RECYCLING, REUSE AND SYMBIOSIS

STATISTICS, FLOW AND TECHNIQUES ON FOOD WASTE

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Abstract

One third of the food produced is wasted while the demand for food is increasing worldwide. The food supply in the consumption phase – restaurants, bars or food retails – is not only the last chain but also the phase when the most food goes to waste. Yet an underestimation of the food waste amount is prevalent among Dutch consumers. In the context of Amsterdam, most of the food waste produced by consumers and customers is not separated or specially treated out of the general residue, which limits the efficiency to reuse and recycle. The goal of a circular economy in Amsterdam is high on the agenda of the municipality, hence a transition is expected to close the loop between the waste, the energy and the resources. This paper aims to investigate the potential and alternative technical approaches to optimize the circulation of food waste, on the basis of a knowledge and criticism of the current situation of the waste flow. The experiences learned from existing practices will help to shape my own design project.

Keywords

Food waste, Flow, Consumers, Anaerobic digestion, Compost, Circular

1. Introduction

Wasting food is not only an ethical and financial issue but also depletes the environment of very limited natural resources. In recent years, the European Commission is taking seriously the issue of tackling the food waste so as to save money and lower the environmental impact from food production and food consumption. The optimisation of food waste flow is an integral part of the Commission's new Circular Economy Package (2015) to stimulate Europe's transition towards a circular economy. The city of Amsterdam, too, issued a report titled Circular Amsterdam (2016), investigating the potential of a transition towards a circular economy, in which food waste flow is one of the important streams addressed. In this case, the traditional waste management and treatment procedures are bound to be challenged.

My site is around the Marineterrein district, not far from the Amsterdam Centre. As this area is going through a transition from an enclaved naval zone to an open public space, the consumption culture and tourism will also spread to this neighborhood quickly. On the one hand, the food waste produced in hospitality industries cannot be neglected; on the other hand, the newly opened district offers an opportunity to rethink the food waste flow under the new guiding theme of circular Amsterdam.

My thematic research question contains:

- What and how is the existing flows of food waste in Amsterdam?
- What are the optimised technical approaches to be integrated in an architectural project in order to reduce, reuse and recycle the food waste?

The methods of the research mainly includes the review of literature (eg. government's report, scientific papers, books, factsheets, etc.), the site visits to investigate residents' relationship with the waste management and the case studies to witness and verify the current technical approaches.

2. Background

2.1. Food Waste in the Netherlands

'Food waste' is referred to any food appropriate for human consumption yet removed from the food supply chain or discarded, whether or not beyond its expiry date or left to spoil. Worldwide, about 1.3 billion tons of food - more than a third of the total food production - end up as waste annually, according to the recent data from Food and Agriculture Organization of the United Nations (FAO). Meanwhile, there is an increase in demand of food due to the growth of the population, changes in the composition of the human diet and the increasing consumption of daily calories. Therefore, reducing the food waste would be effective to help with issues like soaring food prices and unnourished population in the global scape.

The number for Netherlands amounts to 700 million kilograms of food wasted by consumers per year, according to a report by the Economic Affairs and Infrastructure & Environment ministries in 2017. This number has dropped by 15% from the year 2010 though. Averagely, a Dutch resident tossed about 41.2 kilograms of food into trash bins – excluding 21 kilograms of unavoidable losses such as peels, stalks, shells or bones – out of the 337 kilograms of solid food purchased or ordered (Voedingscentrum, 2016). The percentage of waste with respect to the edible solid food is 13%, only a slight drop from 13.6% in 2010 and 13.5% in 2013 (Appendix A). In monetary terms, this amount of waste constitutes 145 Euros per capita per year, and thus about 2.5 billion Euros are thrown away per year throughout the country (Van Westerhoven, 2013). Cutting back the food waste is therefore saving money.

