area of HSY, the emptying charge of mixed waste bins is the most expensive (Figure 35). For example, emptying waste bins of the same volume of 660 l once a week have significant differences in fees:

- Mixed waste - €12.44
- Plastic packaging waste - €6.86
- Cardboard – €4.29

The fee for emptying of **multi-compartment packaging** waste bins (660 l, applies for 5-9 apartment houses) in 2021 was €7.65 per emptying. See more examples of waste bin emptying fees in the Figure 36.

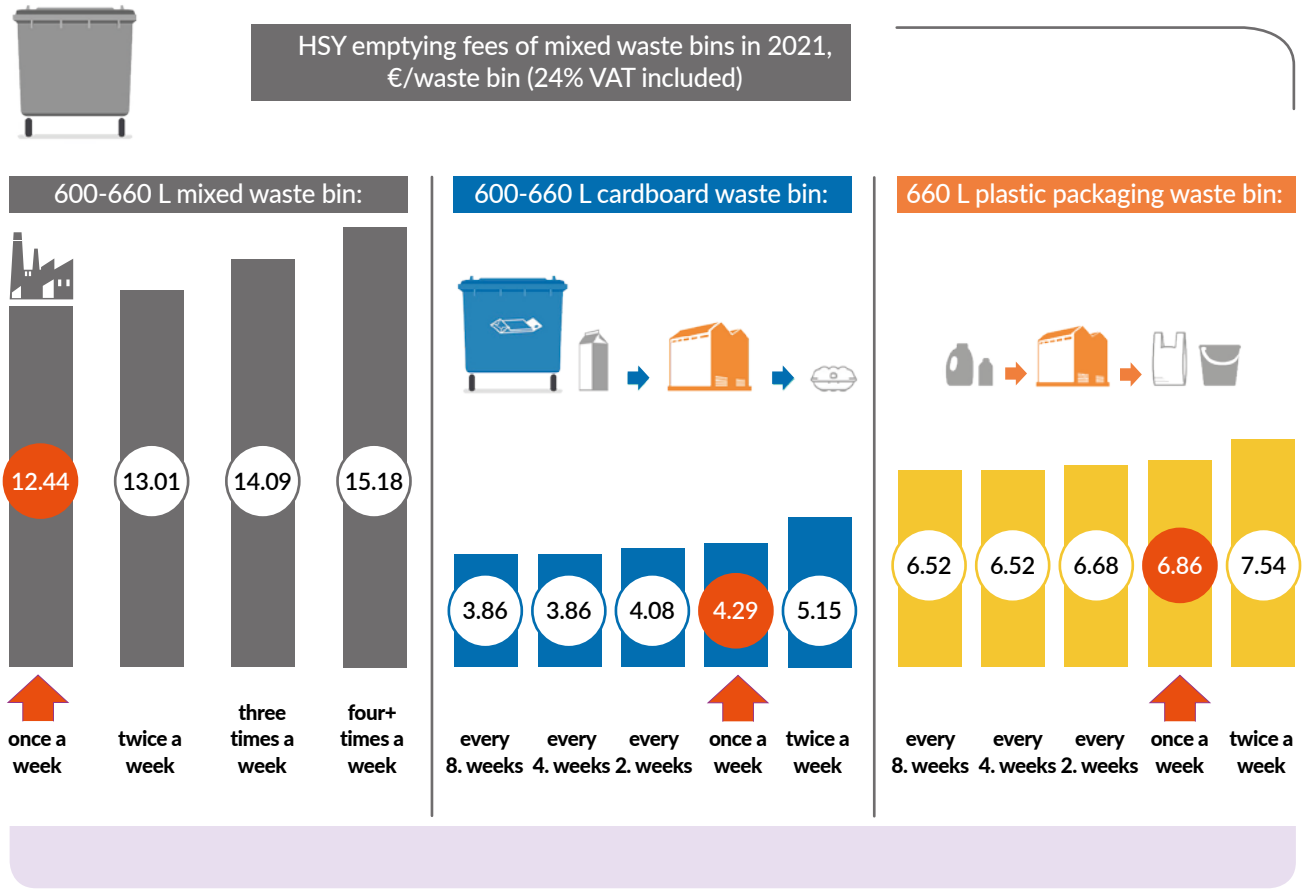


Figure 35. Comparison of emptying fees for plastic package, mixed waste and cardboard in the MWMO HSY; [€]

HSY prices mixed waste bins from a block of flats and a terraced houses according to emptying frequencies, but provides different options in detached and semi-detached houses (from once a week to more than four times a week). For the block of flats and terraced house properties emptying of 600-660 l mixed waste bin, the costs range from €12.44 to €15.18 depending on the frequency from once a week to four or more times a week. The average volume of the waste bins is 660 l, and the more frequent emptying, the more expensive the fee. The fee for emptying of **multi-compartment packaging** waste bins (660 l, applies for 5-9 apartment houses) in 2021 was €7.65 per emptying. Examples of emptying fees of mixed waste bins are presented in the Figure 36.

By setting higher prices of mixed waste, HSY is motivating households to sort more of their useful waste fractions for recycling. The annual growth rate of fees of mixed waste collection is also higher than that of recyclable fractions. Annual fees' growth for a block of flats and terraced houses during 2020-2021 was 9.1% (Table 17)::

Table 17. Annual fees' growth for a block of flats and terraced houses during 2020-2021 in the HSY operational area; [€]

Emptying frequences	2021	2020
once a week	€12.44	€11.31
2 times a week	€13.01	€11.83
3 times a week	€14.09	€12.81
4 or more times a week	€15.18	€13.80

HSY prices emptying mixed waste bins **in detached and semi-detached properties** according to emptying frequencies and volumes of the waste bins**.** Mixed waste is the most expensive, and its price grows each year. For example, from 2020 to 2021, there was about a 10% growth in emptying costs of 300-360l (Figure 36). There are different prices for mixed waste collection for one- and two-dwelling houses and for blocks of flats and terraced houses, for different sized of waste bins and emptying frequencies.

For example, the emptying of mixed waste bins of 140 litres of **detached and semi-detached houses** each other week costs €7.64 and €12.16 for 600-660 litres bins, which means €198.64 annually for 140 litre bins and €316.16 for 600-660 litre bins. Figure 36 shows the prices in euros per emptying per bin. In case of mixed waste, emptying once in 8 weeks requires that the client orders a separate collection of biowaste or compost biowaste property-specifically.

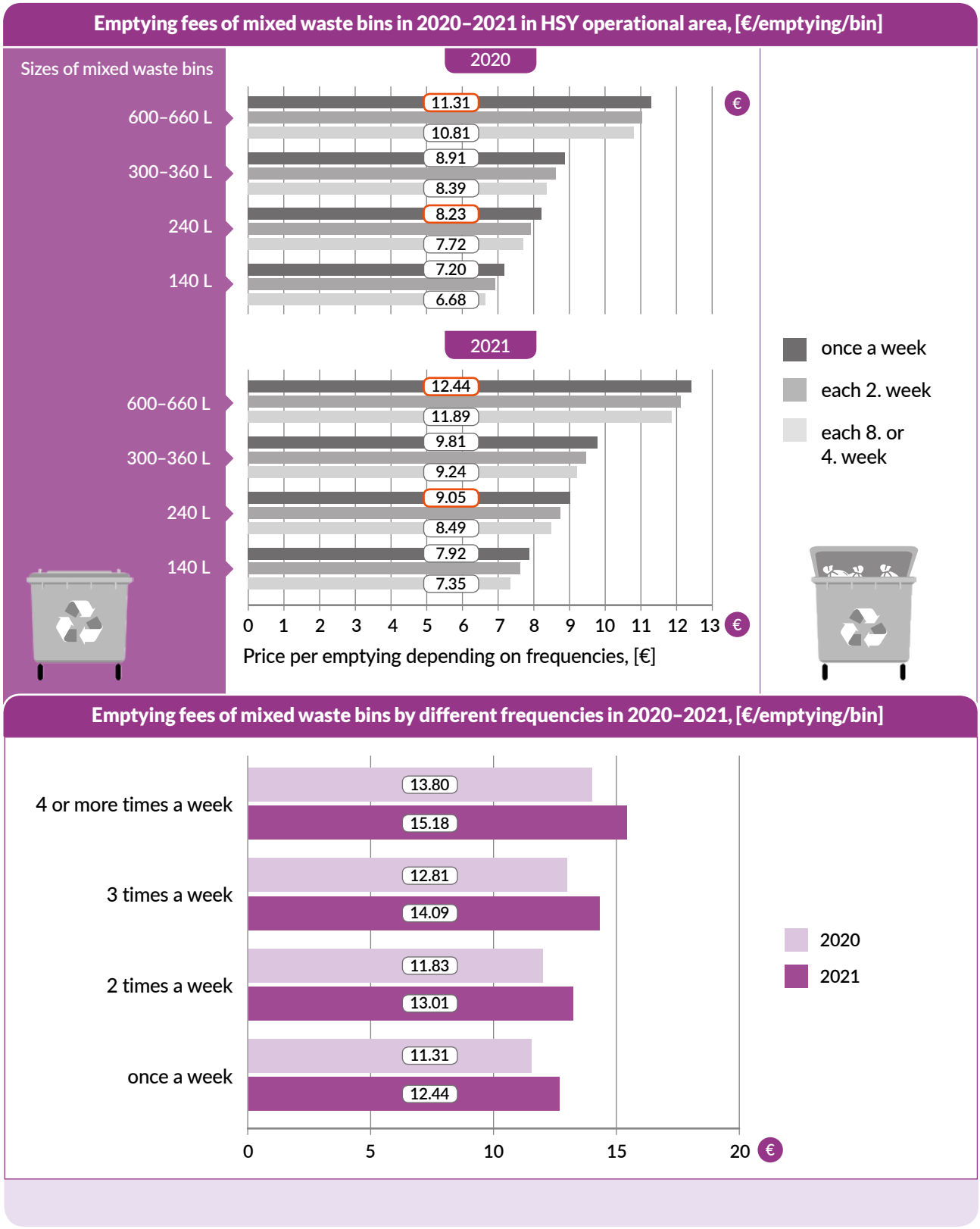


Figure 36. Emptying fees of mixed waste bins for detached and semi-detached houses in 2020 – 2021; [€/emptying/bin]

HSY's pricing of **biowaste** differs by emptying frequencies and by type of customer. For households the fees are lower than for institutions (Figure 37). In case of emptying waste bins once a week or every other week, the emptying costs are €6.58 for households vs. €10.87 for institutions. In case of emptying waste bins four times a week or more frequently, the costs are €8.1 for households vs. €13.06 for institutions.

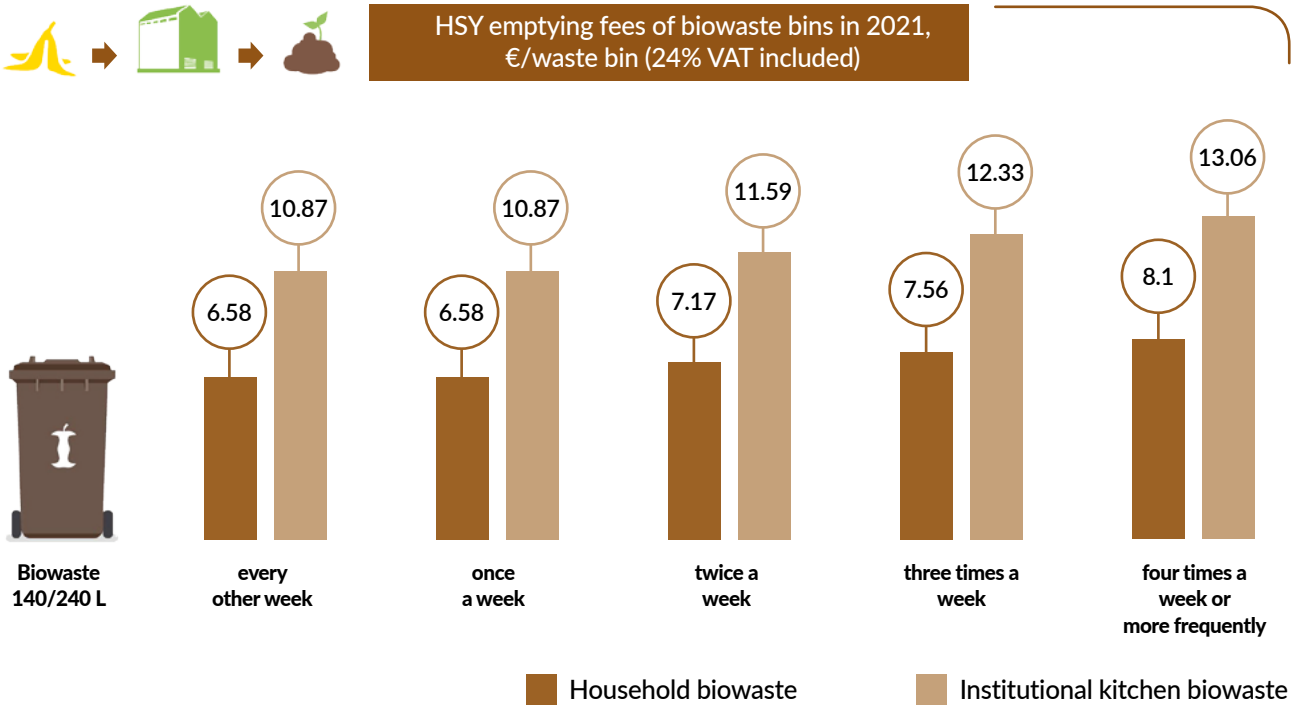


Figure 37. Emptying fees of biowaste bin in the HSY operational area - household vs. institutional kitchen waste; [€]

INFOBOX 17: Examples of successful arrangements of waste collection facilities on a property

Housing properties can influence the amount of their waste costs by sorting, adjusting the number, size and emptying frequency of waste bins.

Example 1

The following case example shows how property-specific waste management costs were reduced by 4,000 € (from 10,000 to 6,000 €/year) by making minor optimizations. The case example takes place in a block of flats in Helsinki in a property with 135 inhabitants.

This was achieved by reducing the number of waste bins and emptying frequency. As the collection of mixed waste is more expensive, intensified collection of recyclable fractions at the expense of mixed waste works as an effective economic instrument to reduce overall costs.

- **Starting situation:** 5 mixed waste bins emptied 3 times a week + 2 paper bins
- **After optimization:** mixed waste bins emptied twice a week + 1 plastic packaging bin emptied once a week + 1 paper bin

Example 2

Another real-life example is a housing company of a block of flats with 40 apartments in Helsinki (Figure 38).

The property-specific separate waste collection was organized in the following way

- 4 mixed waste bins emptied once a week
- 1 cardboard bin emptied twice a week
- 1 plastic package bin emptied once a week
- 1 of each of glass and metal bins emptied once in 4 weeks
- 1 biowaste bin emptied once a week.

Such a composition of waste bins and emptying frequency ended up in €3,956 in waste management costs for the housing company in total, with a share of mixed waste of €2,637 (in the calculations the fees of HSY dated from 2021 are used). If cardboard, plastic packaging, biowaste, glass and metal would not be collected separately, and instead put into mixed waste container, the total costs would be €5,275 (or €1,318 more than in the real-life case).

Example:

- Block of flats housing company
- 40 apartments
- Helsinki
- Outer urban area

Waste management (emptying of property-specific waste bins)

Total costs per year in case example: 3956 eur *

* in calculations used numbers from HSY Waste management service fees 2021

	€/ year	€/ emptying	Volume of bin, L	Number of waste bins	Emptying frequency
Mixed waste	2 637	12.44	660	4	once a week
Cardboard	455	4.29	660	1	twice a week
Plastic packaging waste	364	6.86	660	1	once a week
Glass	76	5.74	240	1	once in 4 weeks
Metal	76	5.74	240	1	once in 4 weeks
Biowaste	349	6.58	240	1	once a week

Figure 38. Case example: waste management costs in block of flats in HSY area

Rental fees of waste bins are not included into the emptying fees of HSY. Those are defined week-based separately. The rental fee for a 140–240 litre bin is €0.25/week, for a 300–360 litre is €0.35/week, and for a 660 l is €0.47/week (Figure 39). Renting of waste bins from HSY is not mandatory. HSY charges its customers separately for damaging waste bins: €55 for a 140-240 l bin, €70 for a 360 l and €140 for a 660 l bin.

The total annual cost of property-specific waste management for housing companies or detached property owners in the HSY area is a sum of emptying and renting fees. Those are shown in the HSY bills to customers in separate lines. Figure 39 shows that mixed waste management of a 660 l waste bin with an emptying frequency once a week costs a client in total €672 per year in 2021. In case of detached property owners, mixed waste management of a 300-360 l bin with an emptying frequency once in two weeks costs €267 in total per year.

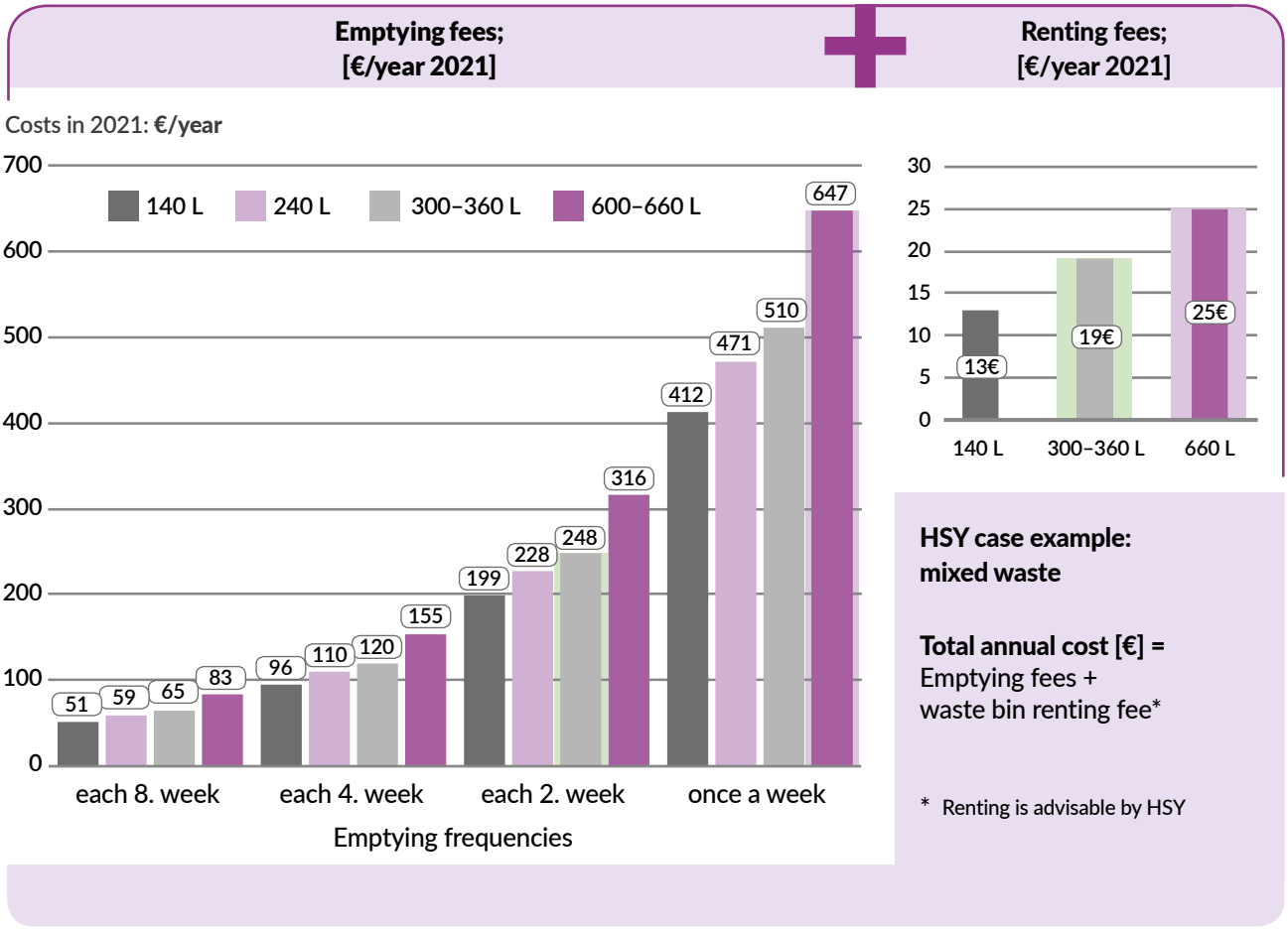


Figure 39. Total annual costs (emptying + renting) of mixed waste bins in the HSY operational area in 2021; [€]

Sorting stations

Sorting stations do not charge a fee for separately sorted fibre packaging and cardboard; glass packaging (bottles and jars), metal, paper or WEEE. Household hazardous waste is also accepted at the stations free of charge. However, a company, institution or similar entity has to pay for hazardous waste. Other waste that is brought to Sortti stations is chargeable (See Figure 40 and Table 18 for more information).

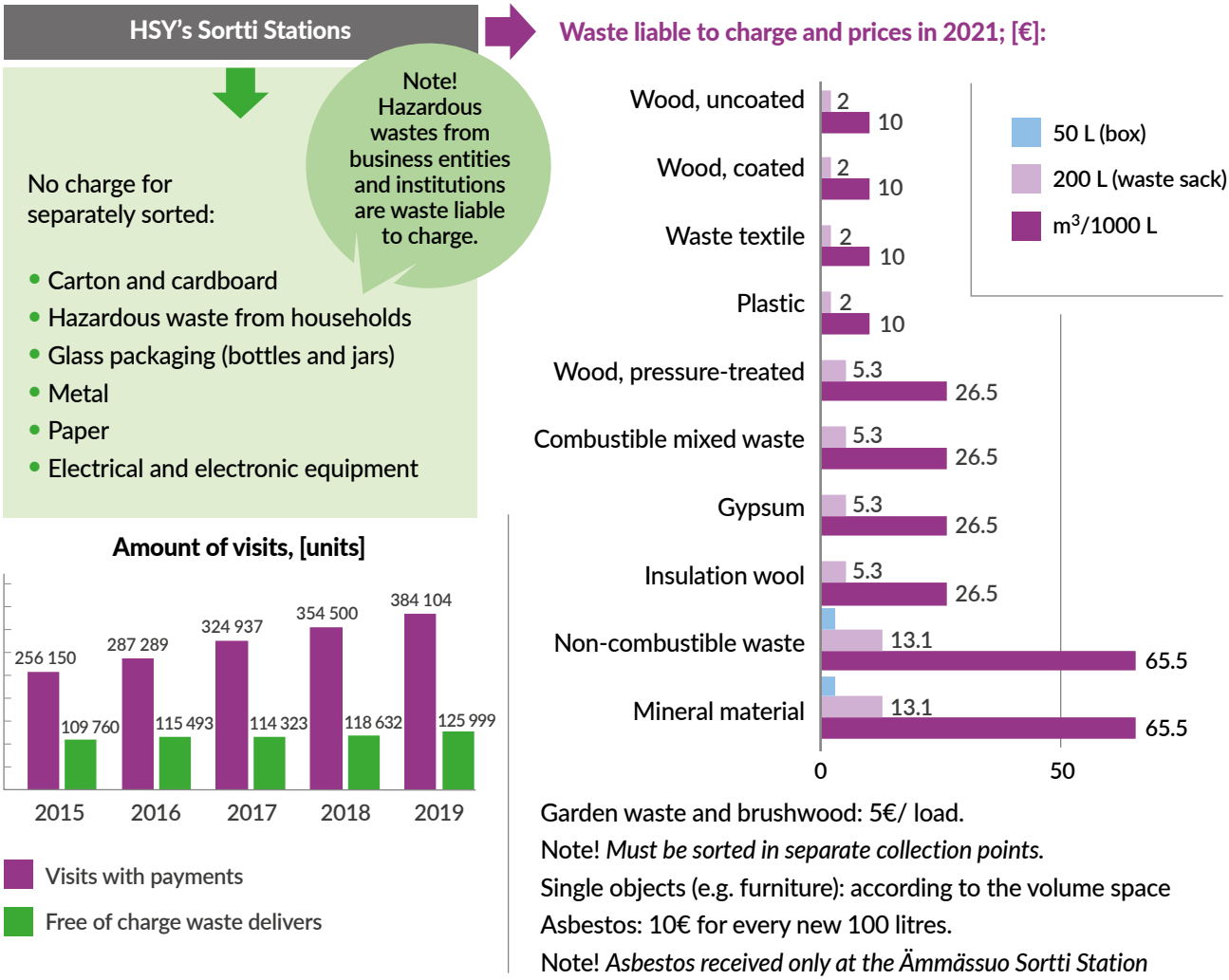


Figure 40. Charges of HSY Sortti Stations; [€]

Table 18. Waste liable for charge at HSY Sortti Stations and prices; [€]

	m³/1000 l	200 l (waste sack)
Mineral material and non-combustible waste	€65.5	€13.1
Insulation wool, gypsum, pressure-treated wood, combustible mixed waste	€26.5	€5,3
Plastic, waste textile, coated and uncoated wood	€10	€2

Sortti Stations accept payment with the most common payment cards or by invoice. On the HSY website detailed information about each station can be found. HSY is continuously developing the operation of the Sortti Stations. Nowadays customers can be e.g. connected to the invoicing and purchasing system by driver's licence and they will no longer have to carry a plastic Sortti card with them and get an invoice when leaving the Sortti Station.