Yet the amount of waste is underestimated by most people in the Netherlands. Interestingly, from a self-assessment research, Dutch residents think they throw out about 21 kilograms on average per person per year – only half of the actual amount of food they discard (Voedingscentrum, 2016). The research also shows that respondents who are already aware of their food wasting behaviors would waste less food in their daily practices. Encouraging the consumers to be more waste-conscious could be an initial step to tackle the problem.

Plus, the consumption phase (comprising both households consumption and the waste out of home channel) is not only the last chain but also an especially thriftless phase within the entire food supply chain. Compared to other phases related to significant food waste (eg. agriculture, food processing, storage, transportation, hospitality industry, supermarket and grocery, etc.), ultimate consumers appear to be the largest waster of food throughout the entire chain – they account for about 30% of the total food waste in the Netherlands (Gustavsson et al., 2011). The last and the most.

In consequence, food wasted in the consumption phase leads to larger energy losses than any other losses prior to it. As energy was already expended during the earlier phases like processing, transport and preparation, the indirect energy of the product per kilogram amounts more at this last stage. "On average, a meal in Amsterdam has travelled 33,000 km before ending up on our plate." (Kurstjens, 2017) When a consumer orders food in the restaurant, 85 - 90% of the energy was already consumed in the previous chain. The consumer therefore do not waste simply the food, but also the energy and resources that were put into the cultivation, transport, packaging , refrigeration and preparation of food. In fact, for every kilogram of food discarded by consumers, 1.3 liters of petrol is estimated to go to waste (Milieu Centraal, 2012). And if taking into account the CO_2 emission during the food

production and transportation processes, climate benefits could also be gained by responding to the food waste in the consumption phase.

Furthermore, the options to recycle the waste in this last chain has more limitations due to the considerable diversity in waste mass, as opposed to losses earlier in the chain where the waste can still be used for high-quality applications.

2.2. Current Food Waste Flow in Amsterdam

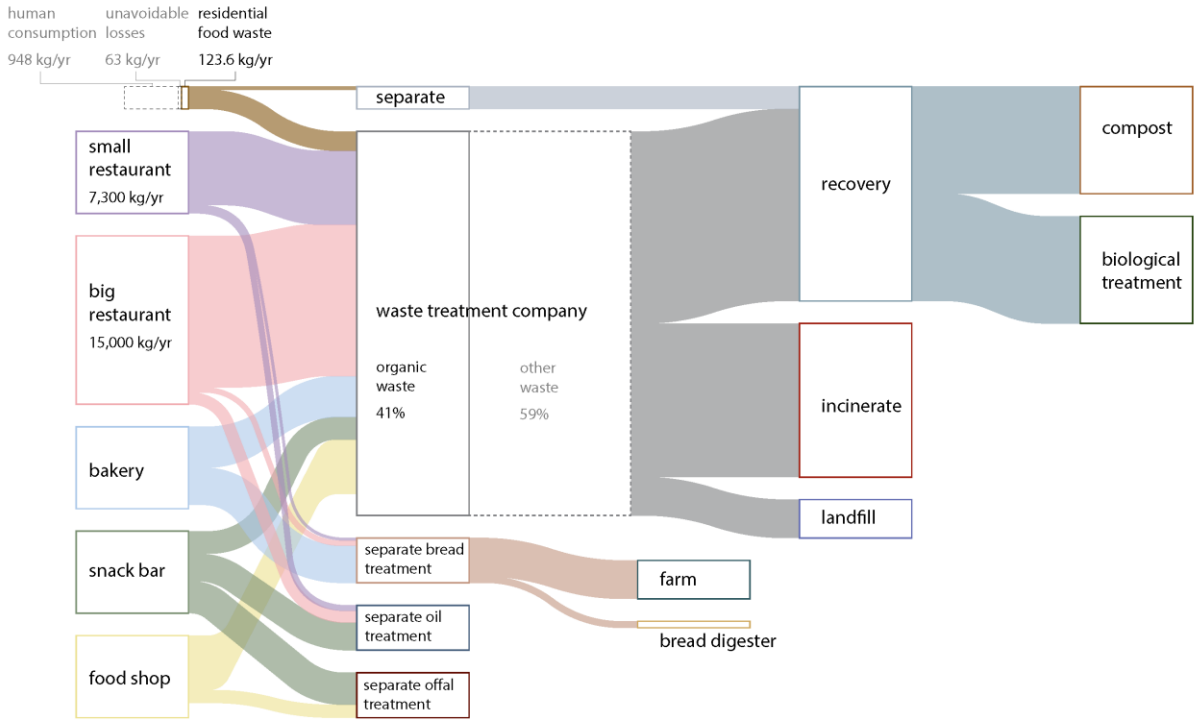
The food waste in the city is categorized under the umbrella of Municipal Solid Waste (MSW) which includes residue from private households and gardens, commercial waste from shops and restaurants, and institutional waste from public organizations. Because of these many different consumer goods converging in this stream, the material composition of MSW is rather complex: organic waste including biodegradable fractions from food and yard waste, paper and cardboard from packages and newspapers, plastic from packaging, bags, bottles or durable goods and fewer parts of glass, textiles, rubber and metal (Pichtel, 2014).