4.7.6.2 Case EKJH, South Karelia (incl. the city of Lappeenranta)

Property-specific waste collection

The pricing of waste management services in South Karelia by the MWMO "EKJH" has the following categories: dry waste (also called mixed waste in other regions), biowaste and recyclable waste. The emptying fees of dry waste are the same for properties of households and institutions, but they vary between municipalities within the EKJH operational area. Logically, the emptying prices of smaller bins are lower than those of bigger bins. The prices in the cities of Lappeenranta and Imatra are almost the same, ranging from €5.4 to €10. In the area of the Parikkala, Rautjärvi, Ruokolahti municipalities the fees range from €7.7 to €12.3 (Figure 41).

The pricing of EKJH for the emptying of biowaste bins is different for housing and institutional propertiesFor example, in the city of Lappeenranta for households the one-time emptying of 240 litres bin costs about €9.5, but for institutional properties €15.8. Variations in the fees between the municipalities also occur as in the case of dry/mixed waste. The fees in the area of Parikkala, Rautjärvi and Ruokolahti are the highest – the emptying of 240 litre bins costs from about €14 for households to €20.3 for institutional properties (Figure 42).

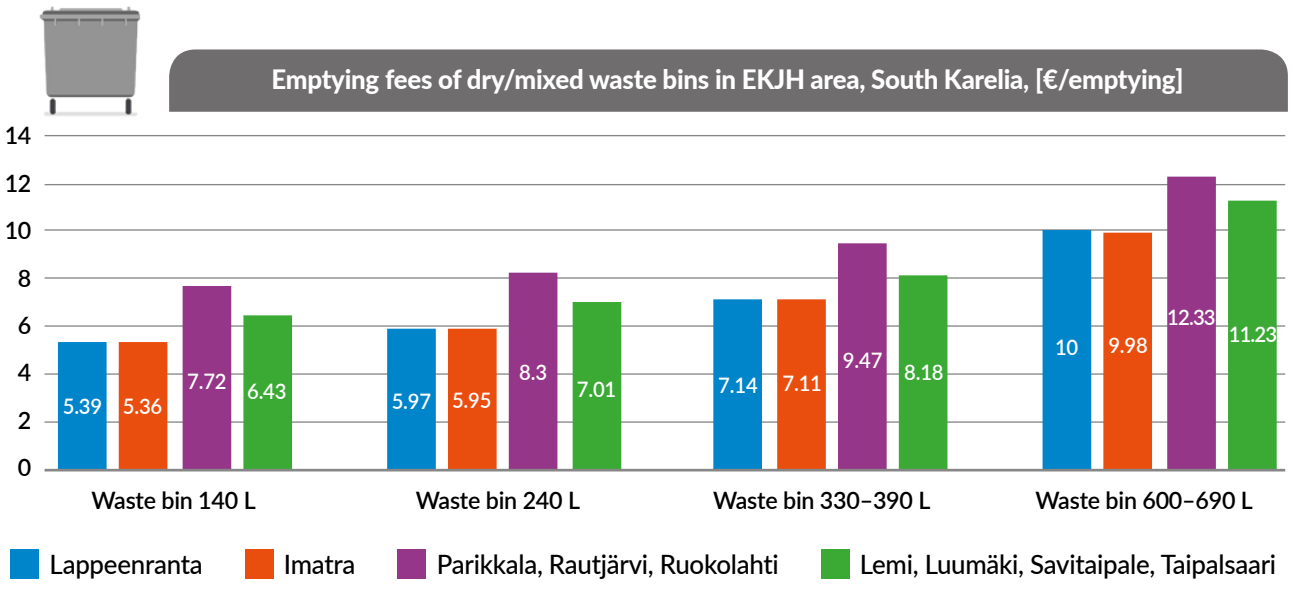


Figure 41. Pricing of emptying of dry/mixed waste bins in the EKJH operational area in 2021; [€]

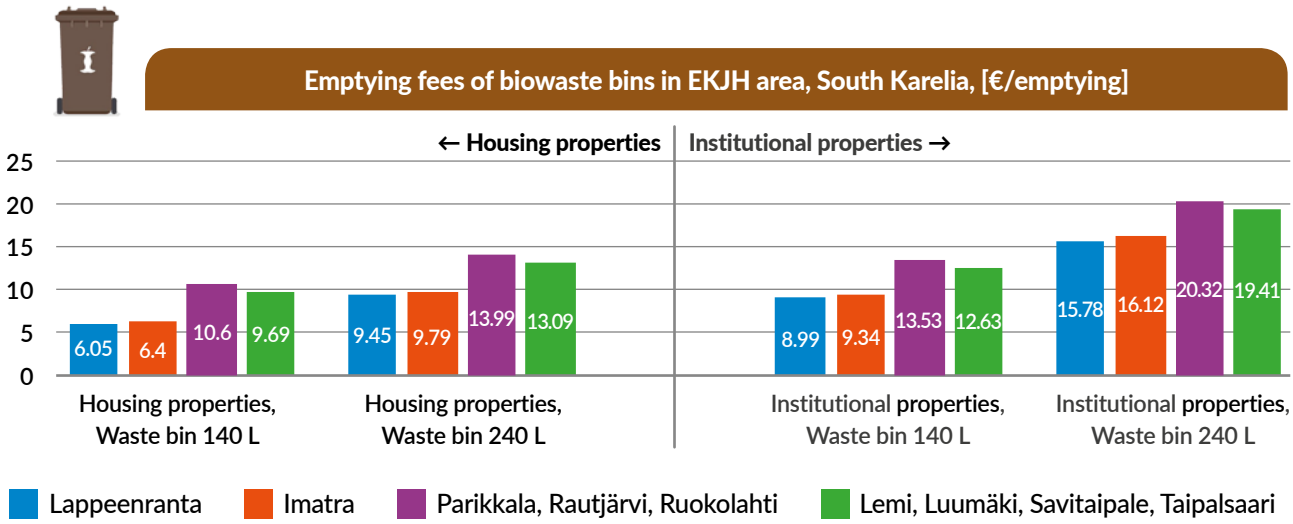


Figure 42. Pricing of the emptying of biowaste bins in the EKJH operational area in 2021; [€]

Typically, a detached house has a 240 l dry waste bin and a 140 l biowaste bin and apartment buildings (one or more depending on the number of inhabitants) a 660 l dry waste bin and a 240 l biowaste bin.

In addition to the emptying fees EKJH also charges from households the so called annual (or basic) fees, which for example for the city of Lappeenranta are described in the Table 19.

Table 19. Annual MSW fees in Lappeenranta in 2021; [€]

Types of properties	Basic fee, EKJH part	Municipal add.	Authority fee	Annual fee, TOTAL
Apartment in block of flats	15.4	3.5	2.24	21.12
Apartment in terraced and semi-detached house	17.3	3.5	2.24	23.04
Detached/one-dwelling house	18.2	3.5	2.24	24.00
Vacation home	13.6	2.3	2.24	18.18
Detached house empty/non-inhabitant	13.6	2.3	2.24	18.18

If some property does not have an agreement on waste bin emptying with EKJH, it has to deliver accumulated property-specific waste to a local waste collection point for mixed waste organized by the MWMO and pay **the annual fee** for this service. In the city of Lappeenranta, the fee is about €68.7 for a year-round permanent home apartment (lower fee of €48.2 for one-person apartment per year) and about €43 for holiday homes and non-inhabited permanent living apartments. EKJH charges €150 for wrong usage of a local waste collection point.

EKJH sells waste bins to the customers. The prices include VAT, delivery, labels and removal of old bin, comprising €61 for 80 – 240 litre bins, €103 for 360 l bins, and €190 for new 600-660 l bins (€120 for used). Multi-compartment waste bins cost €215 for 360 litres and €353 for 660 litres. A renting option is also available and costs €2 per 360 l and €5.5 per 660 l. In addition, customers can buy waste bins without delivery service, and in this case the prices are lower. For example, a 600-660 l bin cost €175 (vs. €190 if delivery service included).

Sorting stations

- Inhabitants can bring their garden waste, hazardous waste, WEEE and scrap metal free of charge to *For use* stations. The other types of waste are paid for. Pricing in sorting stations (*For use* stations) is based on the volume of the waste, but also on the location of the station. For example, in Kukkuroinmäki the price is lower than in other stations, because there is no need for transportation. As such, a trailer loaded with priced waste costs 15€ in Kukkuroinmäki and 25€ in the other stations.

The prices for waste reception at *For use* sorting stations (self-delivered waste by customers) at the sorting station of the EKJH in 2021:

- Small amount (max. 20 l) of household waste: €2
- Housing waste, small amount in 200 l packaging of construction and demolition waste (CDW), solid waste, energy waste: €15/m^3
- Delivered by private car (trailer load) over 2 m^3 of CDW, solid waste, energy waste: €25/m^3
- Biowaste max. 20 l bag: €2
- Frame and spring mattresses: €8 per unit
- Furniture (e.g. sofa, armchair): €12
- Gardening waste (tractor trailer or truck platform): €35
- Disposal fee of barrel containing hazardous waste: €35

4.7.6.3 Case PHJ

The MWMO of the Pirkanmaa region, PJH provides the cheapest waste management services in Finland. Efficient logistics and energy utilization of waste at the co-owned waste-to-energy plant Tammervoima situated approx. 15 km from the centre of Tampere allows to keep the costs of waste management low. Through a centralized tendering process, PJH finds the cheapest transportation and waste treatment services. PJH sells the collected recyclable materials on the market and treats biowaste in its own bio-plant. Some of the collected materials are forwarded to producer corporations.

The waste charge in the Pirkanmaa Region consists of collection and transportation (43 %), treatment of waste (23 %) and VAT (19 %). In addition, the waste fee for mixed and biowaste waste containers includes the basic fee share (15 %) and the waste container itself in accordance with the waste management regulations (for example 140 l, 240 l, 360 l, 660 l). However, the customers' invoice only shows the amount of the total payment. Figure 43 presents use of emptying fee in case of a 240 l waste bin in the PJH operational area in 2020.

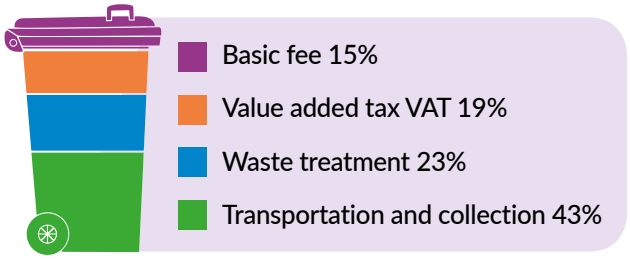


Figure 43. Use of emptying fee in case of a 240 l waste bin in the PJH operational area in 2020

The transportation distance and the type of collection device affect the pick-up and transport costs. The basic charge is used for covering costs incurred by information and advising, collection and treatment of household hazardous waste, the work of the waste board, the operation of the waste sorting station and local collection points, as well support of biowaste management that allows to keep biowaste collection costs lower for customers (Figure 44). PJH uses waste charges also to cover the waste tax and gets approximately a 4 % profit.

In order to get people to sort their waste, the waste charge is being developed as an incentive. In addition to providing collection of biowaste for inhabitants on cheaper prices comparing to real costs, PJH offers inhabitants free property-specific collection services, such as collection of glass packaging and metal for properties in the biowaste regular collection area. On the other hand, mixed waste is correspondingly more expensive. All costs incurred in arranging waste management services are charged to customers, but at cost price. Examples of emptying fees in the city of Tampere are presented in the Table 20.

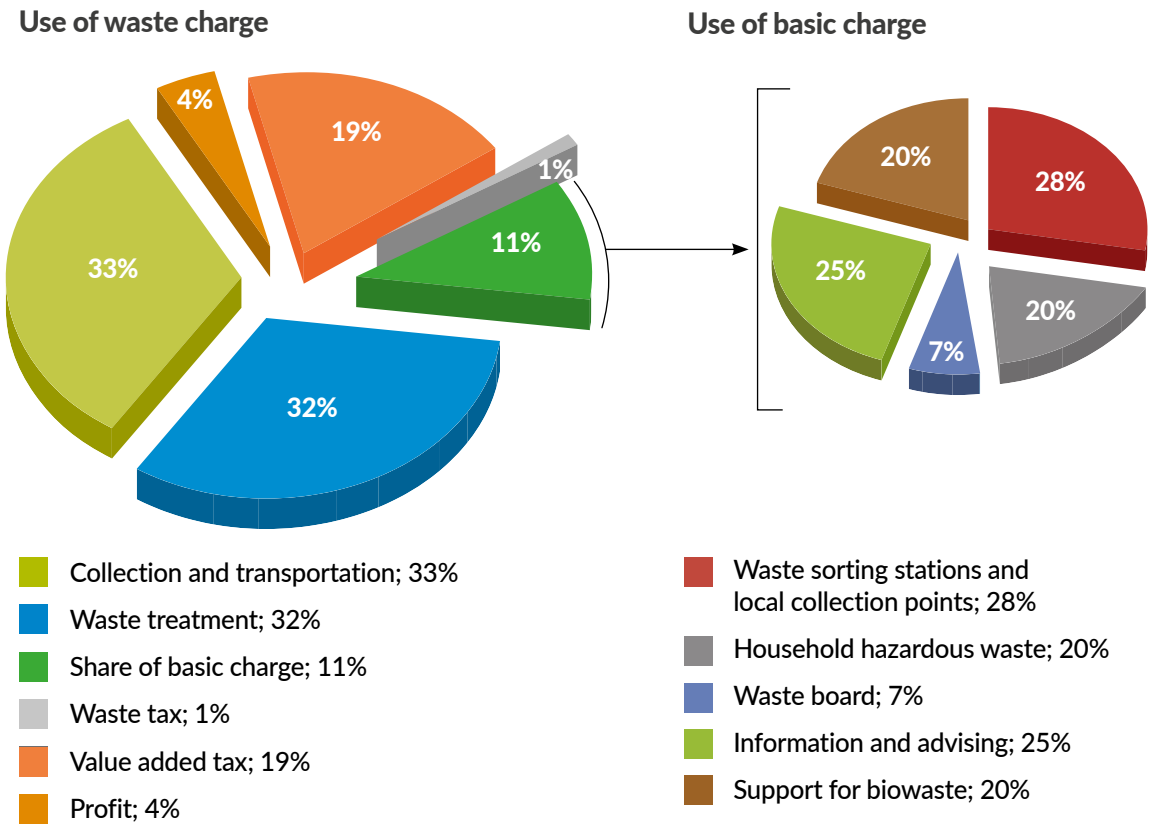


Figure 44. Waste management cost breakdown of PJH in 2020

Table 20. Examples of emptying fees in the city of Tampere for 2022 for different sized waste bins; [€/ emptying, incl. VAT 24 %]

	140 l	240 l	660 l	770 l	Deep collection 800 l	Deep collection 1,3 m³	Deep collection 3 m³	Deep collection 5 m³
Mixed waste	3.96	5.03	9.15				39.22	59.64
Biowaste	4.15	5.11			21.51			
Glass packages		6.75*	8.70*			34.99*		
Metal		6.75*	8.70*					34.99*
Fibre packages					6.45			27.28
Plastic packages				8.70			33.91	41.01

** Free of charge for properties in the biowaste regular collection area in property is involved in biowaste collection.*

Waste sorting stations and the waste centres in the Pirkanmaa region accept the following fractions delivered by households free of charge.

- sorted recoverable waste (e.g. metals, glass packaging, cardboard, paper)
- household WEEE
- hazardous household waste, aside from waste oil and other liquids in batches of over 200 litres
- brushwood and branches (trailer load)
- compostable garden waste, such as raking waste and apples (trailer load)
- car tyres (including rims)

Chargeable waste fractions comprise mixed waste, unimpregnated wood and panels as well as earth, brick and concrete (Table 21).

Table 21. Reception prices charged by waste centres in the Pirkanmaa region for 2022

Waste Type	€/load
Mixed waste	
Up to 0,5 m^3	7.00
Up to 2 m^3	21.00
Up to 4 m^3	36.00
Unimpregnated wood and panels	
Up to 2 m^3	17.00
Up to 4 m^3	34.00
Impregnated wood and panels	
Up to 1 m^3	8.50
Earth, brick and concrete	
Trailer load (up to 2 m^3)	8.00

Separate waste treatment charges apply to waste loads and other types of waste of more than 4 m^3. These prices apply to companies that bring their waste for treatment, energy recovery and final disposal in the municipal waste management system.

4.7.7 Variations between waste charges concerning some waste fractions within operational areas of MWMO case examples

In the previous chapter, the average charges of property-specific waste collection were presented. This chapter will focus on presenting variations of charges by municipalities and waste fraction types. The charges of property-specific waste collection vary quite widely in some example cases of MWMOs, and variations within one MWMO could be noticeable. In addition, there can be variations between charge categories within single MWMO. For example, from the reviewed eight examples of MWMOs, only in two of them the charge category of multi-compartment waste bin exists – in HSY and EKJH. In some MWMO cases the charges are different for different municipalities within the operational area of the MWMO.

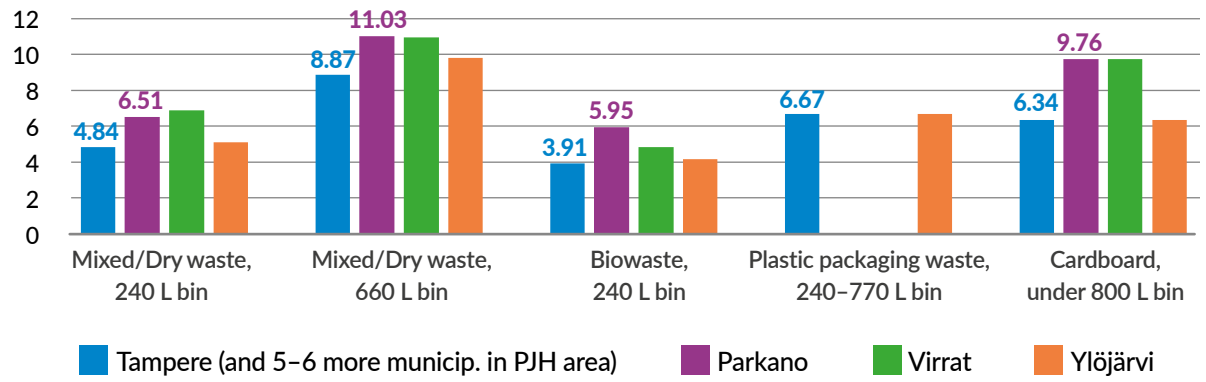
For observing municipality-specific waste charges the five following case examples are selected to illustrate variations in pricing strategies. More information about municipalities is presented in the Chapter 4.4.1.:

- HSY, operates in 5 municipalities
- PJH, operates in 17 municipalities
- EKJH, operates in 9 municipalities
- Kiertokapula, operates in 13 municipalities
- Metsäsairila, operates in 1 municipality

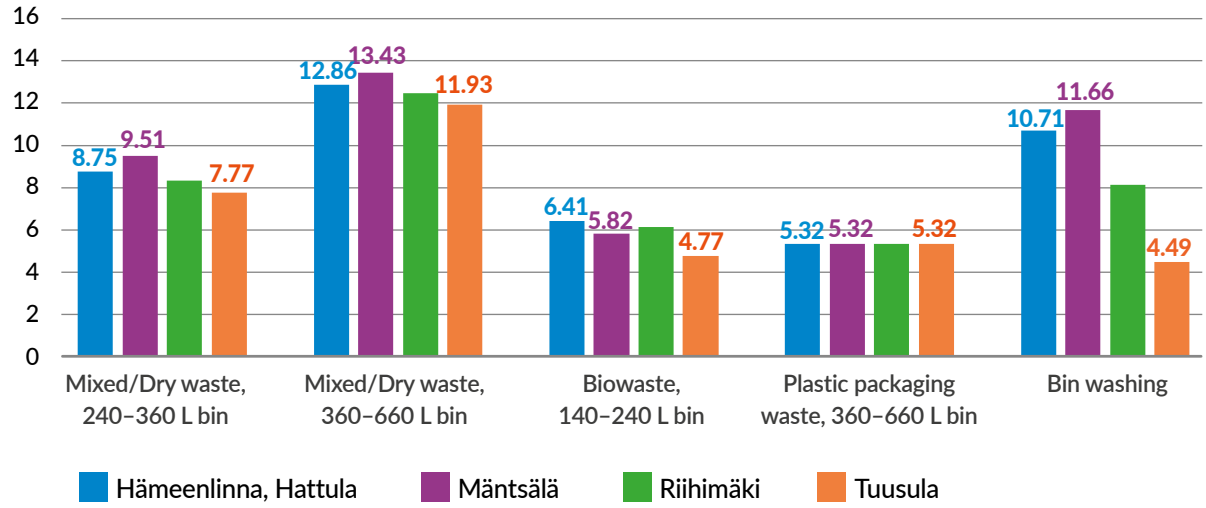
Figure 45 presents examples of fees from some municipalities in these cases. The principle of selection was to showcase different municipalities in terms of population density and proximity to waste treatment facilities. For example: in the PJH case municipalities in Tampere region in the same fee category vs. Parkano, in the EKJH case Lappeenranta vs. Parikkala, in Kiertokapula case Hämeenlinna vs. Tuusula. In densely populated urban areas waste charges are lower than in less densely populated municipalities. In the HSY case, the pricing is the same for all five municipalities within the operational area but varies for different waste fractions. For generic showcases, the emptying fees of some waste fractions and volumes of waste bins are selected. Such volumes are up to 240 l bins for mixed/dry and biowaste, 660 l bins for mixed/dry waste. As shown in the Figure 45 the categories of waste bin volumes vary.

Observing waste fraction-specific pricing is conducted for five MWMOs cases. Figure 46 showcases examples of fees. For more generic overviews, the once a week emptying fee category is selected. Despite the collection of mixed waste always being more expensive compared to other waste fractions, the range can vary significantly in different regions. However, the price ratio between mixed waste and separately collected waste fractions is different in the MWMO case examples. For example, the charges for emptying mixed and cardboard waste in municipalities in Tampere region in the same fee category are €8.87/6.34, in HSY €12.44/4.29. The relations between charges for emptying of mixed and biowaste bins is the following: in Mäntsälä is €13.43/5.82, in HSY €12.44/6.58, in Metsäsairila is €13.00/8.5. A summary overview on the pricing

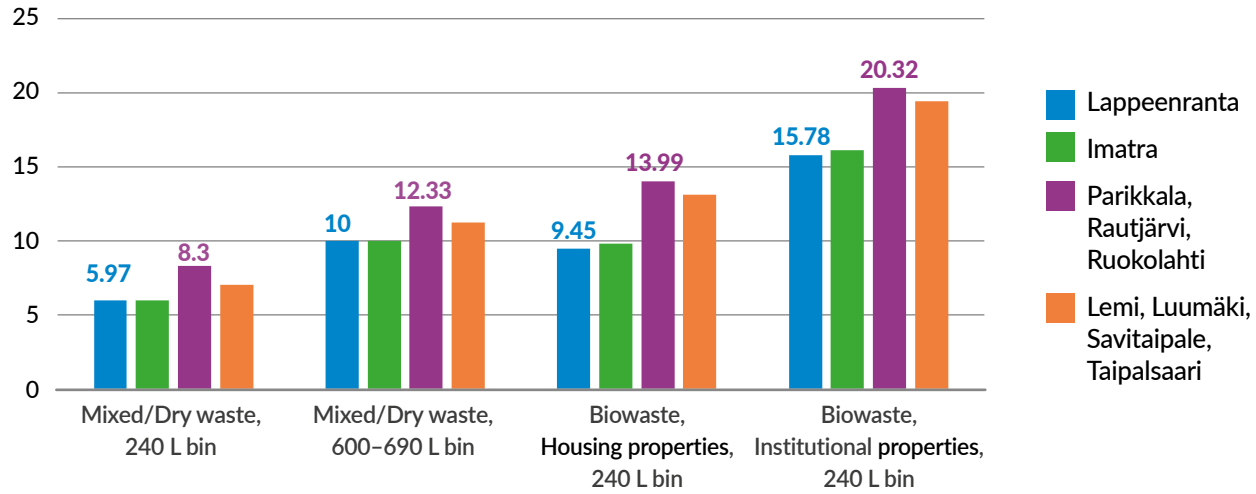
Examples of waste bin emptying fees from PJH operational area in 2021; [€]



Examples of waste bin emptying and washing fees in Kiertokapula's operational area in 2021; [€]



Examples of waste bin emptying fees from EKJH operational area in 2021; [€]



Examples of waste bin emptying fees from HSY operational area in 2021; [€]

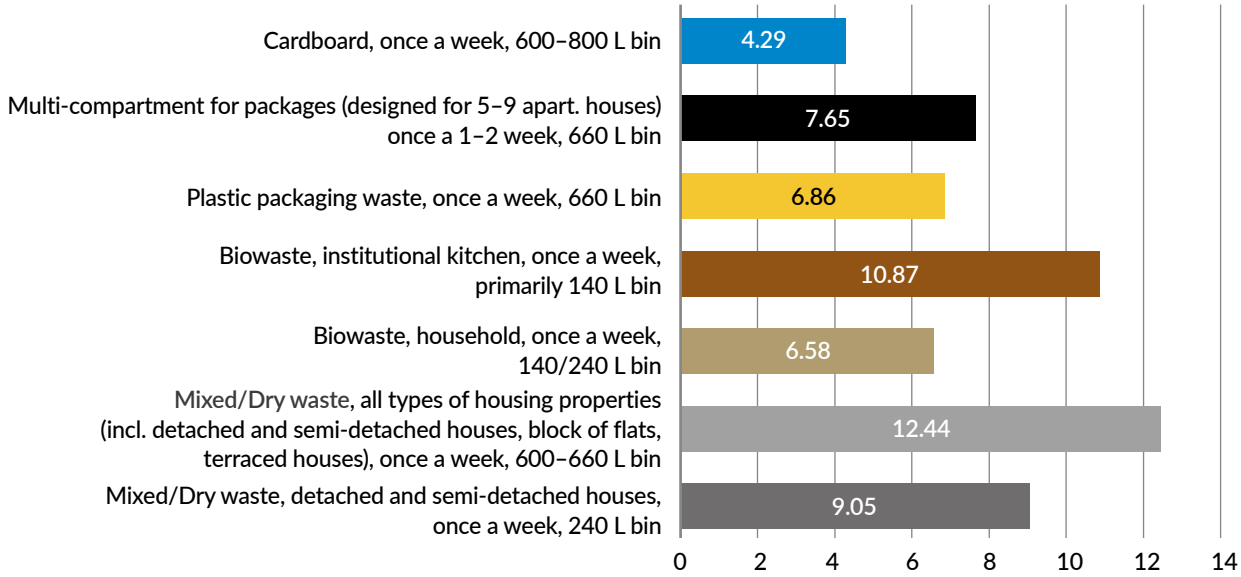


Figure 45. Case examples of differences of waste bin emptying fees by municipalities within the same MWMO (PJH, EKJH, Kiertokapula and HSY) in 2021; [€]

of mixed waste and biowaste by five MWMOs is presented in the Figure 46.

The gradation of mixed/dry waste bin volumes under the same fee category varies in different MWMOs. For a more generic overview, all comparable examples in the Figure 46 include a 660 l waste bin. In the MWMO case examples fees vary from €13.4 (MWMO Kiertokapula, for the municipality of Mäntsälä) to €8.9 (MWMO PJH, for the city of Tampere and six more municipalities within the operational area). In general, the fees for collection of biowaste concern only the category of 140-240 l waste bins, which is regular size biowaste bin. Variations in fees within MWMO case examples are much broader than for dry/mixed waste – from €14 (MWMO EKJH, e.g. for households in the municipality of Parikkala) to €3.9 (MWMO PJH, for Tampere) (Figure 46).

Still, biowaste comprises one-third of the mixed waste, which is considered to be a problem, as a valuable resource is directed to waste-to-energy plants where it could interfere with technological processes of energy production. Currently big efforts are being made to increase the separate collection of biowaste and consequently the production of biogas and biofuels. For example, National Biowaste campaign launched in 2020, aimed at raising environmental awareness concerning the sorting of biowaste. The new waste legislation has stricter requirements concerning separate collection of biowaste and packaging waste.

Examples of emptying fees of mixed/dry waste bins, 360–690 L, in 2021; [€]

Examples of emptying fees of biowaste bins, 140–240 L, in 2021; [€]

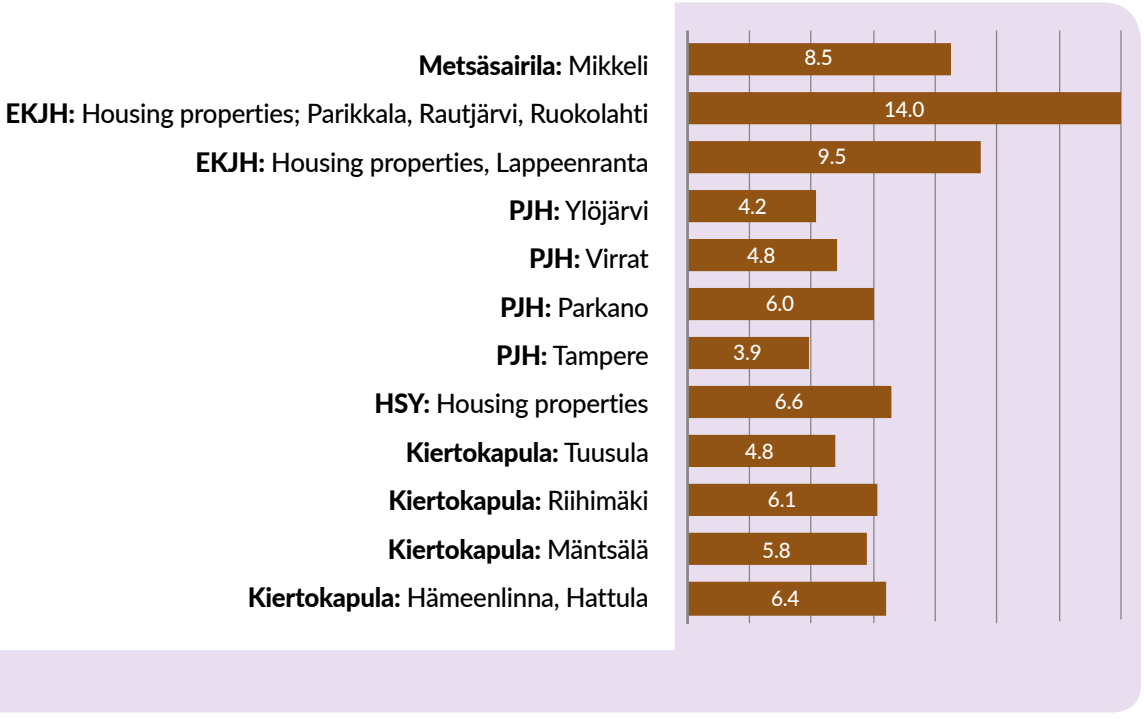


Figure 46. Summary of case examples of emptying fees - mixed waste vs. biowaste; [€]

4.8. Environmental awareness-rising and advising

**Text written by the MWMO HSY*

Meeting strict recycling targets requires more efficient sorting of waste on properties to allow for a larger proportion of waste material to be reused and recycled. In Finland, correct sorting practices are taught to children from preschool age onwards.

Local authorities are responsible for providing statutory communication and guidance related to waste management. Municipal waste management companies provide guidance and education on waste management to local day cares, schools, housing associations, resident groups, associations and communities in the form of free lessons and materials to support environmental education, courses on composting, etc. The costs are covered by the basic waste management fee. The lessons and materials are in line with municipal curricula and support the execution of schools' sustainable development plans. The focus is on practical learning, and waste management companies provide a wide range of instruction on the topic in schools and day cares (games, plays, visits to waste centres).

The goal of providing guidance is to motivate residents to consume sustainably, reduce the amount of waste, and sort waste efficiently at the source.

Environmental education and sorting advice is provided at various information sessions, over the phone, online on websites and on social media and in the form of various handbooks, materials and awareness campaigns. Awareness campaigns are targeted to various audiences based on research data on sorting motivation. Some MWMOs co-operate with local organisations or freelancers to outsource advisory services if they do not have the capacity to employ its own staff for this purpose.

Information services of HSY on waste sorting

The Helsinki Region Environmental Services Authority HSY advises inhabitants on household waste sorting in several ways. The electronic Waste Guide on the HSY's website is a search engine that provides instructions for the searched waste item or material. The Waste Guide works handily on a mobile browser without the need to download a separate app. The HSY's website also has sorting instructions for each type of waste, including information about their reuse and recycling.

HSY also provides printed sorting guides free of charge. HSY waste bins on properties are marked with the name and picture of the type of waste and contact information for questions. In addition, housing associations can order wall posters that provide mainly visual instructions on how and what to sort in each bin (Figures 47 and 48).

Figure 47. Examples of printed sorting guides at household's waste sorting point

Property managers and housing association boards have an important role in relaying information to residents. They can subscribe to a free monthly or near-monthly email newsletter that provides information about current issues related to waste management and recycling and reminders about offered waste management services, such as separately ordered, printed sorting instructions and information sessions.

HSY purchases environmental advice and education

Figure 48. Household's waste sorting point in HSY area

services on waste and water management for residents of the Helsinki Metropolitan Area, children between ages 5–6, schools, associations and private individuals, integration training services, and expert groups visiting HSY's facilities (Figure 49). They service about 35,000 residents face-to-face every year and includes lessons, training for educators, a friendship school programme, information sessions at resident events, and visits to HSY's facilities, among other activities. During the COVID pandemic, the service was expanded to include digital games and remote advisory services. The service is provided by Helsinki Metropolitan Area Reuse Centre on behalf of HSY. Environmental advice is free of charge for users.

HSY regularly carries out public awareness campaigns in the Helsinki Metropolitan Area and Kirkkonummi, one of the goals of which is to increase sorting awareness and motivation. Several awareness campaigns for different target audiences have been carried out under the "Thank you for sorting your waste" slogan. For example, HSY's 2021 campaign on waste bin types raised awareness of new waste management regulations in multiple channels with a customer-oriented approach. The campaign's main message was that new waste bins in housing associations will make waste sorting even easier by providing separate bins for each waste type on residents' backyards. Another message of the campaign was that the journey of waste to recycled raw materials begins at home. The target audiences were, in particular, property managers and chairs of housing association boards as well as residents included in the scope of the expanded sorting service. Communication channels included resident and customer letters, websites, social media and electronic newsletters. In addition, the campaign organised a webinar together with Uusimaa Real Estate Federation, brought a popular Finnish comedian onboard to serve as HSY's recycling ambassador, and produced promotional videos to be shown in cinemas.

HSY's biowaste campaign was targeted specifically at young adults. The campaign emphasised that sorting gives new life to waste as it is converted to raw materials for new products. The campaign's video and audio messaging was distributed on channels popular among young people, including social media, streaming services, and music and audio apps.

Figure 49. Environmental education for children in HSY area

4.9. Waste transportation

Waste transportation is organized by municipalities or, in some regions, by property holders themselves (I.e. contract with waste carrier). If municipalities organize the transport of waste from the properties and select the transportation companies, they need to do that by using competitive bidding. The municipality must carry out a market survey when planning waste transport procurements. The procurement must be tendered in lots and carried out in such a way that more than one company can be selected as the service provider. This ensures that small and medium-sized enterprises have the opportunity to succeed in tenders.

In this way municipalities can better monitor and control waste transportation and obtain information on waste streams in their area. This mode of operation also enables co-operation between municipalities and producers in the collection of packaging waste and other waste of the same material (e.g. plastic, metal) as well as a mechanism by which the producer reimburses the collection costs of packaging waste to municipalities and the municipalities further to residents.

Municipalities can take advantage of waste collection methods that save the environment and transport costs, such as multi-bin, joint or block collection. The environmental impact of transport is reduced compared to a situation where transportation is handled by many different operators in the same area. This usually takes place in detached house areas.

As mentioned in the Chapter 4.3., under certain conditions, the transportation can be also organized by mutual agreement between the property holder and the waste carrier. After the new Waste Act in 2021, this option concerns only mixed waste, while other waste fractions are under municipal responsibility.

4.9.1 Case HSY

The biggest share of HSY's waste management turnover is waste transportation. In 2019, waste transportation charges comprised 80,151 million €, while waste treatment charges comprised only 13,542 million €. The share of procured waste transport services was 31,770 million € (Figure 50).

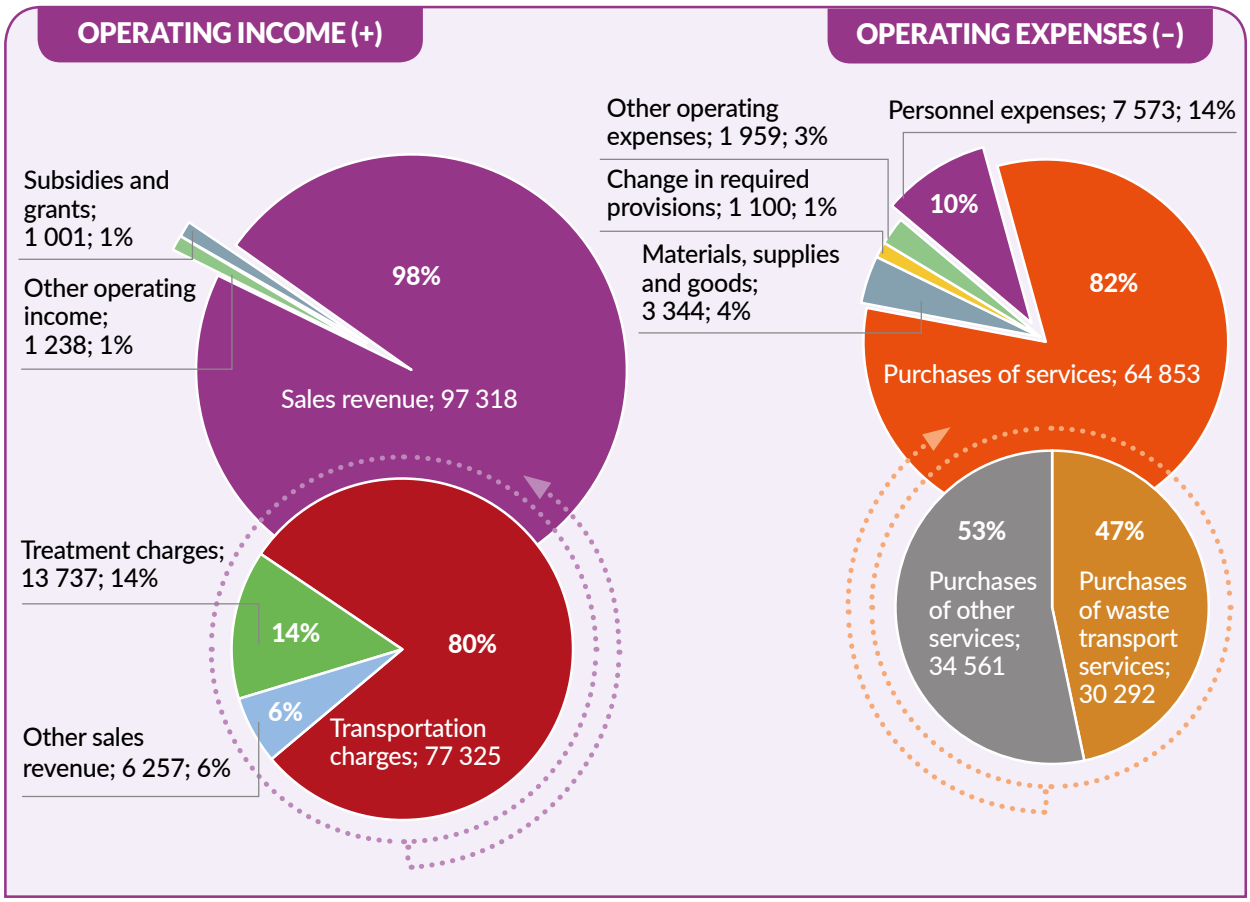


Figure 50. Finances of HSY waste management operations in 2019

There were in total 81,155 transportation agreements between HSY and transport companies (subcontractors) under HSY's waste management operations in 2019. Over 26,000 of those concerned the city of Helsinki, about 23,500 the city of Espoo, and about 22,000 the city of Vantaa. Part of those agreements concern block collection (Figure 51).

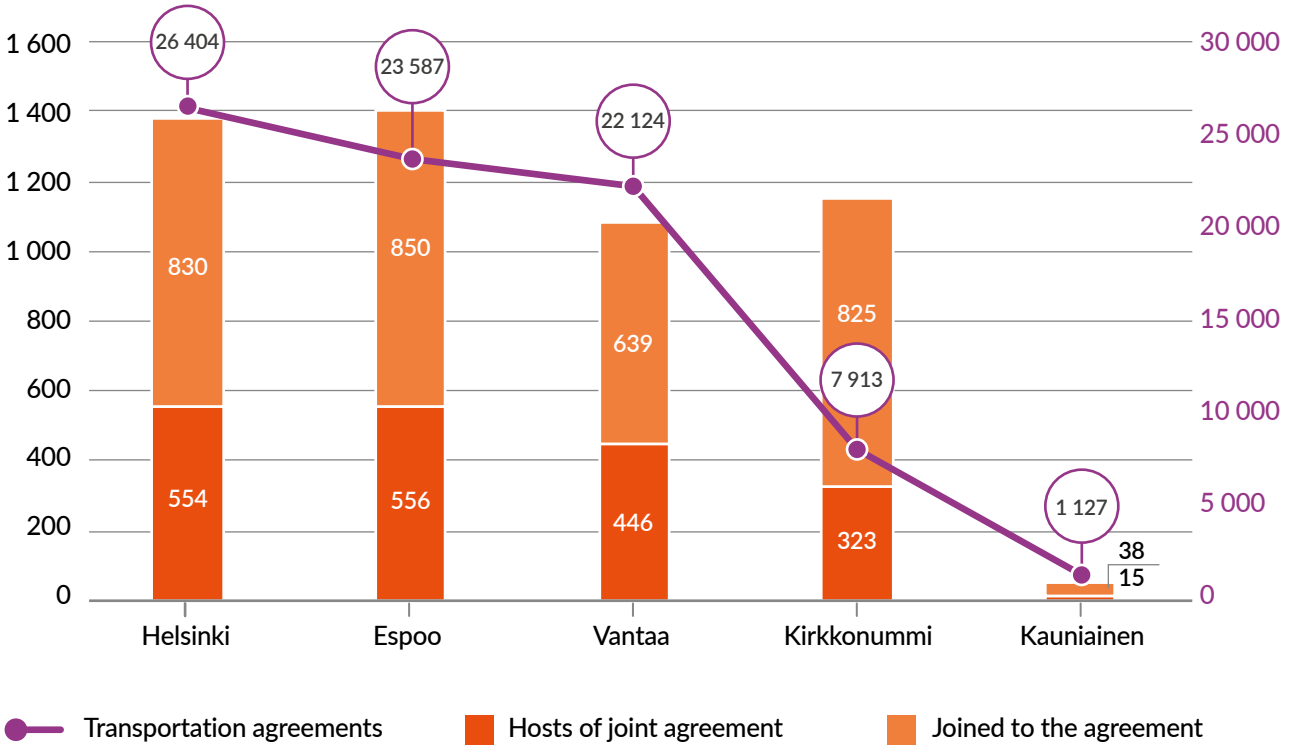


Figure 51. HSY transportation agreements by municipalities

There are about 140 waste trucks emptying waste from households in the HSY area. HSY tenders transport contracts for 5-year periods. HSY sets the requirement of using of non-fossil fuels in all tenders for waste transportation contracts.

In 2019, HSY organised waste transportation in collaboration with twelve subcontractors: Lassila & Tikanoja Plc., Remeo Ltd., Urbaser Ltd., Tapiolan Lämpö Ltd., Sihvari Ltd., Kuljetusliike Piharatamo Ltd., Grönfors Training Ltd., Tumik Ltd., Eerola Ltd., L&T Liete Ltd., Espoon KTK Ltd., Espoon Maansiirtopalvelu Ltd. (Figure 52).

HSY controls transport emissions through route planning, paying attention to the European emission standards of equipment and usage of fuel. The organization of multi-compartment collection can also decrease the need of transportation of waste and decrease GHG emissions. HSY has carried experiments with multi-compartment waste bins in small properties (For a more detailed description see INFOBOX 10) and started collecting packaging waste on properties with 5-9 apartments during 2021 (For more descriptions see Chapter 4.6.1.1.).

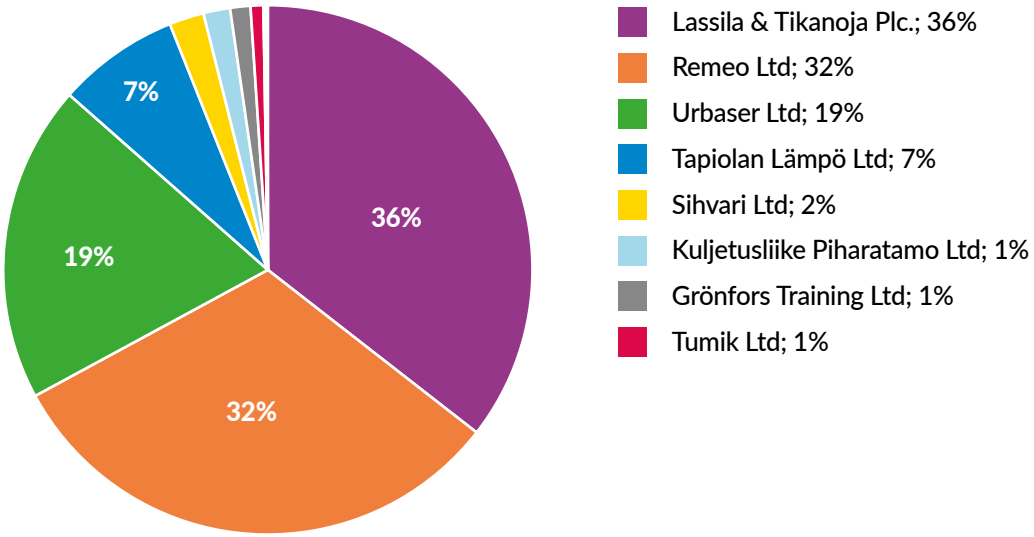


Figure 52. HSY waste transportation contractors' shares

4.10 Mechanical treatment of waste and waste fuel manufacturing

In Finland, municipal waste recycling has been almost entirely based on source separation by the waste holder e.g. in the housing properties and other sites. However, there are several mechanical sorting facilities in Finland that aim at increasing the recycling rate as well as cost-efficient production of waste fuel. The owners of mechanical sorting facilities can be MWMOs, city-owned companies or private companies.

Mechanical treatment such as crushing and screening aim to separate recyclable fractions from waste and modify waste for energy utilization. Mechanical sorting facilities usually treat construction and demolition waste and large-sized household waste. Mechanical sorting facilities are seen as an option to increase recycling rate. Furthermore, mechanical sorting facilities collect waste that is suitable for use as a waste fuel. In 2015 there were 300 waste fuel (REF = Recovered Fuel) mechanical manufacturing plants that use different types of waste for REF production. The waste is derived mainly from industry, construction, and municipalities. In waste fuel manufacturing are used e.g. construction demolition wood, packaging materials (plastic, cardboard and wood), twigs and stumps, and furniture, among other things. Waste fuels can be burned in co-incinerator plants, gasification plants or other waste plants.