The percentage of separate collection on total municipal waste generation in Amsterdam is quite low – only 14% throughout the city (Rijkswaterstaat, 2015). There is no separate collection system established to distinguish the bio-waste from the rest, except for the district Nieuw-West. The Nieuw-West district provides separate containers for bio-waste per household that works with door-to-door collection. Another district – West – provides special bread containers in the streets to collect old bread. Cooking oil wastes can be brought either to civic amenities or to a special point for small chemical household wastes. In the rest of Amsterdam including the Centre and the Marineterrein, food waste is simply disposed of via the residual waste fraction altogether. From a calculation based on the residual waste sorting analysis, bio-waste accounts for 41 % of this stream, which are reusable yet not separated (Rijkswaterstaat, 2013). These residual waste is mostly transferred by trucks to the Waste-to-Energy company AEB (Afval Energie Bedrijf) to be sorted, incinerated or fermented, which could produce 15 million m^3 of biogas per year. This current flow to transport the waste between the Centre and the AEB demands approximately 3566 garbage trucks with an average loading rate of 7 tons per year (Wildenburg, 2016).

Figure 1. food service and waste disposal at Marineterrein

When calculating only the food waste, a resident of Amsterdam discards 92 kilogram of food waste per year on average (Circular City, 2016). In commercial catering business, a small restaurant running on two to three gas stoves produces approximately 7,300 kilogram of food waste per year, while a medium sized restaurant produces around 15,000 kilogram (Vasudevan, 2013). The dense population of households and the large quantities of restaurants in the city center promises great potential if the food waste could be directly collected, reused and recycled.

Figure 2. Sankey diagram of the existing food waste flow in Amsterdam



3. Technical Approaches and Practices

3.1. Technical Approaches towards food waste

Circular food:

To collect and process the surplus food so as to feed other people or animals. The key is to form a business model to offer the network between the supply and the demand.

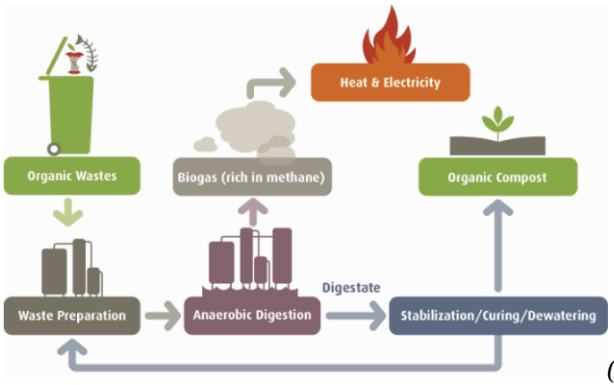
Anaerobic digestion (AD):

To provide a source of renewable energy – biogas – by breaking down the food waste into a mixture of methane (CH_4) and carbon dioxide (CO_2). The biogas can be used to generate electricity and heat to power the on-site equipment or simply used directly to power the stoves for the kitchen. With

optimal conditions, a biogas production of 160 Nm^3 could be achieved with 1,000 kilogram of food waste (Hitachi Zosen Inova, 2015).