In the following some examples of Finnish mechanical sorting plants are presented:

1. The mechanical sorting facility in the Riihimäki Circular economy village called *eco-refinery*, currently owned by Fortum Plc., handles 100,000 tons of mixed waste annually when operating at full capacity. The eco-refinery separates biowaste (approximately 30% of the waste), plastic (4%), metal (3%) and waste fuel suitable for industry (50%). The remaining amount is a reject that is not suitable for recovery is used for electricity and heat production at the waste incineration plants of Fortum in Riihimäki. With this facility, municipal waste recycling rates in the region increased as mixed waste is diverted to recycle metal, plastic and biowaste.
2. The mechanical separation plant LATE in the Kujala waste centre of the MWMO Salpakierto has a capacity of 65,000 tons/year. It separates cardboard, plastic and metal suitable for material recycling and further processing from mixed, energy, construction and industrial waste. The plant has in total 51 different devices and 14 different separation devices, including NIR (Near-infrared) spectroscopy. Non-recyclable waste goes through the MURRE crushing plant and is used for recycled fuel (SRF/RDF) production. In practice, only aggregate and other inorganic waste is directed for final disposal.
3. Oulun Energia, an energy company owned by the city of Oulu has recently launched a mechanical sorting plant in the Rusko waste centre area. It handles 100,000 tons of waste a year including packaging waste generated by trade

and industry, and construction and demolition waste. The waste sorting plant also receives demolition and construction waste generated by households.

In the sorting process recycled materials such as fibres, wood and metals are separated from the waste for recycling. Non-recyclable waste is utilized in producing high-quality SRF for the use of Oulu Energia's Laanila biopower plant that generates electricity, district heating and process steam from wood, SRF and peat. In addition, the sorting process generates combustible waste for the use of Oulun Energia's Laanila eco-power plant that produces steam and heat from mixed waste.

The waste sorting plant recycles a total of about 10–20% of the incoming waste, depending on the quality and demand of the materials. This percentage does not include energy production from waste.

4. The commercial waste management company Remeo Ltd. runs a recycling plant in Vantaa, which aim is to significantly promote the realization of the circular economy in Finland. The plant's annual treatment capacity is 120,000 tons of construction waste and 60,000 tons of energy waste generated by trade and industry. A significant part of these waste fractions was previously transported and treated outside the Helsinki Metropolitan Area or in Estonia. The recycling plant aims to increase the recycling rate in Finland and eliminate the need to export construction waste abroad. With the help of robotics and optical separation, the plant can efficiently sort metals, fibre materials, wood, as well as concrete and fine materials from CDW suitable for earthworks. The plant is able to handle more than 30 percent of the recyclable construction and other industrial and commercial waste in the Helsinki metropolitan area.

4.11 Biological treatment of waste

In Finland biowaste and wastewater sludges from municipalities and the industry are processed in biological treatment plants. In 2020, 186 composting plants were operational in Finland, most of which were windrow composting plants (Figure 53). Windrow composting is mainly used as a post-composting method of wastewater sludge. In recent years there has been a strong shift from composting to anaerobic digestion of biodegradable waste. Composting becomes a post-treatment of already digested waste. Most of the new biological treatment plants under design or in construction are biogas plants.

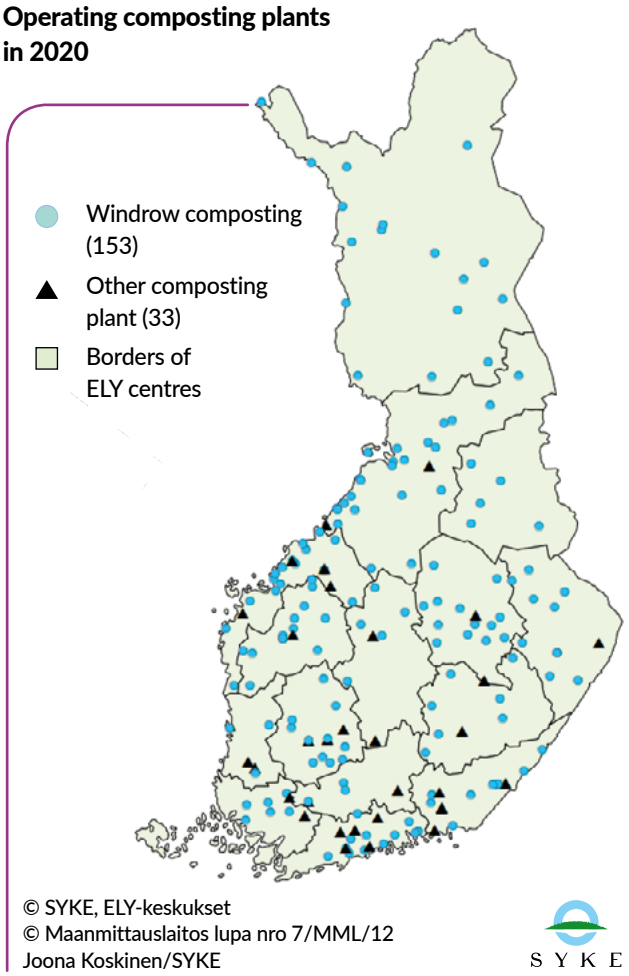


Figure 53. Operating composting plants in 2020

Composting and biogas plants are owned by municipalities, governmental companies, or private companies (including biogas plants in farms). There are also exceptional cases (e.g. Etelä-Savon Biohauki Ltd.), where local farmers and an energy company set up a joint venture to own and operate a biogas ecosystem.

In 2021, there were 78 biogas plants in Finland (Figure 54). Biogas plants can be divided into co-treatment plants, farm plants and wastewater sludge treatment plants. Co-treatment plants treat a variety of biowastes with agricultural manure and wastewater sludges. Farm plants deal with manure as well as other organic waste and by-products of agriculture.

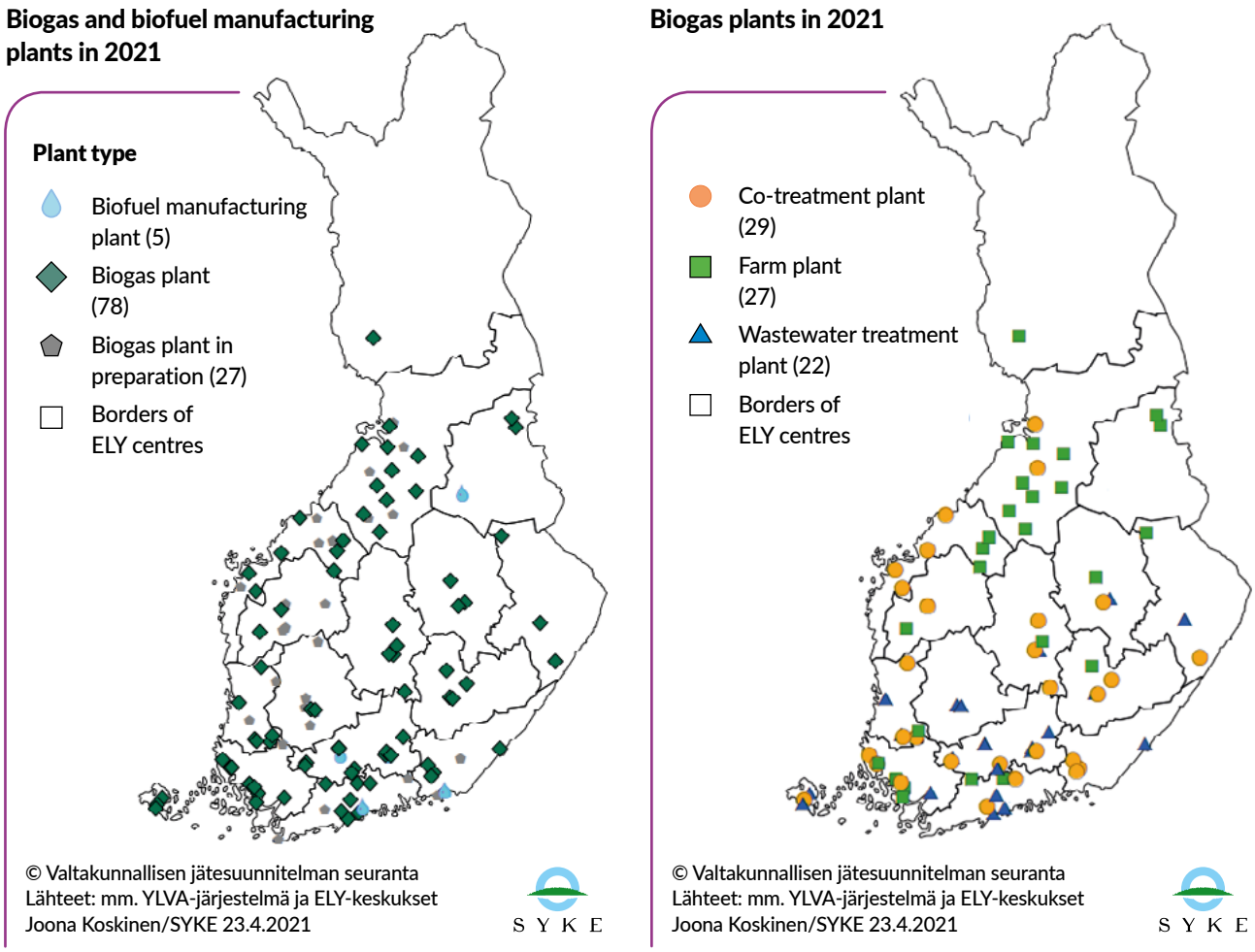


Figure 54. Biogas and biofuel manufacturing plants in 2021

In addition to the widely used wet digestion plant, dry digestion plants are becoming more common. Dry digestion differs from the traditional wet digestion plants as the process uses solid materials, which usually have a dry matter content of about 30%. In this case, the amount of wastewater from the plant requiring treatment is also lower.

In Finland, ethanol is made from biowaste to be used e.g. as transport fuel. There are several plants manufacturing biowaste ethanol in Finland (Figure 54). Plants use municipal biowaste or waste from the food industry to manufacture ethanol.

Ever tightening emission reduction targets have increased the interest of the industry, agriculture and transport sectors in biogas and biomethane, as well as boosting nutrient recycling. Both biogas production and demand have grown steadily in Finland and Europe. The biogas industry has potential in terms of raw material exploitation and biogas production.

New carbon neutrality targets, need for improving the national self-sufficiency of energy and nutrients, advancing the vitality of the regions and emission reduction targets for transport and agriculture create opportunities for biogas. The biogas sector should make a clear shift from waste management towards the production of energy and recycled nutrients. The low profitability of biogas production is challenging, as the end-product markets (energy and nutrient) are still developing.

It is estimated that in 2030 biogas production could be even up to 4-7 TWh. Production would be based specially on the utilization of by-products from agriculture, but also new technologies and feeds would have an important role (e.g. gasification). In 2035, biogas production could be 6-15 TWh. In 2030 there would be a need for biogas and biomethane of 4-11 TWh of which heavy vehicles could consume 2.5-4 TWh, passenger cars 0.5-1 TWh, buses 0.5 TWh, industry 0.5-4 TWh and ships 0.85-4 TWh of biomethane. 0.4-2 TWh of biogas would be used in heat and electricity generation.

Municipal biogas and composting plants are often situated in eco-industrial centres that are presented in the Chapter 4.12.

4.11.1 Case Kukkuroinmäki in South Karelia and biogas plant, EKJH

The Kukkuroinmäki waste treatment centre (waste centre) is located in in South Karelia about 17 km from the centre of Lappeenranta. The treatment centre receives waste from both households and businesses. The biogas plant at Kukkuroinmäki waste treatment centre, currently developing into industrial symbiosis, is owned by the MWMO EKJH (Figure 55). The plant was commissioned in 2020. The plant uses biowaste and wastewater sludge as feedstock. The produced biogas is upgraded to methane to be used as fuel.

The biogas plant project was a significant investment for the EKJH, which also helps owner municipalities to achieve their environmental goals. The project received a €2.2 million grant from the Ministry of Employment and the Economy of Finland for renewable energy production. The Kukkuroinmäki biogas plant is based on dry technology. The nutrient-containing liquid generated in the process is utilized in land improvement and industrial processes.

The processing capacity of the biogas plant is 19,900 tons, and it treats around 6,300 tons of biowaste and around 13,600 tons of wastewater sludge per year. The biogas plant produces about 2.05 million normal cubic meters (Nm^3) of biogas, 1.2-1.3 million Nm^3 of methane and 12,300 MWh of energy in a year.

Figure 55. The biogas plant at Kukkuroinmäki waste treatment centre

4.11.2 Case example: developing of the biogas ecosystem in the city of Oulu

The MWMO of the Oulu region Kiertokaari uses biogas as an energy source in its own operations and sells it to their industrial customers. In addition, they sell biogas as a transport fuel at their own distribution station. In 2020, altogether 2.7 million cubic meters of biogas collected by Kiertokaari from both landfills and biogas plant was utilized in Oulu, replacing 1.1 million litres of light fuel oil.

In total 1.9 million cubic meters of biogas was collected from the closed and currently used waste disposal areas of the Rusko Waste Centre. The recovery of biogas from landfills, calculated using the FOD (First Order Decay) method, prevented the release of gas into the air and the emission of about 12,900 tons of CO_2.

The development of the biogas ecosystem started already in 1997, when Kiertokaari started pumping biogas from the waste disposal area now known as Ruskotunturi (more information: INFOBOX 21). Since then, biogas has been utilized in the city of Oulu as an energy source for industry and for the needs of Kiertokaari.

In 1999, Kiertokaari built a biogas pipeline from the waste centre to the area of Oulu University Hospital. Biogas was used to produce steam for disinfecting hospital equipment in the hospital's own power plant. The central laundry of the city of Oulu (Oulun Keskuspesula Ltd.), located in the same block as the hospital, started to heat the water in the washing machines with steam. The laundry washes 30,000 pieces of textiles a day, including hospital laundry. The hospital's equipment maintenance stopped using biogas in 2017 but is now considering a return to biogas. The laundry moved to another location in Oulu, but it continues to utilize biogas as its main energy source.

Over the years, the gas collection network originating from the landfill bank has been expanded. Today, there are more than 10 km of gas collection pipelines, about 70 gas collection wells and two pumping stations.

In 2006, Kiertokaari has acquired a microturbine plant to generate electricity from biogas for the waste centre for their own needs, and sells the surplus

electricity to the grid. In addition, Kiertokaari utilizes waste heat generated in electricity production to the heat properties of Rusko Waste Centre.

In 2015, a company named Watrec Ltd. built a biogas plant at the Rusko Waste Centre on behalf of Biotehdas Ltd. Since then, Kiertokaari has purchased the treatment service of household and commercial biowaste treatment from this biogas plant, as well as the produced biogas (in 2020 – 0.8 million cubic meters). The biogas plant also treats solid fat waste separated from grease separation well waste at the Rusko Waste Centre's liquid waste treatment plant and liquid waste from milk processing operations. The digestate generated by the biogas plant is utilized as fertilizer for farms. Biotehdas Ltd. has sold the biogas plant to Gasum Ltd. a few years ago.

In 2017, Kiertokaari has invested in a gas processing plant and gas filling station. Kiertokaari processes transport fuel from biogas generated in the treatment of biowaste, which they sell at their own gas station. Kiertokaari was the first to open a biogas station in Oulu.

Since the restriction of landfilling of organic waste, adopted in 2016, the methane content of the gas generated in the landfill has been decreasing. The gas processing plant cleans landfill gas of the impurities, allowing Kiertokaari to use the gas for 10 years longer than would otherwise have been possible.

Starting from 2020, the city of Oulu's public transport uses four biogas buses. Kiertokaari has built a separate gas station for buses. Currently, Kiertokaari produces 93 % of the electricity needs of the Rusko Waste Centre from biogas and solar panels. In terms of heat production, Kiertokaari is completely self-sufficient utilizing heat generated in the production of electricity at the microturbine plant for heating of properties, and additionally uses biogas in their boiler.

4.12 Eco-industrial centres

Municipalities and MWMOs have an active role in helping the progress of the circular economy. Many MWMOs have developed their waste management centres into recycling centres and further into eco-industrial centres (also called eco-industrial parks). Eco-industrial centres contain different waste treatment and recycling facilities in a geographically limited area and waste streams, energy and materials circulate between MWMOs and companies. In this manner, the waste of one actor ends up as the raw material of another actor increasing recycling. The existing infrastructure worked as an important prerequisite for development of eco-industrial centres.

The new emerged eco-industrial centres work as service centres and cleantech areas providing many commercial opportunities and innovation platforms for different businesses. Eco-industrial centres provide added value to companies through e.g. savings in raw material, energy, waste management, production and logistics costs. In addition, co-operation can generate significant cost savings through joint procurements. The companies in the eco-industrial centres are also building joint research and development projects and cooperate with universities. There are around twenty larger eco-industrial centres in Finland.

4.12.1 Case HSY Ämmässuo and Ekomo

Ämmässuo eco-industry centre

The HSY's eco-industrial centre located in Ämmässuo, Espoo, is a modern touchpoint of waste management and the circular economy (Figure 56). Spanning about 200 hectares, the Ämmässuo eco-industrial centre offers services such as:

- treatment of biowaste into biogas and compost (See description in the Chapter 4.11.)
- treatment and utilisation of ash and slag from waste-to-energy plants (See description in the Chapter 4.13.)
- collection and utilisation of landfill gas
- treatment of contaminated soil
- sorting of various waste loads and
- delivering the materials for recycling.

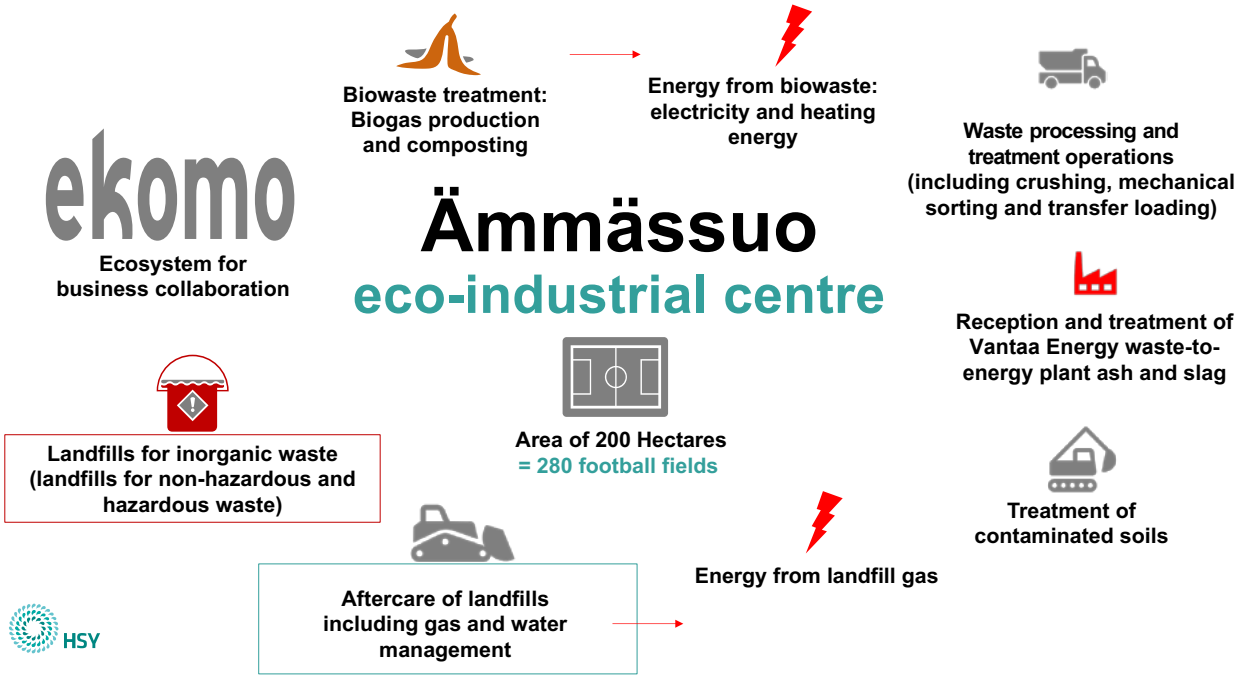


Figure 56. Ämmässuo eco-industrial centre according to HSY

The Ämmässuo eco-industry centre accepts waste loads transported by lorries or other large vehicles. Information of the quality, characteristics and origin of the waste in their possession as well as its suitability for landfill use should be provided by the customers of the centre upon delivery. A Waste Transportation Document is required for certain types of waste in accordance with the current legislation.

The Ämmässuo eco-industry centre charges a treatment fee that is determined by the weight, type and quality of the waste load. The waste load is assessed upon reception. If a load includes several different types of waste, the fee is determined based on the most expensive type of waste (Table 22). In addition, the eco-industry centre charges separate weighing fee that is about €20 per waste load.

Table 22. Examples of fees for reception of waste by Ämmässuo eco-industrial centre in 2021; [€]

Title	Description	Rate €/ton
Construction and demolition waste / Wood waste	Pallets and wooden packaging. Uncoated wood waste.	0
Construction and demolition waste / Coated wood		24.8
Construction and demolition waste (for reuse/recycle or final disposal)	Including pre-processed waste. Including waste containing more than 10% soil and rock material.	167.40- 223.20
Solid food waste	Fully biodegradable and technically suitable for the treatment process. Including packaged. No glass or metal containers. By-product class 3. From commerce and industry, industrial kitchens, restaurants. etc.	24.80-186.00
Mixed waste	Miscellaneous municipal waste. Waste for energy recovery or for final disposal.	167.40-248.00
Concrete under 150 mm Asphalt Bricks	Concrete waste that has been crushed to a grain size under 150 mm. May not contain structural steel or other construction waste. Concentrations of contaminants below the upper guide values specified in the Government Decree on the Assessment of Soil Contamination and Remediation Needs ("PIMA"-decree). Demolition waste from roads and similar asphalt structures. Must not be contaminated by petroleum products (e.g.. from fuel distribution stations, storage areas for petroleum products, etc.) and must not contain coal tar coating or other hazardous waste. Construction bricks resulting from the demolition of buildings.	31.00-62.00
Construction rock material	Reusable rock material, such as plastering and chiselling waste.	49.60-167.40
Stumps	Reusable / recyclable stump waste.	99.2
Impregnated wood	Impregnated wood, may not contain soil.	347.2
Soil and rock material	Excavated soil, which can be utilised as it is on a landfill or in construction. Including blasted rock. Concentrations of contaminants below the lower guide values of the "PIMA"- decree.	0.00-37.00
Soil and rock material. must be pre-processed	Soil and rock material (including liquid soil and rock material delivered by tank truck) that contains a maximum of 10% of other waste by volume. Includes invasive species mixed with soil. The price is determined based on the quality, volume and liquidity of the waste components. Concentrations of contaminants below the lower guide values of the "PIMA"-decree.	49.60-167.40
Contaminated soil that can be cleaned	Soil contaminated by contaminants that exceed the upper guide values of the "PIMA"-decree, and which has been excavated in connection with soil exchange or contaminated as a result of a sudden accident. Can be utilised after preliminary treatment and/or cleaning (removing contaminants). The rate is defined based on the quality and quantity of the waste components, as well as the quality and concentration of any contaminants. *If a recovery option cannot be assigned to soil purified by HSY at reception a landfill tax (€70 per ton) will be added to the prices.*	12.40-248.00
Waste containing asbestos	Final-disposal waste. Building material containing asbestos	254.2
Insulation wool Sandblasting sand Soil and rock material, final-disposal waste Glass	Glass and rock wool. Final-disposal waste. Used sandblasting sand. Final-disposal waste. Landfillability required. Soil and rock material that cannot be utilized but is landfillable. Glass for final disposal.	223.2
Gypsum	Clean and dry gypsum boards, no refuse sacks, slabs, wooden constructions or metal.	62
Invasive species	Invasive species populations. Loads that contain reproductive plant parts and soil. Containing soil: see waste title Soil and rock material, must be pre-processed. Any deliveries must be agreed in advance.	49.60-124.00
Leaves and garden waste	Leaves, grass, plant tops, chipped or unchipped brushwood and other biodegradable garden waste. Including untreated sawdust.	24.80-74.40
Brushwood	Tree branches and twigs. Including invasive species populations that do not contain reproductive plant parts (seed, roots, etc.). May contain soil and rock material.	37.20-74.40
Street cleaning waste	Grit swept from streets.	62.00-86.80
Animal faeces and bedding	Animal bedding as well as manure from horse stables that contains bedding.	12.40-49.60

In case of misbehaviour of the person bringing the waste, HSY can charge an additional fee of 55 €/ton that covers costs arising from e.g.

- unloading done by HSY including scraping of a frozen truck load;
- cleaning a littered passageway;
- delivery of an uncovered cargo that according to the legislation should be transported with a cover;
- transferring a load that has been emptied in the wrong place or other additional machine work;
- missing waste transportation document or incorrect waste type declaration.

Overall, in 2019 the Ämmässuo eco-industrial centre accepted 354,024 tons of waste, which are listed in the Figure 57 by type of treatment/allocation on the site.

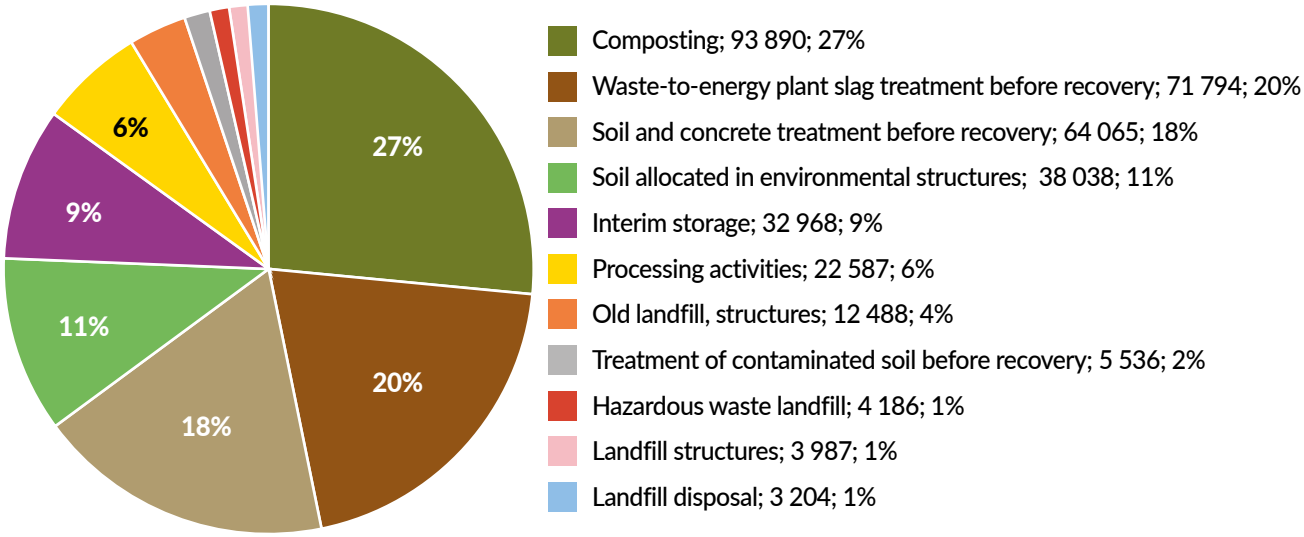


Figure 57. Quantities of waste received at HSY Ämmässuo by treatment / reception location in 2019

In 2019, HSY's Ämmässuo eco-industrial centre received 138,220 tons of recyclable waste, which is listed in the Figure 58.

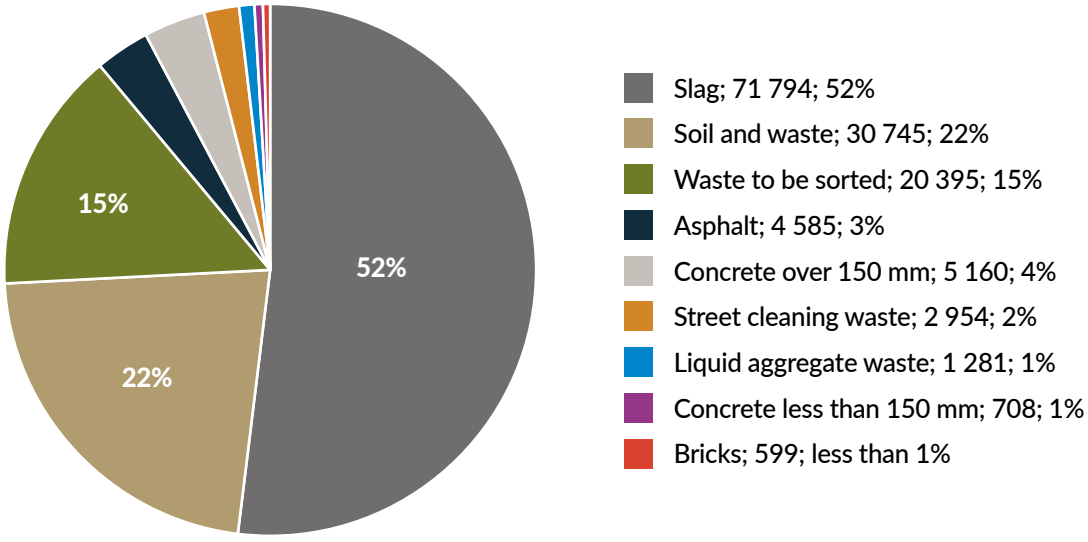


Figure 58. Recyclable waste received at Ämmässuo in 2019, [tons]

HSY's Ämmässuo eco-industrial centre site received in 2019 about 42,000 tons of biowaste via property-specific separate collection. In addition to this source, HSY also treats the biowaste of about additional 5,000 households and organic waste from the food industry, retail, restaurants and kitchens (annually 0-20,000 tons). Ämmässuo produces quality-controlled compost (annual amount about 15,000 tons) and biogas (annual amount is 5.5 million m^3) from treated biowaste.

Figure 59 presents the site for the treatment of organic waste in the MWMO HSY.

Figure 59. Organic waste management in the MWMO HSY (Source: Christoph Gareis. HSY; presentation on 26.8.2021)

In 2019 HSY's Ämmässuo eco-industrial centre received 3,204 tons of waste to be disposed, listed in the Figure 60. HSY also collects landfill gas from the landfill sites in Ämmässuo eco-industrial centre that is utilized in the production of electricity and heating energy.

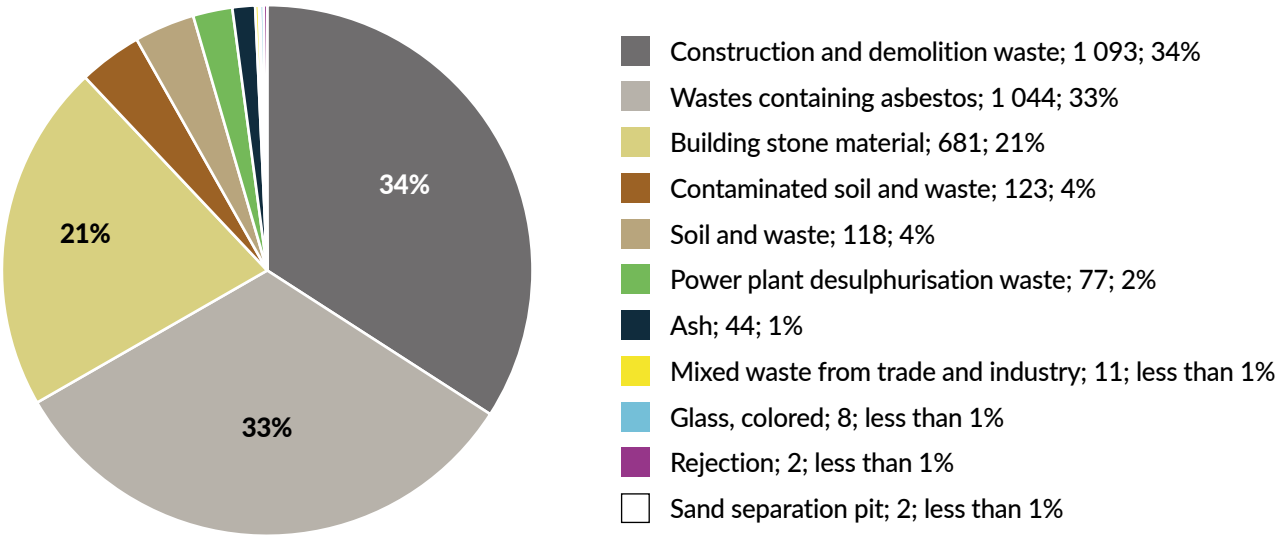


Figure 60. Waste to be disposed of received at Ämmässuo waste, 2019, [tons]

HSY studied the possibilities of utilization of slags and ashes produced as side products from the incineration process at the Vantaan Energy waste-to-energy/WTE plant and has prepared a market survey on ash treatment in 2020. Currently, all slag from the waste-to-energy plant is utilized in HSY's own or external construction objects, for example in the asphalted field area of a landfill extending area. In 2020 about 1.3 hectares of asphalted field was finalised. In addition, in the Cool4City project options for slag utilization also in the concrete elements of supportive walls were developed.

Ekomo

HSY is developing the **Ekomo ecosystem** aimed at business collaboration based on industrial symbiosis and resource efficiency goals of the region together with circular economy companies. HSY's goal is to create a diverse network of companies implementing the circular economy in the region, contributing to the development of new innovations by piloting, testing and processing e.g. industrial material and by-product streams and biowaste.

Ekomo activities are mainly carried out in the area of the Ämmässuo eco-industrial centre including material flows such as biomass, recycled concrete and aggregates, and construction and demolition waste (CDW) (See INFOBOX 18). In addition to Ämmässuo, Ekomo operations are also being developed at Kivikko (Helsinki) and Seutula (Vantaa).

INFOBOX 18: Examples of companies operating in Ekomo Ämmänsuo eco-industrial centre

Several companies operating in the Ekomo area, e.g.:

- the asphalt plant of NCC Industry Ltd. utilizes e.g. recycled asphalt and aggregate from quarries as raw material.
- Delete Demolition Ltd. handles demolition concrete and manufactures DeleKivi® recycled aggregate, the raw material of which is concrete and brick waste from building demolition or the concrete industry.
- Lassila & Tikanoja Plc. has a transshipment station that enhances the logistics of CDW as well as energy waste, cardboard and recycled wood.
- Fortum Plc. receives and temporarily stores horse litter and mixes sawdust or recycled wood chips into it. Fortum delivers biofuel called HorsePower for use in power plants.
- Remeo Ltd. has a transshipment station, which enhances the logistics of CDW and recycled wood.
- Companies that utilize compost can pick up compost produced at Ekomo in Ämmässuo and utilize it, for example, in their own soil production in the Helsinki metropolitan area.
- In 2021, HSY and Stena Recycling Ltd. started cooperation in Ekomo Ämmässuo eco-industrial centre. Stena rented 1.8 hectares of land for recycling operations. Stena will build a service unit in the area, where various metals, WEEE and ELVs will be received, processed and temporarily stored.

In 2020, Ekomo operators received 107,300 tons of various waste fractions in Ämmässuo for material and energy recover, which is almost double the number compared to 2019.

4.12.2 Case ECO3 concept and business area

** Text was prepared together with CEO of Verte Ltd. Sakari Ermala*

The aim of the ECO3 business area is to develop bio- and circular economy businesses and innovations on an industrial scale. A business area of 120 hectares is situated in the Pirkanmaa region and has currently 39 companies and cooperation partners. It has invited 80 million euros in investments and has an investment potential of 200 million euros.

The developed circular economy concept (ECO3) is based on mutually beneficial cooperation between the public sector, private organizations, and local inhabitants, thus comprising a powerful ecosystem. This circular economy's ecosystem produces resource efficiency and economic growth for the whole region in a very cost-efficient way.

ECO3 is a nationally significant competence platform that works as a competence centre, a demonstration and piloting environment. It was developed in collaboration with the city of Nokia and its platform operating company Verte Ltd. and dozens of company and university partners. One anchor company in the concept is the MWMO PJH.

ECO3 emphasizes an ecosystem-level solution-oriented approach from the point of view of a public organization, where public-private-people partnerships are at the core:

- The public sector has created a platform for private enterprises to develop new products and take care of the objectives that society has set.
- Inhabitants are "workers" in this systemic entity that insert source separated waste to the system, and the public sector provides raw materials for private companies.
- Private organizations participate in circular economy business ecosystems and work together with universities in the development of new products.

In this kind of collaboration, there are usually no conflicts of interests. Public waste management (MWMOs) can facilitate private business through several interfaces, for instance, material, data and different information sources, and waste management handling infrastructures, and provide overall management, which contributes to accelerating systemic change. At the same time, public waste management can handle material flows in such a way that the cost of materials recycled is kept to a minimum.

ECO3 currently has several cycles (Figure 61):

- Nutrient cycle which includes e.g. a biogas plant and ash granulation, processing and fertilizer production plant
- Wood cycle which includes e.g. a biomass terminal that offers a centralized area for lumber-based material distribution and refinement
- Energy cycle that includes e.g. biogas production and use of industrial, wood-based and wastewater treatment by-products to produce heat and biofuels
- Technical cycles for extending the life cycle and reuse of technical materials also using digital solutions. This cycle includes e.g. a waste treatment centre (waste centre), paper and plastic recycling plants and a WEEE plant

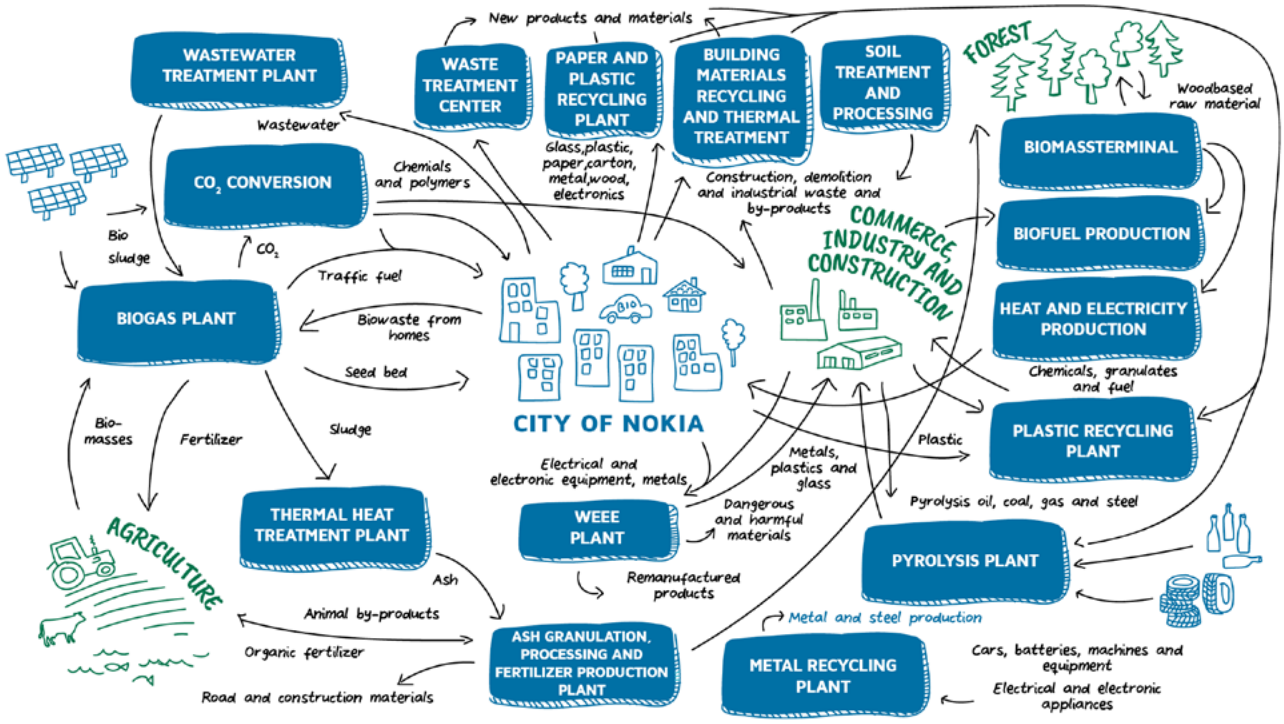


Figure 61. The ECO3 eco-industrial park (Source: ECO3)

ECO3 is continuously being developed and there are several on-going research projects to support potential further investment decisions and selection of advanced technologies for circular economy processes. ECO3 acts as an industrial scale testbed for data-driven businesses as well as other mutually benefitting businesses. For instance, options how to use process by-products such as heat, energy, water and nutrients are examined in innovative ways in a close collaboration with Tampere University.

ECO3 acts as an internationally recognized example of a collaborative, replicable, and scalable business model.

4.12.3 Case EcoSairila and the biogas ecosystem in Mikkeli

EcoSairila is a hub of regional material cycles that offers a full-service innovation ecosystem for companies that settle in the area. The companies in EcoSairila have access to a modern RDI infrastructure and educational organizations that support business activity and enable growth. In 2021, the EcoSairila area is home to the local MWMO Metsäsairila, biorefinery BioSairila Ltd., Mikkeli wastewater treatment plant Mikkelin vesilaitos Ltd., local energy company ESE Ltd. and PEAB Group, which is one of the largest construction companies in the Nordic countries.

The biorefinery in EcoSairila is one of three biogas plants in operation in the Mikkeli region (Juvan Bioson, BioHauki and BioSairila) that together form the local biogas ecosystem (Figure 62).

- Commissioned in 2020, BioSairila Ltd. is owned by the MWMO Metsäsairila and the local energy company ESE. It uses wastewater treatment plant sludge, biowaste from households and companies, garden waste, agricultural side streams as well as grass silage as a feedstock.
- Commissioned in 2016, BioHauki Ltd. is owned by ESE and local farmers, producing 700 tons of biomethane annually.
- The oldest biogas plant Juvan Bioson Ltd. was commissioned in 2011. It is owned by local farmers and produces 1,400 MWh of electricity annually and 2,000 MWh of heat.

The biogas produced in the Mikkeli region is distributed via three biogas filling stations.

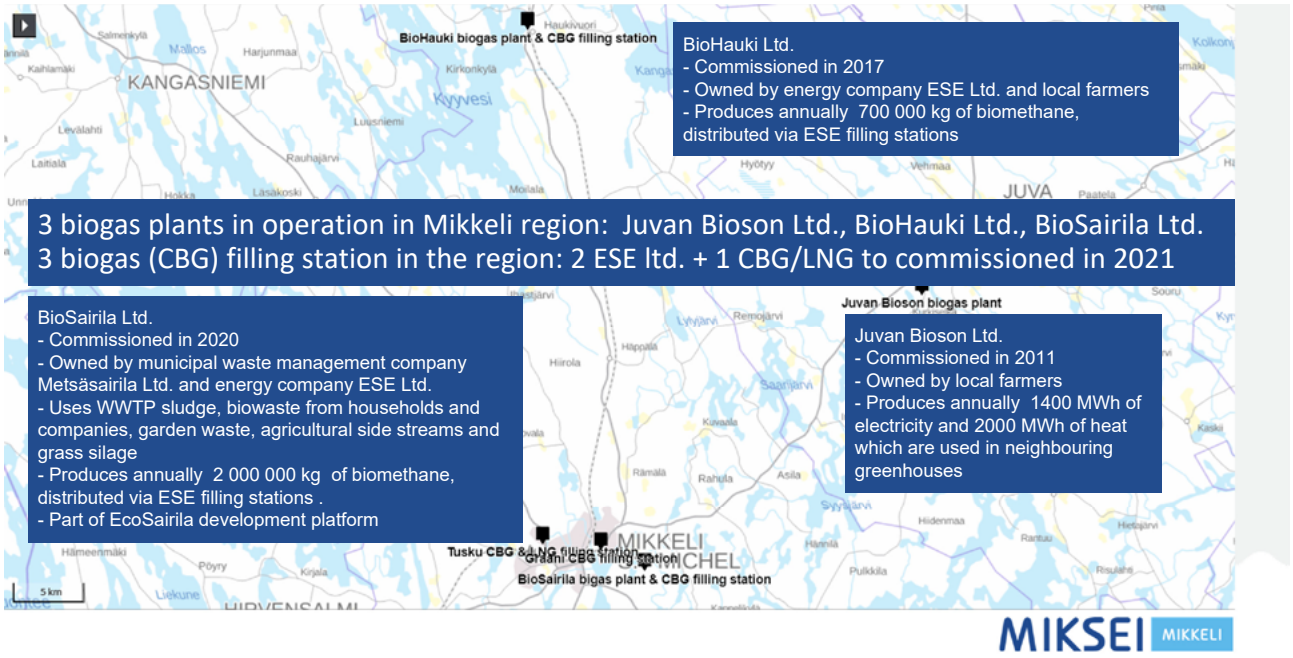


Figure 62. Biogas ecosystem in Mikkeli

All waste management operations in the Mikkeli region are concentrated in the area of Metsäsairila's sorting and recycling centre (waste centre). In 2020, Metsäsairila received a total of about 68,000 tons of waste.

Treatment types of waste collected by Metsäsairila:

- All mixed waste is transported to Leppävirta and Kotka for energy recovery in Riikinvoima Ltd. and Kotkan Energy Ltd. waste-to-energy plants. The shipping frequency is five days a week.
- Wood panels and clean wood are crushed at the sorting and recycling centre. After crushing, the materials are shipped out and used for energy production.
- Concrete and brick waste as well as glass are stored and crushed at the sorting and recycling centre. The crushed material is used at the centre as pavement for roads and lots.
- Metals and WEEE are stored temporarily at Metsäsairila's sorting and recycling centre and shipped out for reuse or recovery as raw materials.
- Paper and cardboard are baled at the sorting and recycling centre in the baling facility operated by Encore Ympäristöpalvelut Ltd. The materials are delivered to the paper industry for reuse.
- All separately collected biowaste and wastewater sludge from the city's wastewater treatment plant are processed at the biorefinery into biogas. The end product is composted at the sorting and recycling centre's composting plant and used to produce various types of soil for landscaping.

In February 2021, a new recyclable goods reception and sorting hall was built in the Mikkeli EcoSairila area, where inhabitants can deliver all surplus goods and materials from their households. The hall was built as a joint project between the MWMO Metsäsairila, Mikkeli regional development company Miksei Ltd. and Uutta Elämää Group (New Life Group). The project was named EcoSairila – a centre for recycling and green business. The sorting hall was named KIEPPI.

At the forefront of KIEPPI Hall activities, Uutta elämää Group accepts goods and materials suitable for recycle. The continuing life of any usable goods is prolonged at another branch of the association through manufacturing recycled products. Metsäsairila, on the other hand, is responsible for waste management of materials that cannot be reused as such on the other side of the hall.

The cooperation model promotes material recovery and encourages Uutta elämää Group employees to obtain more information about materials, among other things. KIEPPI has created a new recycling economy learning environment associated with the New Work and Expertise in the Circular Economy project (ESP). Further development of the operative model will be continued in the Cool4City project.

4.12.4 Case LHJ: Envitech Area and LHJ Group

The city of Forssa has a long industrial tradition. It made a strategical decision to focus on recycling and the circular economy by developing an Envitech Area that is an eco-industrial symbiosis situated in a zoned area of 255 hectares. Several companies operate in the Envitec area, as well as the MWMO LHJ that receives the municipal waste of 135,000 inhabitants. The area works as an important hub for the recycling of the glass, refrigerators and other electrical equipment. Contaminated soils, solid hazardous waste, construction waste and plastic waste are also processed and recycled here. The area also has biogas production facility that produces gas for industrial use. The area is developing to be carbon-neutral.

LHJ actively promotes material recycling and develops business activities. LHJ has established the LHJ Group that is concern consisting of the MWMO itself and several subsidiary companies that work at the Kiimassuo Waste centre, situated in the Envitech area. The companies provide services to households, companies and public administration units. The group operates nationwide and partly also internationally in the Nordic and Baltic region.

Companies that are part of LHJ Group:

Suomen Materiaalikierrätys Ltd. (Finnish Material Recycling Ltd.)

The company offers recycling solutions for all electrical and electronic equipment (excluding refrigeration equipment) as well as scrap metal recycling and sorting of secondary raw materials. The company also provides comprehensive waste management services to companies. The company is a wholly owned subsidiary of LHJ.

Suomen Erityisjäte Ltd. (Finnish Special Waste Ltd.)

The company is a pioneer in handling challenging materials in Finland. In addition to contaminated land and solid hazardous waste, the company has focused on developing waste power plant slag treatment operations in Finland and the surrounding areas. LHJ owns 51 % of this company.

Cool Finland Ltd.

The refrigeration equipment recycling company is a joint venture that is half-owned by LHJ. The company has strong technology expertise in the field. Cool Finland works closely with the LHJ Group.

Suomen Tietoturva Ltd. (Finnish Information Security Ltd.)

The company provides services of secure disposal of confidential materials (e.g. paper documents, archives, electronic devices and digital data) for companies and public administration. LHJ owns 51 % of this company.

Tarasten Kiertotalousalue Ltd. (Circular economy Area of Taraste) is an eco-industrial park in the Pirkanmaa Area. It is partly owned by LHJ subsidiary company **Suomen Erityisjäte Ltd. (Finnish Special Waste Ltd.)**.

4.12.5 Case Salpakierto and Kujala Waste centre

Since 2001, the MWMO Salpakierto has developed an effective waste management symbiosis at Kujala Waste Centre in Lahti that is the only waste treatment site of the MWMO. Kujala Waste Centre receives municipal and production waste. Its main activities are temporary storage, handling, utilization, transfer and final disposal. Kujala Waste Centre receives about 200,000 tons of waste annually and almost 100% of the waste received

is recovered. The share of municipal waste is about 85,000 tons per year.