The food waste needs some preparation to optimize this production – they need a good separation from all the non-organic materials that cannot decompose, such as plastics and metals. The food also needs to be chopped to a proper size and sometimes water needs to be filled due to its high percentage of dry substance.

Figure 3. anaerobic digestion process



(Source: Foodwasteexperts)

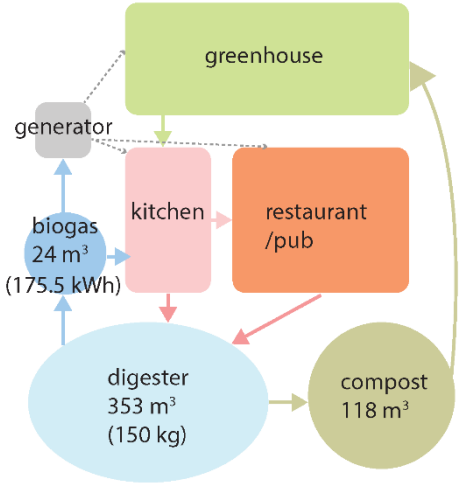
Composting:

To biodegrade the organic waste and turn into fertilizer to grow fruits, vegetables, herbs or crops. The remnant co-product from the anaerobic digestion – liquid fertilizer, solid fertilizer, compost – can also be used for composting (as shown in Figure 3).

Biofuel:

To purify and recycle the second-used cooking oils into biofuel or biodiesel for vehicles.

Figure 4. calculation of energy transfer in anaerobic digestion
(taking restaurants in Marineterrein as an example)



	Waste generated	Gas needed
small restaurant	20 kg/day	22.5 kWh/day
medium restaurant	41 kg/day	44.6kWh/day