The total area of Kujala Waste Centre is 70 ha. Approximately 5.3 hectares is reserved for recyclable waste reception and storage, 2.5 hectares for contaminated land treatment, about 5 hectares for a biogas and composting plant, 5.4 hectares for an existing landfill and 24 hectares for a decommissioned old landfill.

Salpakierto contributes to the developing of industrial symbiosis in the Kujala Waste Centre and attracts new companies to the area. For example, Tarpaper Recycling Finland Ltd. has a plant in the Kujala Waste Centre, where it receives, stores and processes roofing felt containing bitumen. The roofing felt is crushed into bitumen crumb, which is utilized as a substitute for bitumen in the asphalt industry, e.g. at NCC Industry Ltd.'s asphalt plant, also located in Kujala.

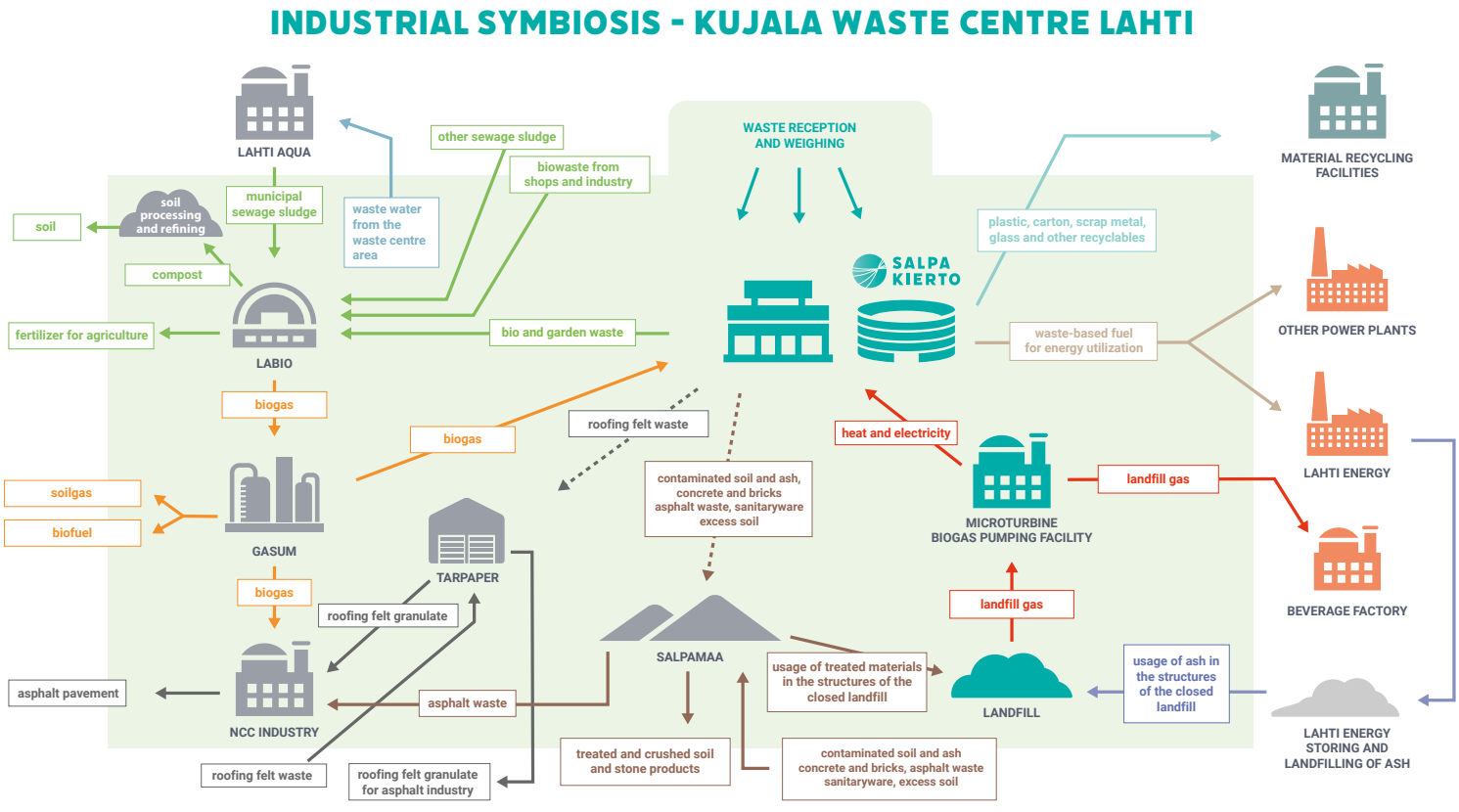
Two subsidiary companies of Salpakierto also work at Kujala Waste Centre:

- Salpamaa Ltd. that treats a variety of soil and aggregates, such as clean surplus soils, contaminated soil, asphalt, concrete, brick waste, sanitary ware and ash. Soils and aggregates are recycled as secondary raw materials or diverted for use in construction.
- Labio Ltd. treats municipal, commercial and industrial biowaste and wastewater sludge and produces biogas and compost products. Salpakierto owns 40 % of Labio Ltd., and the other owner is the regional water company Lahti Aqua Ltd. owned by the city of Lahti.

The private company Gasum Ltd. further processes the biogas produced by Labio Ltd. into fuel for gas cars and needs of NCC Industry Ltd. and for other plants and buildings in the Kujala Waste Centre.

Salpakierto has also built other treatment facilities in Kujala Waste Centre:

- Energy and wood waste crushing plant MURRE and mechanical waste sorting plant LATE (For more information see Chapter 4.10).
- OILI – liquid waste treatment plant that treats stormwater well sludges, wastewater sludges, oil and grease separation well sludges and industrial sludges.



Source: Salpakierto Ltd.

Figure 63. Kujala eco-industrial park (Source: MWMO Salpakierto)

Landfill gas has been recovered since 2002. About 70 % of the landfill gas is led to the Hartwall Ltd.'s soft drink factory, where it is used to produce steam for bottle washing. About 30% of the biogas is utilized at the Kujala Waste Centre, where it is used at microturbine plant to generate electricity and heat.

Important actors in the symbiosis are also the companies Kuusakoski Ltd., Stena Recycling Ltd. and Tramel Ltd., which handle materials that are cannot be efficiently treated by Salpakierto, like recycling of metal and electrical waste, for example.

A diagram of Kujala eco-industrial park and its waste streams is presented in the Figure 63.

4.13 Waste-to-energy

In Finland as well as in most of Western European countries waste-to-energy (waste incineration plant with energy recovery) plays a very significant role in municipal waste management. Waste-to-energy plants are usually CHP (combined heat and power) plants that can generate electricity and district heating. Waste-to-energy plants produce around 1% of Finland's electricity production and around 8-10% of district heating production, depending on the annual heating demand of properties and variations in winter weather. In addition to municipal mixed waste, waste-to-energy plants also incinerate industrial and construction waste. It is estimated that municipal mixed waste accounts for about 70% of the total capacity.

Finnish waste-to-energy plants are the most modern in Europe. In 2021, there are ten waste-to-energy power plants operating in Finland with a total capacity of approximately 1.9 Mt/a (Figure 64). One of the existing plants is currently expanding and is scheduled to be commissioned in Autumn 2022.

Energy recovery from waste in Finland: 10 Waste-to-Energy plants [in 2021]

Location:	Power plant:	Organization:	Capacity: (tons/year)
1. Vantaa	Vantaa Waste-to-Energy plant	Vantaa Energy Ltd	360 000
2. Riihimäki	Waste-to-Energy plant	Fortum Plc.	150 000
3. Riihimäki	Waste-to-Energy plant 2	Fortum Plc.	120 000
4. Kotka	Korkeakoski Power Station	Kotka Energy Ltd	100 000
5. Lahti	Kymijärvi II Gasification Power plant	Lahti Energy Ltd	250 000
6. Leppävirta	Riikinvoima Eco Power plant	Riikinvoima Ltd	145 000
7. Mustasaari	Westenergy Waste-to-Energy plant	Westenergy Ltd	190 000
8. Oulu	Laanila Eco Power plant	Oulu Energy Ltd	120 000
9. Tampere	Tammervoima Waste-to-Energy plant	Tammervoima Ltd	160 000
10. Salo	Korvenmäki's Waste-to-Energy plant	Lounavoima Ltd	120 000

Figure 64. Waste incineration plants in Finland according to the Finnish Solid Waste Association KIVO

Most of Finland's waste-to-energy plant capacity is under municipal control. There are several different models by which waste-to-energy plants are owned and operated:

1. There are four **municipal energy companies:**
   - Kotkan Energia
   - Lahti Energia
   - Oulun Energia
   - Vantaan Energia (city of Vantaa owns 60% and city of Helsinki 40%)
2. The biggest plant owner in Finland is the **government-controlled energy company** Fortum Plc. which also treats hazardous waste and generates energy from it. Fortum's largest owner is the Finnish state with a share of almost 51 percent.
3. The third form is a **joint venture of an MWMO and an energy company**, as is in the case of Tammervoima, Lounavoima.
4. The fourth form of plant ownership is **a joint venture of several MWMOs together or jointly with an energy company**:
   - Westenergy owned by six MWMOs
   - Riikinvoima owned by eight MWMOs and Varkauden Aluelämpö Ltd.

In addition, more than 20 conventional power plants have a license to co-incinerate waste derived fuels, like a variety of solid fuels prepared from municipal, construction and industrial waste (SRF= Solid Recovered Fuel; RDF = Reduce Derived Fuel; REF = Recovered fuel). Also, waste derived fuels can be co-fired in cement kilns. Today less than 10 plants are co-incinerating waste derived fuel. The emissions of co-incineration are strictly regulated. Regulations are based on the share of co-fired waste. For more information about the regulation and safety of energy production from waste, see INFOBOX 19.

INFOBOX 19: Safety of energy production from waste

The production of energy from waste is considered to be a safe practice as it is strictly regulated by legislation. Incineration is regulated by the Government Decree on Waste Incineration, which is based on the EUs Industrial Emissions Directive and the Best Available Techniques (BAT) Conclusions, which set strict emission limit values for dioxins and furans and set out monitoring requirements. Legislation, environmental permits and monitoring of their implementation ensure that the incineration plant does not cause harm to health and the environment. According to the environmental permit, an incineration plant is required to submit annual reports containing data on emissions to the supervisory authority (ELY Centre).

Emissions are measured directly at the incinerator from the chimney. In the Government Decree on Waste Incineration, the limit value for emissions of dioxins and furans is designated as the average value of one measurement (0.1 ng / m^3 I-TEQ). The limit value for dioxins and furans in wastewater from flue gas cleaning is 0.3 ng / l. These or more stringent emission limits are specified in the environmental permits of the incineration plant.

In practice, emissions from incineration plants are often significantly less than the limit values (by 10 times or more). Emissions of dioxins and furans from one incinerator are on average about 0.01 g per year, and at many incineration plants this figure is much lower.

BAT Conclusions on Waste Incineration are updated approximately every 10 years. After the publication of the new version of the conclusions, the environmental permits of incineration plants should be reviewed, and the necessary amendments should be made. If necessary, the incineration plant should improve technologies and monitoring systems. The BAT Conclusions published in 2019 already set stricter limits on dioxins and furans emissions: less than 0.01–0.06 ng WHO-TEQ / Nm^3 for new plants and less than 0.01–0.08 for existing plants (average value of one measurement).

Waste-to-energy production is responsible for only a fraction of Finland's total dioxin and furan emissions. Dioxins and furans are also formed during the combustion of other fuels (for example, coal), in industrial processes and in transport emissions. The formation of dioxins and furans is minimized primarily by controlling combustion processes, since the purification of flue gases has only a secondary effect. In addition to dioxins and furans, incineration plants control, among other, the emissions of solid particles, carbon monoxide, nitrogen oxides, sulfur oxide, total organic carbon, hydrogen chloride, hydrogen fluoride, and heavy metals. High standards of safety and monitoring, as well as the use of the latest technologies, allows locating incineration plants near residential areas without exposing residents to any risk.

4.13.1 Case Vantaa Energy waste-to-energy plant in the Helsinki metropolitan area

The waste-to-energy value chain in the Helsinki metropolitan area involves three main organisations – the local energy company **Vantaa Energy** (owned by the municipalities of Vantaa and Helsinki), the MWMO **HSY** (association of four municipalities – Helsinki, Vantaa, Espoo and Kirkkonummi; the population in this region is 1,2 million) and the MWMO **Rosk'n Roll** (owner municipalities are Lohja, Raasepori, Vihti, Hanko, Karkkila, Inkoo and Siuntio in Western Uusimaa and Porvoo, Sipoo, Loviisa, Pornainen and Askola in Eastern Uusimaa; the population in this region is 230,000).

The business model of the collaboration is quite simple and is based on three aspects (See visualization of the value chain in the Figure 65):

1. Waste collectors and carriers of the MWMO HSY and Rosk'n Roll pay the so-called gate fee to Vantaa Energy
2. Vantaa Energy sells the produced electricity to open markets via the national grid
3. Vantaa Energy sells district heating to properties connected to the Vantaa Energy's network

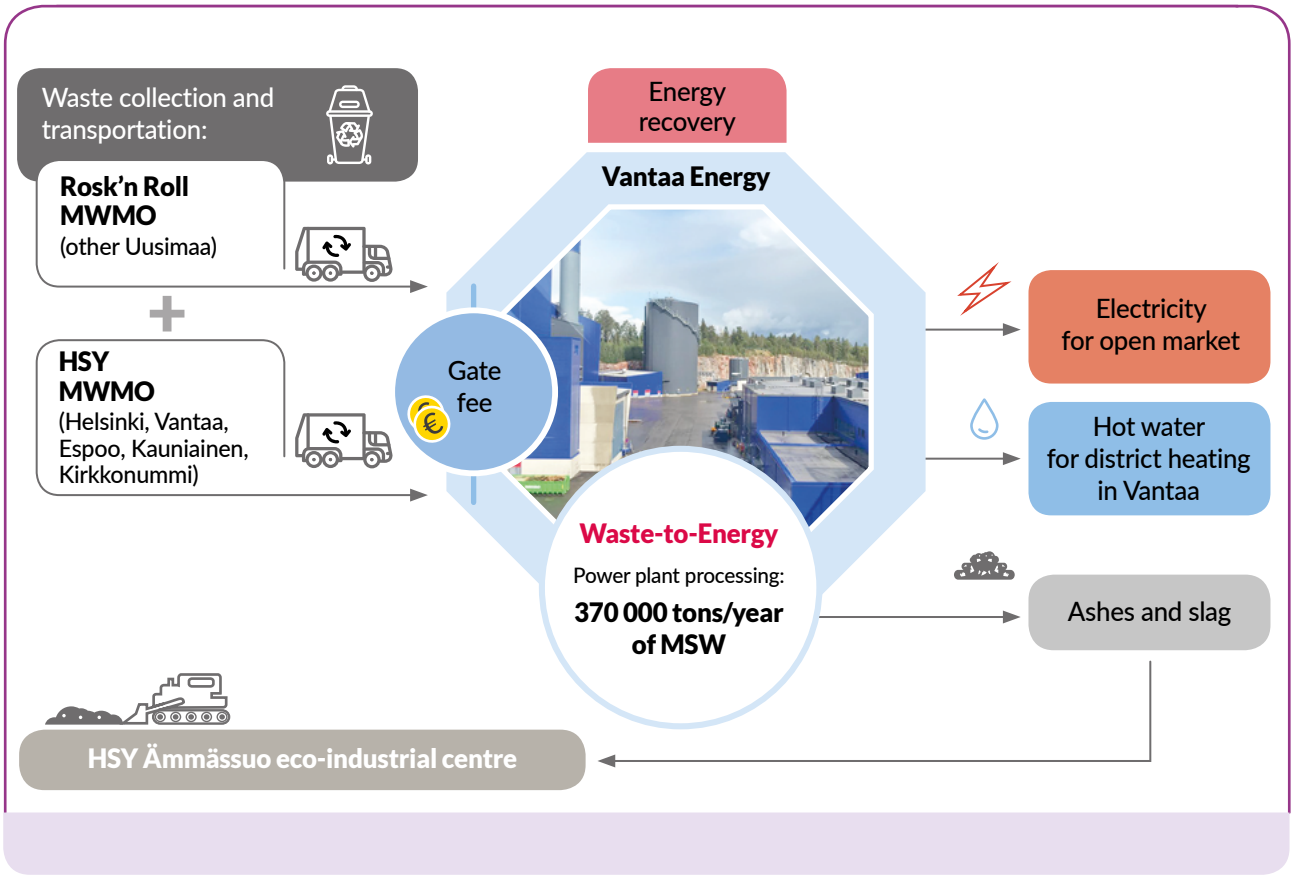


Figure 65. Waste-to-energy value chain case example: Vantaa Energy, Rosk'N'Roll, HSY

Vantaa Energy constantly works on ensuring that emissions to air and the adverse environmental effects they cause are kept to a minimum.

HSY takes samples of incinerator bottom ash, raw, untreated slag or treated slag from waste-to-energy plant at Ämmässuo eco-industrial park and prepares an annual basic or equivalence test report as required by the Waste Act. The analysis results and reports are submitted to Vantaa Energy. Four times a year a 3-month aggregate sample of raw slag is taken for analysis of dioxins and furans. Samples are collected according to the sampling instructions either from the stockpile or directly from the slag treatment process.

In 2020, 4,099 tons of ash and 70,125 tons of slag were received by HSY in Ämmässuo from the Vantaa Energy waste-to-energy plant. The ash from the plant goes though a stabilization process and is disposed of in a hazardous waste landfill. Metals are separated from the slag by screening with magnets, eddy current separators and manual sorting and goes to metal

manufactures. The remaining mineral material is utilized in construction and landfill structures.

The agreement between HSY and Vantaa Energy stipulates that fly ash, boiler ash and incinerator bottom ash are the responsibility of HSY, so this does not require any payments. HSY transports IBA from the Vantaa Energy plant to the Ämmässuo site.

4.13.2 Case Tammervoima in Pirkanmaa region

The Tammervoima waste-to-energy plant is a joint venture of the MWMO PJH and energy company Tampereen Sähkölaitos Ltd. owned by the city of Tampere. The waste-to-energy plant is situated in the area of an old landfill around 15 km from Tampere city centre. The waste-to-energy plant receives a total of 170,000 tons of mixed waste per year from about 650,000 inhabitants: 450,000 inhabitans from the Pirkanmaa region and 200,000 inhabitans from other regions in Finland. The plant produces 430 GWh of district heat and 40 GWh of electricity, and around 12 % of the energy consumed by the city. The waste-to-energy plant uses grate technology that is proven to be energy efficient and reliable. The efficiency of Tammervoima is 95% and the operating hours comprise over 8,300 hours/year.

The plant is highly automated: it has only 20 employees; on weekends and at night only two operators are responsible for the production of the entire plant. The plant is able to regulate the production of both electricity and district heating. For example, if the price of electricity is affordable, it can drive all the steam into heat, because there is enough demand for district heating even in the summer.

The plant works on minimizing the amount of disposable waste after the incineration process. It is especially important to develop a bottom ash recycling system because valuable metals can be recovered, and minerals can be recycled as well. Only 6,000 tons or 3.5 % of the incoming waste end up in landfills as flue gas cleaning waste. New technologies are being developed that makes the recycling of fly ash possible in the future.

The waste-to-energy plant is safe for the environment. The activity of Tammervoima is well supervised and pollutants cannot enter the environment. The plant provides monthly reports on the operation of the plant and an annual summary for the local environmental authority and undergoes annual inspections. The plant's emissions are monitored in real time, and if emissions are exceeded, the plant can be shut down in four hours.

Through good cooperation, the MWMO and the energy company have developed an efficient power plant solution, organized operations in a cost-effective way, and managed to reduce CO_2 emissions.

PJH and Tammervoima provide services clearly below the market prices. Thanks to the municipal waste-to-energy plant, waste charges in Pirkanmaa region have decreased by 20 % and are currently the lowest in Finland. The price of district heating has been very stable already in ten years' time. Similarly, the energy company Tampereen Sähkölaitos Ltd. buys energy from the waste-to-plant that is clearly cheaper than the market price. As municipally owned, the waste-to-energy plant does not aim at making a profit, and possible benefits are transferred to the owner organizations and are used for development of operation.

Energy production from waste provides cost-effective alternative to landfilling, as the gate fee is lower than the landfill tax in Finland (€70 per ton). Compared to the landfill solution, the regional benefit of waste incineration provides annual savings of 20 million euros. However, increasing of incinerated volumes is not a priority; by contrast, PJH makes efforts to increase sorting at the place of origin and not to increase capacity, for example by recycling plastics, metal, and glass. The recycling rate in the Pirkanmaa region has risen by almost 10% in five years, as residents' enthusiasm for sorting has increased. Waste incineration has replaced fossil fuels and reduced emissions from the region's energy production. At the same time, more efficient recycling (e.g. plastic recycling) can further reduce CO_2 emissions.

4.14 Landfilling of waste

Landfills are the final disposal site for different types of waste. A landfill is classified as 1) a landfill for hazardous waste; 2) non-hazardous waste; or 3) inert waste. In 2020 there were 419 operational landfills in Finland that include landfills of non-hazardous (99), hazardous (27) and inert waste (7), as well as landfills for soil and mining waste (Figure 66). Most of the waste placed in landfill sites was a different kind of mineral waste. Over half (235) of landfills in operation are landfills for soil and 64 were for mining waste. More than half of the landfills are maintained by public bodies, the rest are private landfills for industrial and mining waste.

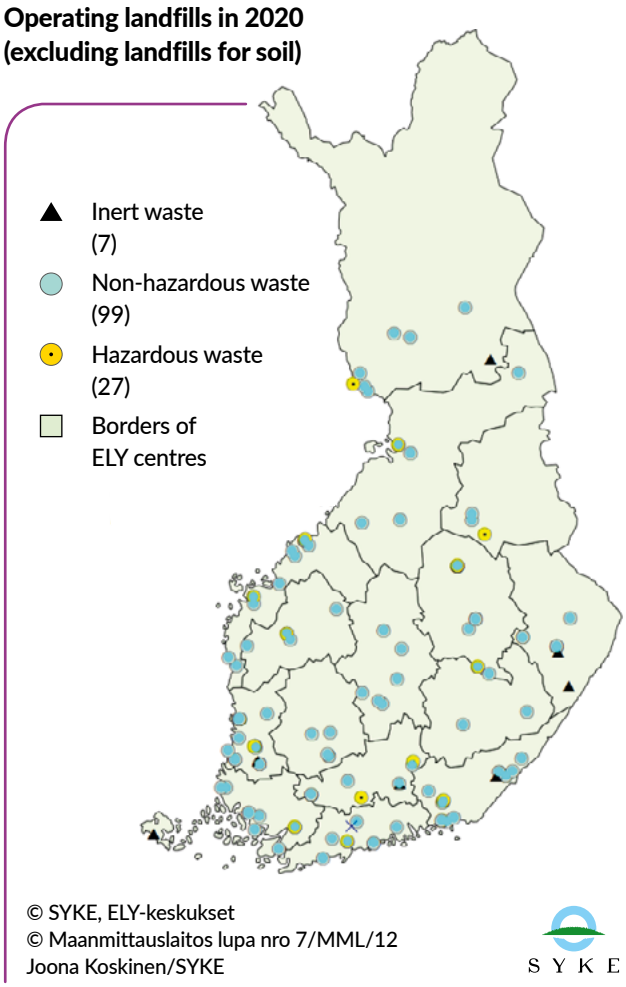


Figure 66. Operating landfills in 2020 (excluding landfills for soil)

Landfill gas was collected from 33 landfills in 2021. The most common method of exploitation of gas collected from landfills is heat production. In some plants the gas is utilized in combined heat and electricity production. Limiting landfilling of biodegradable and other organic waste substantially reduces landfill gas formation and may reduce the need to establish new landfill gas pumping stations.

Landfill disposal of municipal waste is possible only in exceptional cases, and currently only 0.5 per cent of MSW is landfilled in Finland. The materials deposited in landfills primarily include aggregate, asbestos, other fine particles (e.g. ash) and non-combustible waste. Still, there is need for landfills for hazardous and inert waste, so complete denial of waste disposal is yet not possible.

4.14.1 General requirements and control measures

4.14.1.1 Waste legislation and permits concerning landfilling

The Government Decree on landfills (331/2013) restricts the placement of organic waste in landfills. According to it, waste generated in housing and similar waste from industrial, service and other activities in terms of its characteristics and composition shall not be placed in a landfill of non-hazardous waste, if most of the biodegradable waste has not been separated from other waste for recovery purposes. The Government Decree also restricts placing waste to landfills of inert and hazardous waste, based on the concentration of the organic matter they contain. In certain situations, the licensing authority may grant exemptions from restrictions. Landfills for soil are not covered by the Government Decree on landfills.

Other legislation also has acts to be taken into account e.g. the Waste Act and the Waste Decree.

Waste tax

The waste tax is levied on all waste deposited in landfills, provided that its recovery is environmentally justifiable and technically feasible and that it can be made more commercially exploitable by imposing the tax. Waste types subject to the tax are given in the Annex of the Waste Tax Act (1126/2010).

The waste tax is subjected to all the landfills where taxable waste is deposited. The taxable landfill excludes storage of waste lasting under three years, waste recovery and waste composting areas and soil landfilling areas. The waste tax has been €70/ton of waste since 2016.

Waste types exempt from waste tax are wastes with no technical treatment or recovery options and also wastes causing more harm than good if recovered, e.g. waste generated by inorganic chemical processes and mineral waste. Hazardous waste deposited in landfills and waste used in landfill structures with permission are also tax exempt. The waste materials used in landfill structures are e.g., soil and stone material, crushed concrete, mildly contaminated soil, treated sludge from wastewater treatment plants, construction waste material containing stone material, and crushed asphalt.

Landfill operators liable for the tax must register with the Tax Administration. The waste tax is imposed based on the mass of the waste and is the same regardless of the quality of the waste.

Environmental permits

The Government Decree on substances hazardous and harmful to the aquatic environment (1022/2006) may cause the need to monitor the emissions of the substances specified in the regulation. Activities, such as professional waste management (e.g. landfill construction), that pose a risk of environmental pollution should have environmental permits. The Regional State Administrative Agencies issue environmental permits also for landfills in addition to major waste treatment facilities, such as large-scale waste recovery and final treatment plants that treat non-hazardous waste, waste incineration plants, hazardous waste treatment plants.

If the planned activity may have significant negative effects on the environment, the environmental permit application needs to have a separate environmental impact assessment. For instance, landfills of hazardous waste with an annual amount of waste of at least 5,000 tons always require an environmental impact assessment as an annex to the environmental permit.

4.14.1.2 Landfill categories and waste to be approved for different landfills

A landfill is classified as a landfill for hazardous waste, non-hazardous waste or inert waste**.** Only waste of those specific classes is accepted for the landfill. Normal household waste is placed in the **landfills of non-hazardous waste**. To **inert waste landfills** are placed the waste that does not biodegrade, dissolve, burn or biologically, physically, chemically react to other substances causing danger. Such waste includes glass, concrete, bricks, ceramics, soil and stone materials. **Hazardous waste landfills** have waste which due to its chemical or other properties may pose a risk to the environment or health. These include the following types of waste:

- substances and products which may explode under the influence of flame
- flammable substances
- oxidising agents
- substances harmful and irritant to health
- toxic and carcinogenic substances
- corrosive substances
- substances and products hazardous to the environment
- wastes which may generate harmful fluids

General assessment requirements

For the assessment of waste landfill eligibility, a three-level procedure shall be applied, divided into the following steps:

1. a basic definition of waste which, using standardized methods, ascertains the characteristics of waste sufficiently to demonstrate that the waste meets the requirements for landfill defined for each category, and that the placement of waste to landfill is safe even in the long term;
2. waste equivalence testing where standardized short-duration methods regularly measure the typical characteristics of waste identified in the basic definition to ensure that the waste meets the authorization provisions;
3. a waste inspection at the landfill to ensure that the waste corresponds to the documents presented.

The assessment of landfill eligibility shall be based on reliable data of the origin and characteristics of the waste. Assessment criteria for the characteristics include:

1. the composition of the waste;
2. the quantity and degradability of the organic matter in the waste;
3. the quantity and solubility characteristics of the harmful substances in waste;
4. ecotoxicological characteristics of the waste and the resulting landfill water.

Furthermore, the assessment shall be based on the following information on landfill:

1. the characteristics and quality of the landfill site and the protection of its environment;
2. the quality level of environmental protection arrangements and their ensuring;
3. stability of waste filling and its ensuring;
4. preventing hazards that threaten human health.

4.14.2 Establishment of the landfill

When planning a landfill area, one must first find a suitable location for it. The Government Decree on Landfills, the Environmental Protection Act and the Waste Act provide location restrictions and guidelines that must be taken into account in the planning.

The landfill shall not be located in areas classified by the Centre for Economic Development, Transport and the Environment as important groundwater areas

or groundwater areas suitable for other water supply, unless it can be ensured that the groundwater quality of these areas does not suffer. In addition, the landfill shall not be located in areas where the movement of soil could cause damage to structures in the future or harm the aftercare of the landfill (e.g. areas with soft soil, marshlands and areas where there is the possibility of landslides or flooding).

Areas such as protected areas for natural and landscape values, as well as areas protected for the preservation of national cultural heritage or natural heritage, also restrict the location of the landfill area. The selection of the area must also take into account sufficient distance from settlement and urban areas. In addition, the landfill must be suitable for the environment or landscape.

The landfill regulations define the requirements and thicknesses of structures (For more information see INFOBOX 20). Based on the classification of the landfill, its intended use and general instructions, the structures of each landfill must be designed on a case-by-case basis. General structural differences per category of landfill are that the ground structure of a hazardous waste landfill is thicker, no artificial insulating layer is required for a landfill of non-hazardous waste and the need for a gas collection layer in a hazardous waste landfill depends on the characteristics of the waste to be placed on the site.

INFOBOX 20: Foundation and surface structures of the landfill

1. Requirements for sealing of foundation structures

The landfill soil (mineral soil or rock) shall meet the water permeability and thickness requirements of the water saturated soil. They are different for each landfill type, and they can be found in the Government Decree.

2. Layers of surface structures

Layer	Non-hazardous waste landfill	Hazardous waste landfill
Top layer ≥ 1 m	Required	Required
Drainage layer ≥ 0.5 m	Required	Required
Sealing layer ≥ 0.5 m	Required	Required
Artificial insulation	Not Required	Required
Gas Collection Layer	Required	When needed

4.14.3 Control and monitoring of the landfill sites

**the chapter is written by the Centre for Economic Development, Transport and the Environment (ELY centre) of Southeast Finland*

Landfill sites are inspected every one to three years using a risk-based control plan. The site's risk classification, that is, the control frequency, may be changed if deficiencies are observed during the inspection. However, if the site has been managed particularly well, the risk classification may be lowered by one. The inspections carry a fee which is determined in accordance with the decree on chargeable fees and depends on the size of the site. The fees are used to pay for the resources required for control.

During scheduled regular inspections, the site's environmental permit or permits are reviewed, the operations are checked to ensure their continued compliance with the permit, and a review is carried out to determine whether any disturbances have occurred in operations, or any public complaints have been filed concerning the operations. The operator also gets the opportunity to discuss topical matters. If required, the supervisor provides guidance in questions concerning permits and control.

The regular inspection includes a review of documents, including surveillance reports, previous memoranda and any recommendations or requests. During the tour of the site, attention is focused on, for example, general tidiness, the integrity of structures and the water treatment and diversion structures, as well as the storage of chemicals and liquid fuels. The

site's filling is monitored to ensure that it remains within the limits defined in the permit and that open surfaces are not excessive. If changes occur in operations, an amendment must be sought for the permit. Under law, changes must be notified in advance to ensure that any need for permit amendments can be assessed.

A memorandum is drawn up of the inspection, detailing the matters reviewed, as well as any corrective measures and the schedule for implementing them. The operator may be required to carry out measures or conduct surveys to ensure that the matter to be rectified complies with the permit or legislation or to obtain enough information indicating that the matter has been taken care of. If a deficiency has not been rectified by the deadline, the operator will be served a request, which will ultimately lead to a fine or a notice of enforced compliance if the operator still fails to rectify the matter. In cases that have caused or may have caused environmental pollution or a risk of it, a request for investigation will be filed with the police.

In addition to regular inspections, the supervisor reviews the annual report, which is submitted once a year and includes a summary of, for example, the water monitoring results (emissions and impact monitoring), the amount and types of incoming, treated, disposed and delivered waste, as well as any other results, such as those of odour control. Monitoring is carried out in accordance with the provisions in the environmental permit, and the supervisor ensures that the appropriate reports on operations have been filed and that the amounts remain within the limits specified in the permit. The monitoring provisions usually indicate the frequency of monitoring, measurement methods and the assessment and delivery of results. Limits may also be specified in the provisions. The inspection of annual reports also carries a fee which is based on the decree on chargeable fees and depends on the size of the site.

Water monitoring follows concentrations in outgoing water, as well as loading and long-term results, which makes it easier to detect any deviations. If the site has its own water treatment system, the results can be used to examine its purification efficiency. If water is let out into the surroundings, results from above and below the landfill site are compared to assess the impacts on waterways. As for groundwater, comparisons are made between higher and lower points in the direction of the flow. Results of water monitoring within the landfill site can be used to follow the stage of waste decomposition. Observations of the storage situation help ensure that the site's receiving and processing capacity has been properly planned and that the received, processed and stored volumes remain within the limits specified in the environmental permit. The effective capacity and elevation of the landfill are monitored to ensure compliance with the limits specified in the permit. The reported waste and emissions data are public.

Operators are required to be aware of the environmental impacts of their operations and of ways to reduce adverse effects. In addition to the inspections carried out by the authorities, landfill sites conduct their own inspections in accordance with their self-monitoring plan, which can include, for example, settlement measurements, audits of accounting and waste types, as well as the recording of personnel training. A separate filling plan must also be made for the landfill site, and operations must be carried out according to it. The filling plan presents a schedule and the order and method of filling, covering and compacting the site. It also details the locations of road connections and areas at different stages of the filling process. Various environmental management systems may also require different forms of control and monitoring methods.

4.14.3.1 Case MWMO Kymenlaakson Jäte

**the chapter is written by the Centre for Economic Development, Transport and the Environment (ELY centre) of Southeast Finland*

Kymenlaakson Jäte is a MWMO in Southeast Finland. The municipally owned company handles statutory household waste management services on behalf of its owner municipalities and also provides services to businesses. The waste management facility receives and processes waste, allocates waste for recovery and safely deposits the remaining waste. In addition to a landfill, the facility includes a plant for treating liquid waste, a plant for sorting construction waste and a dry digestion plant.

In accordance with its environmental permit, the facility receives and processes, for example, household waste, industrial waste, spoils, biowaste, energy waste, oil damaged soil, bottom sludge, and asphalt and concrete waste. The premises have been divided into different areas, used for different operations, to keep waste processing and storage under control and prevent different types of waste from being mixed.

The waste arrives at the facility through the weighing station. Upon receipt, the waste transfer document and waste type are inspected to ensure

that the facility is allowed to accept the waste. The waste code, as specified in the Waste Decree, is transferred to accounting at this stage, in addition to information about the sender, weight and type of waste. If required, the owner of the waste must present separate documentation demonstrating that the waste is suitable for the landfill. Waste accounting is kept up to date to ensure that the facility can provide the latest information about, for example, stored and disposed waste, including the waste types. Accounting is based on a national set of codes.

At the waste treatment facility, part of the waste is pre-treated prior to its use for recovery or landfilling. The goal is to minimize the amount of waste ending up in the landfill. Each stage is carried out under careful control, minimizing environmental emissions. To prevent emissions, pre-treatment is carried out in a hall, the treatment areas are coated, and daily cover is applied in the landfill. Access routes and storage areas are kept clean and the storage periods as short as possible, to reduce dust as well as the presence of pests.

Testing of waste deposited in the landfill of non-hazardous waste

A basic characterization must be made of all waste deposited in the landfill. This must be made for each waste batch. A basic characterization must also be carried out for regularly generated waste before the first batch is accepted for deposit in the landfill. The waste must also be tested to obtain information about the composition and solubility properties, as required for the basic characterization.

In addition to the basic characterization, the MWMO submits samples of individual batches for laboratory analyses. These are usually taken from components of waste to be deposited in the landfill of non-hazardous waste. Samples are taken twice a year. These batch-specific samples are taken from pre-sorted waste, landfill waste delivered to municipal waste stations and fines resulting from the facility's own pre-treatment.

The materials landfilled by Kymenlaakson Jäte are listed in the Table 23.

Table 23. List of waste deposited in the landfill, from the 2020 annual report of Kymenlaakson Jäte

- Glass (used in landfill structures)
- Insulation wool
- Mixed municipal waste
- Waste from municipalities, the type of which is not mentioned elsewhere
- Sorting fines and windsifter fines (in sorting, e.g. wood waste, energy waste, demolition waste to be sorted, fractions for special treatment)
- International food waste (more than 10% of organic matter) *
- Produce from own compost facility for intermediate cover
- Waste from pre-sorting (more than 10% of organic matter) in accordance with exemption
- Asbestos waste
- Soil (degraded), oil-damaged compost soil
- Bricks and concrete
- Non-marketable products
- Wet ash

The company also receives fire waste, which is sorted before final deposit.

* Note! It is not possible to deliver international food waste to a biogas or composting plant

Observations

The site's waters are fed through sedimentation basins to the facility's own biological wastewater treatment plant. After treatment, the waters are discharged into the municipal sewer system. Samples can be taken from all the waters in the treatment area before the waters mix, and the lines can also be closed. Landfill gas is collected and burned. The resulting energy is used for heating the facility's buildings.

The facility has a monitoring programme for environmental impacts, which has been approved in connection with the environmental permit. Among other things, the programme includes water sampling (wastewater from own operations), quality control of bottom sludge, quality control of biogas and composting processes, landfill monitoring (filling and seepage water), as well as quality control of waste (components suitable for landfill, odour control).

The site's impacts on local surface and groundwaters are monitored jointly with other operators in the area through the area's common water monitoring programme. The facility also has its own monitoring

programme, with two sampling points concerning the landfill. The quality of internal water is monitored 4 times per year and the height 2 times per year at the landfill. The quality sample is taken from an inspection well and the height is measured in a gas drainage well. Landfill gases are observed at the microturbine plant, which features a continuous measuring installation. The quality and discharge of gas is observed through measurements conducted once a year.

In addition to water and gas samples, observations focus on the landfill's surface area and volume (present and remaining), composition and settlement. Other properties internal to the landfill are monitored sensorily during the daily landfill compaction. Waste disposal is systematic, and waste is deposited in the landfill one sector at a time. Settlement is monitored every two months.

In the clarification basin of the site's own wastewater treatment plant, continuous measurements are taken of the flow rate, dissolved oxygen, electrical conductivity, the incoming and outgoing level at the pumping station, the pH of outgoing water, temperature and the level of the flowing well. Samples are taken in accordance with the environmental permit and the industrial wastewater agreement concluded with the waterworks.

Detailed monitoring parameters are presented in Tables 24, 25, 26.

Table 24. Landfill seepage water and level of internal water

Analysis/specification						
	Inspection well for water from landfill				Gas drainage pipe	
	May	Jul.	Sept.	Nov.	May	Nov.
Level of internal water					x	x
Temperature					x	x
Solid matter	x	x	x	x		
$COD_{(Cr)}$	x	x	x	x		
BOD_{7ATU}	x	x	x	x		
Total nitrogen	x	x	x	x		
Total phosphorus	x	x	x	x		
Petroleum hydrocarbons	x	x	x	x		

Table 25. Observation of landfill gases

Analysis/specification	
	Once a year
Amount	continuous
Quality	continuous
Oxygen (O_2)	x
Carbon dioxide (CO_2)	x
Methane (CH_4)	x
Hydrogen sulphide (H_2S)	x
Nitrogen (N_2)	x
Methane-carbon dioxide ratio (CH_4/CO_2)	x

Table 26. Clarification basin of own wastewater treatment plant (waters in landfill and treatment areas, *required by waterworks)

Analysis/specification	Once a month	Sept.	Spring *)	Autumn *)
Temperature	continuous			
pH	continuous			
Electrical conductivity	continuous			
COD (Cr)	x			
BOD7ATU	x			
Total nitrogen	x			
Total phosphorus	x			
Ammoniacal nitrogen	x			
Solid matter	x			
Antimony (Sb)		x		
Arsenic (As)			x	x
Mercury (Hg)			x	x
Phenols and cresols			x	x
Volatile solvents			x	x
Cadmium (Cd)			x	x
Chloride			x	x
Chromium (total) (Cr)			x	x
Copper (Cu)			x	x
Lead (Pb)			x	x
Molybdenum (Mo)		x		
Nickel (Ni)			x	x
Zinc (Zn)			x	x
Sulphate			x	x
Cyanide (CN-)			x	x
Vanadium (V)		x		
Petroleum hydrocarbons			x	x
1,2-dichloroethane			x	
Aldrin			x	
Dieldrin			x	
Endrin			x	
Isodrin			x	
DDT (para-para-DDT)			x	
Hexachlorobenzene			x	
Hexachlorobutadiene			x	
Hexachlorocyclohexane (gamma isomer, lindane)			x	
Carbon tetrachloride			x	
Pentachlorophenol			x	
Tetrachloroethylene			x	
Trichlorobenzene (1,2,4-trichlorobenzene)			x	
Trichloroethylene			x	
Trichloromethane (chloroform)			x	

Landfill structures

The foundation and surface structure of Kymenlaakson Jäte Ltd's landfill is the following:

Foundation bottom-up:	Surface structure bottom-up
Subsoil drainage under the sealing layer Sealing layer of clay 500 mm (permeability requirement from the Government Decree on landfills) High-density polyethylene (HDPE) liner 2 mm Protective coat for liner (slag was used for the expansion, but crushed stone fines etc. are usually used to protect the liner) Drainage layer, crushed stones 4-32 mm, 500 mm. Internal waters collected with a drainage pipe åfor water treatment. Non-woven fabric	Levelled and covered waste fill (cover using, e.g. fines or soil) Gas drainage layer 300 mm. Conducts water downward and gas upward. Gas drainage pipes under impermeable structure. Impermeable layer 500 mm, clay or bentonite carpet Drainage layer, drainage carpet or permeable crushed stone Soil layer 800 mm Growth layer 200 mm

4.14.4 Decommissioning of a landfill

**the chapter is written by the Centre for Economic Development, Transport and the Environment (ELY centre) of Southeast Finland*

Discontinuation of waste disposal

The decommissioning of a landfill begins once the surface area reserved for the landfill site and site capacity are reached. Environmental permits for landfills contain provisions on the surface area reserved for the landfill as well as its total capacity and final height. The permit also contains provisions on the construction of capping structures, including their materials and layer thicknesses, as laid down in the Government Decree on Landfills. Separate requirements apply to the structures of landfills for conventional and hazardous waste.

Different legislation has been applied in different periods, which means that the decommissioning methods for current and old landfills are not the same. Consequently, the permit provisions and submitted plans may differ somewhat. In addition to containing provisions on final decommissioning, the permit usually also requires that the open surface area of the landfill should be minimised. This is why a landfill may contain sections in different operational stages.

At least an intermediate cover is laid on areas which have reached the design height before the entire site is closed down. At the start of the decommissioning contract, it is often necessary to shape the disposed waste to obtain sufficient but safe slopes in the berm, and it may also be necessary to compact the waste. This may make it necessary to redo the intermediate cover. Consideration must also be given to overlapping any finished layers of the capping and joining them with new structures if the work is carried out in stages.

Approval for construction work

Before constructing the capping layers, the operator commissions plans for the decommissioning contract. The plans should include an exhaustive description of the materials to be used and their properties as well as quality control measures. The plans should also include layout drawings and detailed drawings of the layers to be built, the installation of gas collection pipes, and possible penetrations and their sealing. The plans are usually first approved by an independent quality controller who issues a statement on the matter. The plans and the statement are then submitted to the authority for approval, and the authority issues its opinion on the plans. If the plans are first approved by the authority, an independent quality controller must be designated in connection with the approval. After the approval round, construction work can begin.

During the construction period, meetings are held regularly at the landfill site between the contractor, operator, independent quality controller and the authority. A test structure is constructed for each structural layer before it is built in full. The work stages are documented with photographs and as built measurements. The independent quality controller inspects all construction stages, takes the necessary quality control samples and checks, among other things, the water permeability results of the materials used and the analysis results of wastes to be recycled and their suitability for the structures. A final report is produced on the contract, which contains information on the construction work and any deviations. Attached to the final report is a statement issued by the

independent controller verifying that the construction work was carried out in compliance with the plan and environmental permit. The supervising authority issues a statement on the final report. If significant deviations from the original plan turn out to be necessary during the construction period, the new plan should be approved by an independent quality controller and the authority.

Layers to be built and waste reuse

The following layers are built in the landfill on top of the compacted waste layer (from top to bottom):

- Top soil/growth layer ≥ 1 m
- Geotextile filter
- Drainage layer ≥ 0.5 m
- Impermeable mineral layer ≥ 0.5 m
- Geotextile liner if artificial sealing is used
- Artificial sealing, such as an HDPE membrane, is not mandatory in a non-hazardous waste landfill, but it is required in a hazardous waste landfill
- Geotextile filter
- Gas drainage layer; at least 0.3 m is recommended, in a hazardous waste landfill if necessary
- Geotextile filter
- Intermediate capping layer

The layers of the structures can also be thinner than this. In this case, a geosynthetic drainage medium is used as the drainage layer and a bentonite mat as the impermeable mineral layer. When using thinner layers, it must be ensured that their properties, including water permeability, correspond to those of thicker layers.

In addition to new materials, waste materials can be used in the surface layer structures. However, in this case it should be ensured that the waste is classified according to the category of the decommissioned landfill and that its properties, including water permeability and granularity, meet the requirements set for the layer. Environmental permits contain provisions on the utilization of waste in landfill structures, or, alternatively, an approval of the independent quality controller and the relevant authority must be obtained.

Water control

Clean surface waters should be led to a drain system that is separate from landfill leachate. Clean surface waters can be discharged into the environment without treatment. Landfill leachate is often directed to the municipal sewer network through a detention basin. Some landfills have on-site pre-treatment equipment for leachate, such as a biological treatment plant or a soil filtration system, from which the water is led to a sewer. Waters from industrial landfills are usually treated in the industrial plant's wastewater treatment system, to which they are pumped or transported by a tanker if necessary. In old decommissioned municipal waste landfills, not only clean surface waters but also leachate have been directed to a drain after the detention basin (at old landfills, this may also be referred to as a sedimentation basin) and from there into the water system. The guide to landfill decommissioning gives limit values for the need and methods of water treatment.

Gas collection

The methods of gas collection and treatment depend on the volume of gas the waste generates, or is expected to generate. As placing organic waste in landfills has been prohibited, the volume of gas-releasing waste taken to landfills has been reduced, and there usually is no need for gas collection at landfills for hazardous industrial waste, for example. If necessary, the collection system can be equipped with a gas burner, which means that the gas can also be used to generate energy. If less gas is produced, biological gas purification is sufficient. At small sites, the gas has been released through permeable stone layers, or no collection pipeline has been built. Estimates and gas measurements are used to determine the volume of gas and the required treatment technique. The Guide to landfill decommissioning contains instructions regarding the required treatment, which depends on the gas volume and concentrations.

Restoration and post-closure use of the site

After decommissioning, the landfill site is restored. The restoration plan is usually drawn up as a separate project. Suitable vegetation on a landfill site consists of grasses or low shrubs. If trees are planted at the site or allowed to grow there naturally, there is a risk of the structural layers being damaged. Closed landfill sites are occasionally used for new activities. Examples of such activities in Southeast Finland include a golf centre and a mountain biking track. In post-closure use, particular attention should be paid to maintaining the integrity of the landfill structures and the environmental safety for those using the area. The necessary agreements on using the site should be concluded between the municipality and the operator or association.

Aftercare and monitoring

The obligations associated with a closed landfill do not end with the completion of the decommissioning contract. According to the Waste Act, the waters from landfills must be monitored for at least 30 years after the site's decommissioning. Water treatment should usually also be continued if this is required under the environmental permit. The sampling frequency, substances to be tested for and sampling locations are specified in the environmental permit or a monitoring programme approved by the authority on a case-by-case basis, taking into account the waste materials treated at or tipped into the site in question. The sampling frequency usually is twice a year, at least initially. Sampling locations should be set up as follows:

- Gases (at all vents)
- Surface waters (upstream and downstream from the landfill)
- Water inside the landfill (at least one point)
- Leachate (each point where water is led outside the site)
- Groundwater (one upstream and two downstream)

Not only sample-taking but also regular monitoring of surface structures and vegetation are an important part of the aftercare. Heavy rain can cause erosion and degrade surface layers, increasing the potential environmental load. If trees or other vegetation that may damage the structures have started growing in the area, or if invasive alien species or litter are detected, they must be removed. Measuring settlement is also an essential part of monitoring both municipal and industrial waste landfills. The functioning of gas collection pipes, subsurface drains and any water treatment structures should be checked regularly. Drain systems carrying water away from the landfill should also be checked. It is also a good idea to take care of the condition of sampling points and access to the site, ensuring that representative samples can be collected safely.