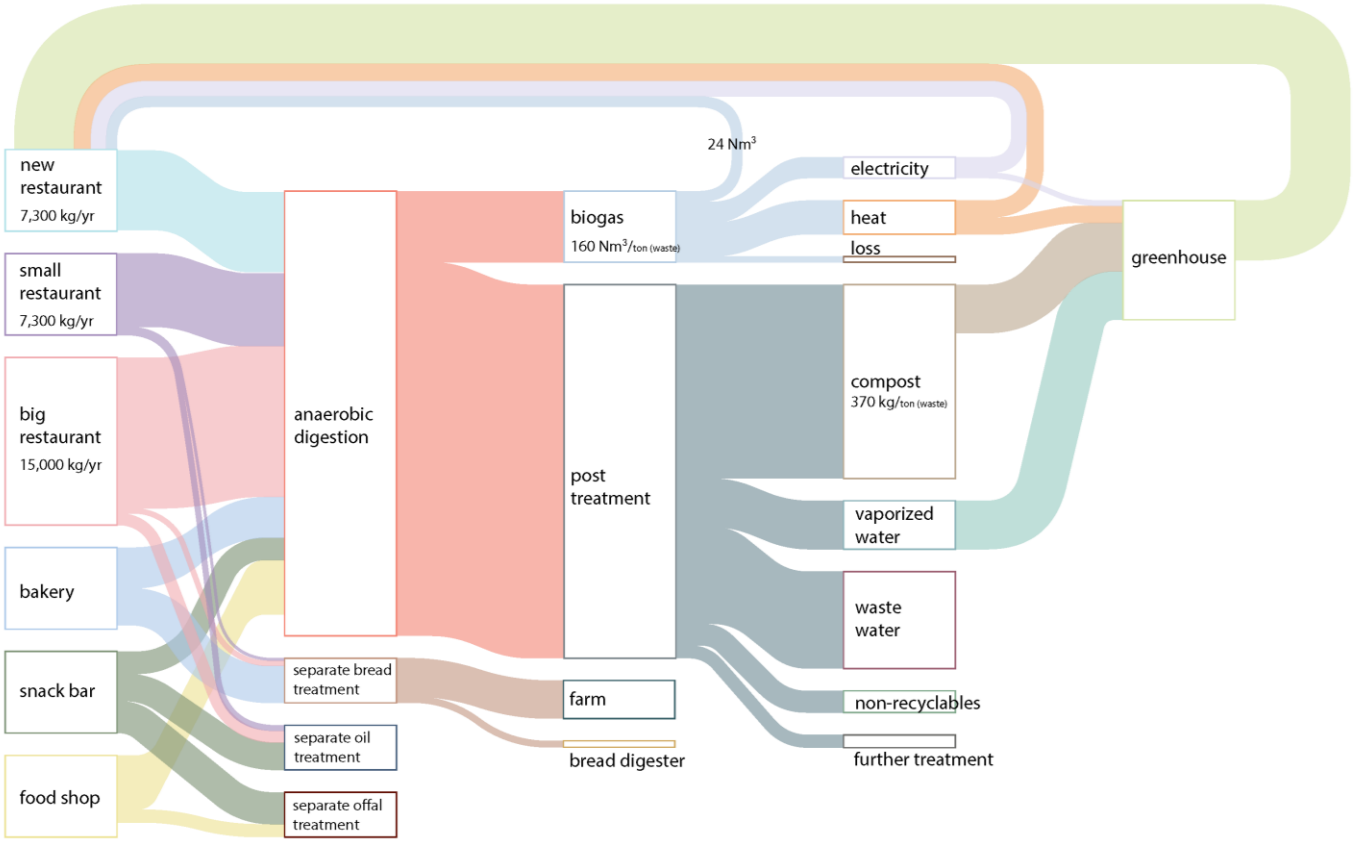
(Vasudevan, 2013)

1000 kg food waste

= 160 Nm3 biogas + 370 kg compost

(Hitachi Zosen Inova, 2015)

Figure 5. Sankey diagram of the potential food waste flow in Amsterdam, applying anaerobic digestion system with a greenhouse



3.2. Typical Case Studies in Amsterdam

Though there is no separation system and special waste management for food waste in most districts of Amsterdam yet, several small-scale neighborhood-based projects have made attempts to tackle the issue with various approaches.

Instock – circular food:

Instock is a restaurant in Amsterdam that cooks surplus food products which would otherwise remain unsold in supermarkets. Most of the food material are collected from the return-freight center of Albert Heijn supermarkets in Zaandam, while some fish from packagers and drink from Heineken. These food and drink they gather are either approaching the expiration date or damaged in packages, so it's usually free to get from the suppliers. Instock either process the food into meals following the same food safety requirements as any other restaurant, or sort and re-sell the vegetables and fruits in the 'food rescue center' to other restaurants and catering businesses. They claim to have rescued 400,000 kilograms of food in the past three years.

They also cooperate with an Amsterdam based brewery to develop food waste beer out of surplus bread and potatoes. While Dutch residents consume 60 kilograms of bread on average per year, 20% of which is being wasted. Likewise, 340 million kilograms of potatoes go to waste every year because of overproduction, excessively high quality standards or aesthetics. The surplus bread and potatoes are collected from Albert Heijn as well as a potato packaging company.

Mediamatic – circular agriculture and compost:

Mediamatic, located between the Central Station and the Marineterrein, contains a restaurant and a greenhouse called Aquaponics. In the closed system within the greenhouse, plants and fish are cultivated together, so that water is pumped from the fish tank through the breeding beds of the vegetation. The excrements from the fish serve as a fertilizer (the ammonia excreted by fish gets transformed by bacteria into nitrate, which serves as fertilizer for the plants) while the plants filter the water returning to the fish tank. This sustainable system takes up little space in the urban scale and wastes little water. The vegetables, herbs and fish grown within the Aquaponics greenhouse serve as ingredients for their restaurant.