Substances to be tested for

Below is a list of common parameters that should be tested for in landfills. Case-by-case discretion should be used regarding the analyses, taking into account the types of waste contained in the landfill. The list of samples is different for municipal and industrial waste landfills, as well as for non-hazardous and hazardous waste landfills. In addition to taking water samples, the water level inside the landfill site, the level and flow direction of groundwater, and the flow of surface waters should be monitored.

- Parameters typically analysed in leachate and waters inside the landfill: pH, different forms of nitrogen, phosphorus, biological or chemical oxygen demand and chloride or electrical conductivity. Once, or every few years: heavy metals, petroleum hydrocarbons and volatile organic compounds.
- Parameters typically analysed in surface water: pH, different forms of nitrogen, phosphorus, biological or chemical oxygen demand, chloride or electrical conductivity. Once, or every few years: heavy metals, petroleum hydrocarbons and volatile organic compounds.
- Typical parameters analysed in groundwater: pH, electrical conductivity, ammoniac nitrogen and chloride. In addition, it is often necessary to monitor the leaching of arsenic, chromium, copper, lead, zinc or nickel.

The results should be gathered into an annual report describing the current and previous years' results and averages. The reports should also contain a calculation of the surface water load originating from the landfill by comparing an upstream and downstream point. Nitrogen and phosphorus loading has often been described as population equivalents (only municipal waste landfills), making it possible to assess any need for water treatment. When waters are led to a sewer, the local wastewater treatment plant sets limit values for harmful substances in industrial wastewater treatment contracts.

When to stop or reduce the frequency of sampling

The sampling frequency may be reduced when the values of the analysed parameters have decreased and remained unchanged for a long time and no impacts have been observed in natural waters. This is decided on a case-by-case basis. If the permit does not contain limit values for emissions into water, the results obtained are compared to monitoring programme reference points and, for example, to general results on natural waters and quality standards laid down in legislation.

The limit values and sampling frequency of waters led to the sewer have generally been agreed with the local wastewater treatment plant. If deviations are observed in the results after reduced sampling frequency, the frequency must be increased. Any reductions in frequency and additional sample-taking are approved and ordered by the authority. If the waters from the landfill are treated on site, the possibility of discontinuing treatment can be examined as described above. The monitoring of waters led to the sewer should be discussed with the local wastewater treatment plant. A reasoned proposal should be made on discontinuing water treatment. Depending on the permit provisions, the proposal is approved by the supervising authority or permit authority.

Before monitoring ends, it should be ensured that the landfill no longer poses a risk to health or the environment. Gas monitoring and treatment by burning can be discontinued when the gas volume decreases or its quality changes to the point that burning becomes unprofitable or impossible.

Indicative values for concentrations in discharge waters when making decisions on reducing the frequency of or discontinuing monitoring:

- BOD7ATU 30 mgO_2 /l
- CODCr 125 gO_2 /l
- solids 35 mg/l
- P-tot 2 mg/l
- N-tot 15 mg/l.

Oversight by authorities

Oversight by authorities takes place annually on the basis of sampling reports. In addition to sampling results, the reports should include descriptors of long-term results, making it easier to monitor the trend. The report should contain a comparison of results from downstream and upstream sampling points, a description of the effectiveness of any water treatment equipment, and conclusions on the possible impacts of the landfill. On-site inspections are conducted as set out in the monitoring programme (See Figure 69). Decommissioned landfills are usually placed in control category 4, which means that inspections are carried out around every 10 years. If necessary, the authority may inspect the site as a result of deviating results or a report made by a member of the public. The inspection pays attention to the condition of surface structures and drain networks, general tidiness, and the implementation of appropriate monitoring.

4.14.4.1 Example of water monitoring and post-closure use of an old decommissioned landfill, Sammalsuo landfill

Monitoring and post-closure use of a decommissioned landfill

Sammalsuo is a municipal waste landfill owned by the city of Kouvola. While the site was operational, it was used for tipping mixed municipal waste and composting wastewater sludge. The surface area of the landfill is approx. 4.3 hectares and total capacity approx. 398,000 m^3. The landfill started operating in 1958 and was closed down in 1998. The decommissioning work was completed in late 2002. The Government decision on landfills (861/1997) was not applied when building the capping structures as the environmental permit had been granted before the decision entered into force. The leachate from the landfill site is directed to the city's wastewater treatment plant.

The capping structure specified in the plan was put out to tender. As the contract work started, the contractor proposed that a golf course be built on top of the capping structure. The plans were negotiated and approved by both the municipality and the government.

Bogey Golf Ltd. signed a lease on the site, and a golf course was built on top of the capping structures, taking into account both user safety and the integrity of landfill structures. The open nine-fairway, par 3 course was completed in 2003 and is particularly suitable for beginners (Figure 67). Clean stormwaters from the landfill and the adjacent rail and road terminal site are collected into a sedimentation basin and used to irrigate the lawns of the golf course.

Structural layers

The following surface layer structures were built in the Sammalsuo landfill:

- Top soil layer 0.3 m
- Protective layer 0.5 m
- Geotextile filter
- Drainage layer 0.3 m
- Impermeable layer 0.5 m
- Intermediate cover 0.2 m

A gas collection pipe system was installed in the emplaced waste, and no separate gas drainage layer was built. The gases are directed to a gas burner.

Figure 67. Golf course on the top closed Sammalsuo landfill.

Post-closure monitoring

Water monitoring

Water monitoring in the decommissioned landfill of Sammalsuo is carried out following a monitoring plan updated in 2005. At that time, operational monitoring was replaced by post-closure monitoring. Samples are taken twice a year, in spring and autumn. The samples are collected by a certified technician and analysed in an accredited laboratory. There are four sampling locations for surface water, five for groundwater and one for leachate (See Figure 68).

The surface water and leachate samples are tested for the following parameters:	The groundwater samples are tested for the following parameters:
• flow • temperature • oxygen • electrical conductivity • colour, cloudiness • pH • CODCr • BOD7 • Total nitrogen • Ammoniac nitrogen • Total phosphorus • Chloride • Bacteri	• electrical conductivity • ammoniac nitrogen • bacteria (total coliform, total thermally resistant coliform) • iron • manganese • pH • chloride • colour • sulphate • oxygen

Every three years, more extensive sampling from groundwater points and one surface water point is carried out in the autumn. These samples are tested for the following, in addition to the parameters listed above:

- chromium (total chromium and chromium-6 separately)
- nickel
- cadmium
- lead
- mercury
- aluminium
- copper
- arsenic
- AOX
- phenols

Gas monitoring

The landfill has a burner for gas treatment. The system was completed in 2001. The operation of the gas collection installation and the burner is monitored regularly, and measurements are taken monthly. The recorded operating parameters of the landfill gas plant include operating hours, gas flow, total pumping volume and fuel efficiency. The shares and concentrations of methane, carbon dioxide and oxygen are analysed in the collected gas. Measurements are carried out separately for each gas well, making it easier to monitor the operation of the gas pipes and the installation as well as the need for maintenance.

Figure 68. Sammalsuo landfill groundwater sampling point

Other practical examples of landfill decommissioning and post-closure use are presented in the INFOBOX 21 and the INFOBOX 22.

Figure 69. A periodic inspection at the Sammalsuo landfill

INFOBOX 21: Old landfill is now a beautiful energy-producing park and ski resort

**written by Markku Illikainen, Ecomentor Ltd (CEO of the MWMO Kiertokaari and Oulun Jätehuolto 1995–2020) 6.12.2021*

Rusko landfill's history in brief

Rusko landfill is situated in Oulu, on the current territory of the MWMO Kiertokaari. The landfill area was originally a swampy meadow where in the summertime the peasants did the hay for their cows. The first loads of waste were brought into the area by horses in the late 1950s. After 1981 the Rusko landfill was the only official landfill in the city of Oulu. The landfill covered an area of 12 hectares.

The landfill caused an odour nuisance to the surrounding area. Landfill biogas recovery began in 1997 with 30 sucking wells and one pumping station (capacity 1,000 m^3/hour). At the time it was the biggest biogas pumping station in Finland. The biogas recovery reduced odour nuisances. (See Figure 70).

Figure 70. Rusko's landfill in use in 1997

In 1999, the old landfill became full, and the new emission-free landfill opened nearby. There was at that time 2 million tons of waste in the old landfill. The landscaping of the landfill was carried out in 2002 - 2005. The hill is 60 meters above sea level and has an altitude difference of 45 meters. When the hill was ready, the people named the site "Ruskotunturi" ("Rusko fell").

A private company built a ski resort at Ruskotunturi in 2013. The ski resort was put into operation in December of the same year.

Surface structure of a landscaped landfill

The landscaping of the Rusko landfill was carried out in accordance with EU and Finnish national regulations. The surface structure built on top of the waste backfill is 2 meters thick. This layer has a 500 mm thick water-insulating layer made of a mixture of fibre sludge from a paper mill and ash from a peat power plant (mixing ratio 4:1). The top layer has a 200 mm growth layer made of a mixture of composted biowaste and sand. In other respects, the structure is mineral earth and crushed stone. In connection with the landscaping, an irrigation system was built under the structure so that the waste filling would receive water and anaerobic decomposition would continue. The landscaped landfill has been completed by planting 40,000 trees and shrubs on top of it. It is one of the most important carbon sinks near the centre of Oulu (See Figures 71 – 73).

Figure 71. The first stage of the landscaping of Rusko's landfill has begun

Figure 72. Rusko landfill in the early summer 2005

Figure 73. Ruskotunturi is a popular mountain biking destination

Utilization of landfill biogas

Biogas has been pumped from the landfill since 1997. The capacity of the pumping station is 1,000 m^3/hour (Figure 74). The gas is sucked under vacuum from 30 collection wells. Since 2000, all recovered biogas has been utilized. Biogas has been purchased by Paroc's mineral wool factory, Oulu University Hospital and 2 laundries. For example, Oulu University Hospital uses biogas to produce disinfectant steam. Some of the biogas goes to the Rusko waste centre's microturbine plant, which produces all the electricity needed by the waste centre. The energy content of the biogas collected and utilized annually corresponds to 3 million litres of oil (which amounts 60 million litres of oil in total during the past 23 years). The amount of methane recovered in biogas corresponds to 40,000 tons of carbon dioxide equivalent per year. MWMO Kiertokaari, which operates in the Rusko waste centre, invested in a biogas purification plant in 2017. This eliminates the need to cancel landfill gas recovery when the methane content of the gas falls below 40 %. It also allows biogas to be recovered 20 years longer.

Figure 74. Biogas pumping station

Note! A good example of the circular economy is the biogas ecosystem in Kiertokaari. Biogas has been collected from landfills and used in industrial processes for over 20 years. Kiertokaari produces all the heat and electricity for their operations with biogas. Since September 2017 it has been possible to buy biogas from the Rusko waste centre as traffic fuel because there is now also a biogas plant of Gasum which produces traffic gas at the premises (Figure 75). See more information in the Chapter 4.11.2.

Figure 75. Rusko biogas fuel station

Ski resort Ruskotunturi

The city of Oulu built a road to Ruskotunturi in 2013. In the same year, a private company, Ruskotunturi Ltd., built a ski centre on the hill (Figure 76). There are 4 lifts on 5 slopes, ski rental and a restaurant. The hill is a very popular downhill and skiing location especially among young people and children because it is the only high place in Oulu. Every year, many schools and hundreds of schoolchildren have a winter sports day at Ruskotunturi. In the summer, Ruskotunturi is a popular place for jogging and mountain biking.

Figure 76. Rusko Ski Center

Climate award 2014

In 2014, the city of Oulu and Kiertokaari received a climate award from the Association of Finnish Local and Regional Authorities (AFLRA) for their work for the climate. The biogas pumped from the landfill replaces fossil fuels in plants and harmful methane is not released into the atmosphere. The trees planted on Ruskotunturi are an important carbon sink. Ruskotunturi ski resort will reduce driving to the ski resorts of Lapland and northeast Finland because now the city has its own ski resort.

INFOBOX 22: Tapiola Golf removed a barrier preventing natural urban development

**written by Managing Director Pertti Itkonen, Ocarina Ltd.*

In the 1950s, residents unlawfully started the landfill operations of Mankkaa, Espoo in a nearby peat bog. Espoo formalized the landfill operations in the early 1960s. In the period 1982–1985, waste from the entire Helsinki Metropolitan Area was shipped to the Mankkaa landfill. Over the decades, the population expanded around the landfill. The landfill operations would have been continued for a long time if it had not been for a large surface landslide that was caused by a loose layer of clay under the peat layer. The high susceptibility to a landslide put an end to the activities, and the around 4 million m^3 landfill body was only covered with thin soil layers. Some of the landfill was fenced due to the collection of landfill gas. This left an around 50-hectare-wide area that was problematic from an environmental and land use perspective right in the centre of the city (Figure 77).

Figure 77. Mankkaa landfill before landscaping

In 2000, Ocarina Ltd. was established to determine whether the former Mankkaa landfill area can be converted into a full golf course. After some initial hiccups, the city of Espoo decided that the appropriate measures to restore the landfill would be launched alongside the golf course construction for which the company was responsible. Reports revealed that similar transitions had been accomplished dozens of times, mostly in the United States and Japan. Based on experience, a golf course is one of the best, if not the best, final use of a former landfill, provided that the properties of the landfill allow it. The location of the landfill as close as possible to the golf market, i.e. players, is also essential. Golf is an ancient form of physical activity whose popularity is still growing strongly. The golf course and its surroundings serve as a beautiful recreational area for everyone.

The construction of a golf course on a landfill requires the simultaneous expertise of a number of sectors and a diverse group of experts. The experts must manage both the technology used in restoring the landfill site and the construction of the golf course and, most importantly, the coordination of these at all stages of the project, from planning and conducting preliminary and feasibility studies all the way to implementation. This is a demanding and complicated project in which integration from start to finish is key. The golf course established on the former Mankkaa landfill was named Tapiola Golf, as it is located in the Suur-Tapiola ("Greater Tapiola") neighbourhood (Figure 78).

Figure 78. The golf course is ready (2013) Photo: Tage Strandström

Turning a landfill into a golf course is a means, not an end. The goal is to transform a neighbourhood stigmatised by a landfill into a healthy and comfortable living environment worthy of its location. A golf course provides a key to the solution and offers a win-win situation for the city and its residents, the natural environment and golf enthusiasts. When a golf course can be constructed on idle land, located near recreational golfers, there is no need for using dozens of hectares of land in virgin nature areas. An additional benefit brought by the golf course is also the year-round surveillance and management of the area, which makes the statutory after-care of the landfill significantly easier and prevents the illegal dumping affecting many old landfills. The city and other landowners in the neighbourhood surrounding the former landfill gains most of the versatile benefits. In addition to the direct and indirect economic and employment impacts of the golf course itself, the increase in the value of properties in the nearby environment and the emerging opportunities create an economic impact dozens of times higher than the investment costs. Without smart end use, the former landfill would only be a former landfill, even if it had been appropriately restored. The golf course has a revolutionary effect on the image and regard of the former landfill area (See Figures 79 and 80).

Figure 79. Tapiola Golf in use during summer season

In Europe alone, there are dozens of old landfill sites near urban centres, which may even prevent the natural development of an entire neighbourhood. Our long-term experience at Ocarina Ltd. has enabled us to achieve the kind of know-how that can be used to remove the barrier that prevents development and turn this into a solution that promotes urban development, at the core of which is the golf course. We call this integrated development process the Ocarina Concept.

Figure 80. Tapiola Golf in use during winter

5 Conclusions

The Finnish waste management system is explicit and transparent, as responsibilities and authorities are clearly defined, and is based on effective regulation. It is based on cooperation between municipalities as well as between the public and private sector. Finnish waste management system has evolved strongly during the last decades and due to ever strictening regulations, it will change in the future as well.

The latest updating of waste legislation - the new Waste Act and Waste Decree - entered into force in 2021. The aim of the Waste Act is to reduce the amount of waste and increase reuse and recycling in line with ambitious recycling goals set by the EU and Finland. According these goals, 65% of MSW should be recycled by 2035 and 70% of packaging waste by 2030. Separate waste collection is in the heart of Finnish waste management system, and it starts at every house, municipal organization or enterprise. The Waste Act defines the key principles of waste management, and the municipality waste management regulations define practical implementation and e.g. determine which waste should be sorted separately and how often properties' waste bins must be emptied. In addition to the regulations, municipalities and municipal waste management organisations (MWMOs) offer a wealth of guidance material and advice to various target groups.

This publication describes the waste management realization by MWMOs before 2021 and therefore highlights the importance of local regulations, as waste management has been organized in different ways in different municipalities and regions. However, the updated waste legislation already contain more precise requirements for the waste management of households, businesses and other operators. It can be expected that MWMOs make adjustments in their own WMRs and waste management in the whole Finland will be harmonized. The new Waste legislation is an important step in boosting recycling and the circular economy and to achieve the ambitious separate collection goals set by the EU. Also development of other legislation would impose some changes in e.g. responsibilities concerning waste management in the nearest future.

The implementation of waste management on the municipal level happens mainly in co-operation of municipalities rather than by one municipality. For operational purposes of the cooperation is established the two main types of legal entities – municipal enterprises and associations of municipalities, which are owned by municipalities within this cooperation. Both types of municipal waste management organisations (MWMOs) are public entities and are non-profit. Municipalities could also agree on the joint purchasing of the service with another municipality or association of municipalities or can have or agreement on the joint production of services with another municipality or association of municipalities.

Organization of waste management in a cost-effective way is important also in terms of self–sufficiency, as there is usually no possibilities to get any subsidies from the state. All costs related to the organising of waste management are covered by income from the collected payments from waste producers and waste holders and revenues from energy and material recovery. Tax money is not used to cover the costs of municipal waste management. MWMOs are responsible for receiving free of charge also hazardous wastes from households and operate waste sorting stations and waste centres.

For some product groups, the producer and importer of a product is responsible for organizing the waste management for six groups of products at the date of this publication (2021) and bear all related costs (extended producer responsibility, EPR). There are upcoming changes due to tougher EU legislation and several other waste fractions are coming under EPR in the next few years. Each waste group under producer responsibility has its own recycling rate targets, and in case of packaging, there are separates targets for different packaging materials. A producer can take care the responsibility itself or establish a producer corporation and transfer the responsibility to the corporation by paying recycling fee to it. The producer corporation is a non-profit legal entity.

Municipal waste charges are an important instrument that provides incentives for recycling and encourages residents in separate waste collection. Waste tariffs are defined by municipal authority, which updates those annually. To increase recycling rates and separate waste collection, the fees for emptying of mixed waste bins are higher than separately collected fractions. In practice, the higher value of waste fraction on the market, the lower price of collection or even free of charge. Also population density may have an effect on waste charges and municipalities within single MWMO operational area can impose different waste charges. On the contrary, there may be the same waste charge in all municipalities within single MWMO.

The collection and transportation of waste has the highest share in the economic balance of the municipal solid waste management. Municipal waste management organisations can organise the process by their own tools and transport or via open public procurement to buy the service from private enterprises or, in some areas, property holders may organize the collection themselves by having contract with waste carrier.

The dominating treatment of MSW in Finland to date of this publication (2021) is energy recovery in large-scale waste-to-energy plants, and 42 % of MSW is recycled. Operational activities of material and energy recovery from municipal solid waste in Finland are happening via public-private cooperation between MWMOs local energy companies, waste to energy plants, producer corporations, and private companies. The share of landfilled MSW is currently 0.5 per cent. Finland has already closed more than 2,000 landfills. After decommissioning, the landfills are sometimes transformed into unique recreational areas that bring value to the city.

Despite many investments into recycling, the percentage value of recycling has not increased as there is a rising trend in the generation of mixed waste. The share of recycling is going to increase on the expense of energy recovery of mixed waste. Separate biowaste collection is under big attention at this moment. The share of mixed waste is still high, and biowaste comprises one-third of mixed waste. New waste legislation imposes requirements that would increase the separate collection of biowaste. Also, the government and municipalities initiates awareness-rising campaigns that also stimulate the separate collection of biowaste. Biowaste is utilized as feedstock for digestion in biogas reactors, which produce electricity for facilities' own consumption and for sale as well as heat for use in district heating networks. In some cases, biogas is further processed into biomethane and bioethanol for vehicles. Also, farm-level biogas reactors are very common in Finland. The second type of treatment of biowaste and digestate is composting which on the municipal level happens in facilities e.g. owned by municipal waste management organisations in eco-industrial centres and other suitable facilities.

The increasing of recycling is a big challenge for every country, as it requires in addition to a effective waste management system also profound changes in consumer behaviour and production (in terms of product and package design, processes and life cycle approach). It is expected that the transition towards a carbon neutral circular economy will decouple economic activity from consumption of natural resources and lead to the emergency of new sustainable business models and responsible lifestyles. However, all of this starts from the development of a holistic and cost-effective waste management system that integrates all the elements: legislation and regulation, organization of value chains, environmental awareness-rising and information sharing activities, technologies and public-private cooperation.

Acknowledgements and final words

This publication is the output from two projects, which are *Sustainable waste management – Cooperation project with Russian Federation* and *The Green City by Smart Waste Management (Cool4City)*. Sustainable Waste Management - Cooperation project with the Russian Federation (2020 – 2021) was coordinated by the Ministry of Environment of Finland and financed by the Ministry for Foreign Affairs of Finland. Cool4City project was co-funded by the European Union (2021 – 2022) (in the framework of the South-East Finland-Russia CBC Programme 2014-2020).

Both projects included the purpose of preparing open and public reviews of Finnish waste management. Due to clear synergies, the projects decided to co-operate in the preparation of this publications. Cool4City project focuses on the Helsinki metropolitan area in the Uusimaa region and Mikkeli in the South Savo region. Cool4City project is also collaborating with another South-East Finland-Russia CBC Programme 2014-2020 project *Cata3Pult – Finnish Russian PPP catalyzing new green business*, which is lead by the City of Lappeenranta in South Karelia.

This publication focuses on the up-to-date status of Finnish waste management and practices that are currently in use. The legislation update process going on in Finland will cause some changes in waste management practices in the nearest future.

A major part of the content of this publication is written by group of authors, which are Sveta Silvennoinen-Hiisku (Ministry of the Environment of Finland), Evilina Lutfi (Green Net Finland) and Sari Piippo (Finnish Environment Institute SYKE). Content gathering and writing work was implemented during 2021. To give a more comprehensive and holistic overview, this publication is covering descriptions of municipal level case examples not only from mentioned above areas – Helsinki metropolitan area, Mikkeli and South Karelia, but also from other regions of Finland, such as Päijät-Häme with its centre in Lahti, Pirkanmaa with its centre in Tampere, Northern Ostrobothnia with its centre in Oulu, as well examples from Riihimäki and Forssa. These selected examples represent different types of municipal waste management organizations (the authors developed abbreviation MWMO for those for the purpose of this publication) and specifics of their operational areas. The authors tried to describe differences of these case examples.

Descriptions related to operational and economic aspects of activities of selected MWMOs were shared between the authors. Content related to MWMO HSY (in Helsinki Metropolitan area / Uusimaa region), Metsäsairila (in Mikkeli in South Savo region), EKJH (in South Karelia) is written by Green Net Finland. In addition, the Chapter 2 is authored by Green Net Finland. Content related to Kiertokaari (Northern Ostrobothnia), PJH (Pirkanmaa region), Salpakierto (Päijät-Häme), LHJ (Kanta-Häme, Satakunta, Pirkanmaa) – by the Ministry of the Environment of Finland based on publicly available data. In addition, other Finnish waste experts were invited to write thematic articles in this publication.

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This publication is aimed at a wide audience, so the authors have developed adapted terminology for easier perception of information. The list of references presented in the current publication is structured according to the content and are not exhaustive. Their aim of the list of references is to guide interested readers to find more specific information.

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OTHER ONLINE SOURCES

Kierrätys.info - online service on waste recycling: https://www.kierratys.info/

Ympäristöministeriö
Miljöministeriet
Ministry of the Environment

SYKE

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