Figure 6. Mediamatic greenhouse and composting



(Source: Mediamatic)

In return, the organic waste from the kitchen of the restaurant serves for the composting process via the Bokashi (meaning 'fermenting organic matter') container, which uses effective microorganisms to enable low oxygen levels in the compost tank so that food waste will be fermented into fertile soils with the most optimal results. In this way the herbs and vegetables grown in the Aquaponics greenhouse will again absorb nutrients from the food waste.

Biogas Boat, De Ceuvel - anaerobic digestion and biofuel:

The biogas boat by Café de Ceuvel aims at a circular system between food waste and energy. The boat converts organic waste from the De Ceuvel community into biogas to be used to cook within the kitchen – to cook on yesterday's waste via a bio-digester. This bio-digester breaks down the large organic molecules in food waste and converts them into methane gas which can directly launch the gas cookers in the pantry. The remnants after the digestion process can still serve as a rich source of compost to fertilize plants and insects.

In addition, the biogas boat proposes a filter system to convert deep fried cooking oil into fuel for the De Ceuvel van. The goal is to close as many loops as possible between the waste production and energy supply.

4. Conclusion

The problem of food waste is severe. With one thirds of the food production going to waste, the loss is not only in money but also a lot of resources consumed in all the phases within the food supply chain (eg. water, land, etc.) as well as the energy used up for growing, packaging, transporting and cooling the food. Besides, food production has a big impact on the climate due to CO_2 emissions, and by wasting the food, the environment is burdened unnecessarily. However, most residents or consumers in the Netherlands have underestimated this appalling number, which hinders people to make conscious choices towards food waste and reduce the eco footprint.

Under the current circumstances in Amsterdam, the food waste is mostly categorized and processed as the general residue, and there is no special food waste management in the Centre or the Marineterrein. What is inspiring is the emergence of several neighborhood-scale projects that adopt a variety of current techniques to tackle the food waste issue, of which the paper only lists a few. The technical approaches can be roughly categorized into food circulation, compost, biogas and biofuel conversion. These technologies are more sustainable to close the loop between waste and resources, compared to traditional landfilling and incineration procedures which are prone to fade out in waste management solutions in the future.

The objective of this paper is to investigate the food waste situation and flow in the context of Amsterdam, in order to take a clear stand in embedding the architectural project within the Marineterrein district. Besides, the analysis into the current practices and reference projects around the district helps me with a critical understanding of the technologies already applied and other innovative opportunities to be integrated in the project potentially. The research will be carried on to aid the following design process of the architectural project.

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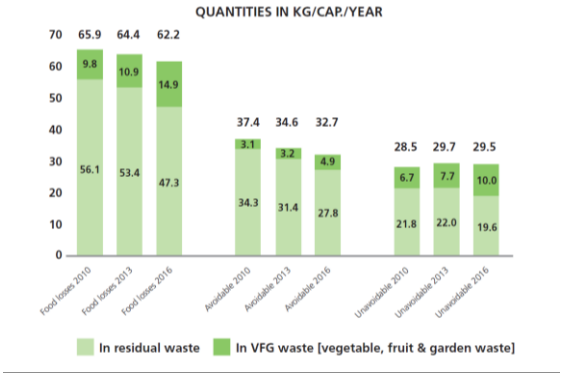
Appendix

1.



Share of food waste

	2010	2013	2016
Total purchased	376	368	337
Unavoidable loss	22	19	21
Total edible	**353**	**349**	**316**
Waste composition analysis*	35	32	30
Waste via other routes*	13	15	10
Total waste*	**48**	**47**	**41**
Percentage of waste with respect to edible	13.6%	13.5%	13%
Consumption	**306**	**301**	**276**

Distribution of food waste via household waste Share of food waste relative to quantities purchased

(Source: Voedingscentrum, 2016)

2.

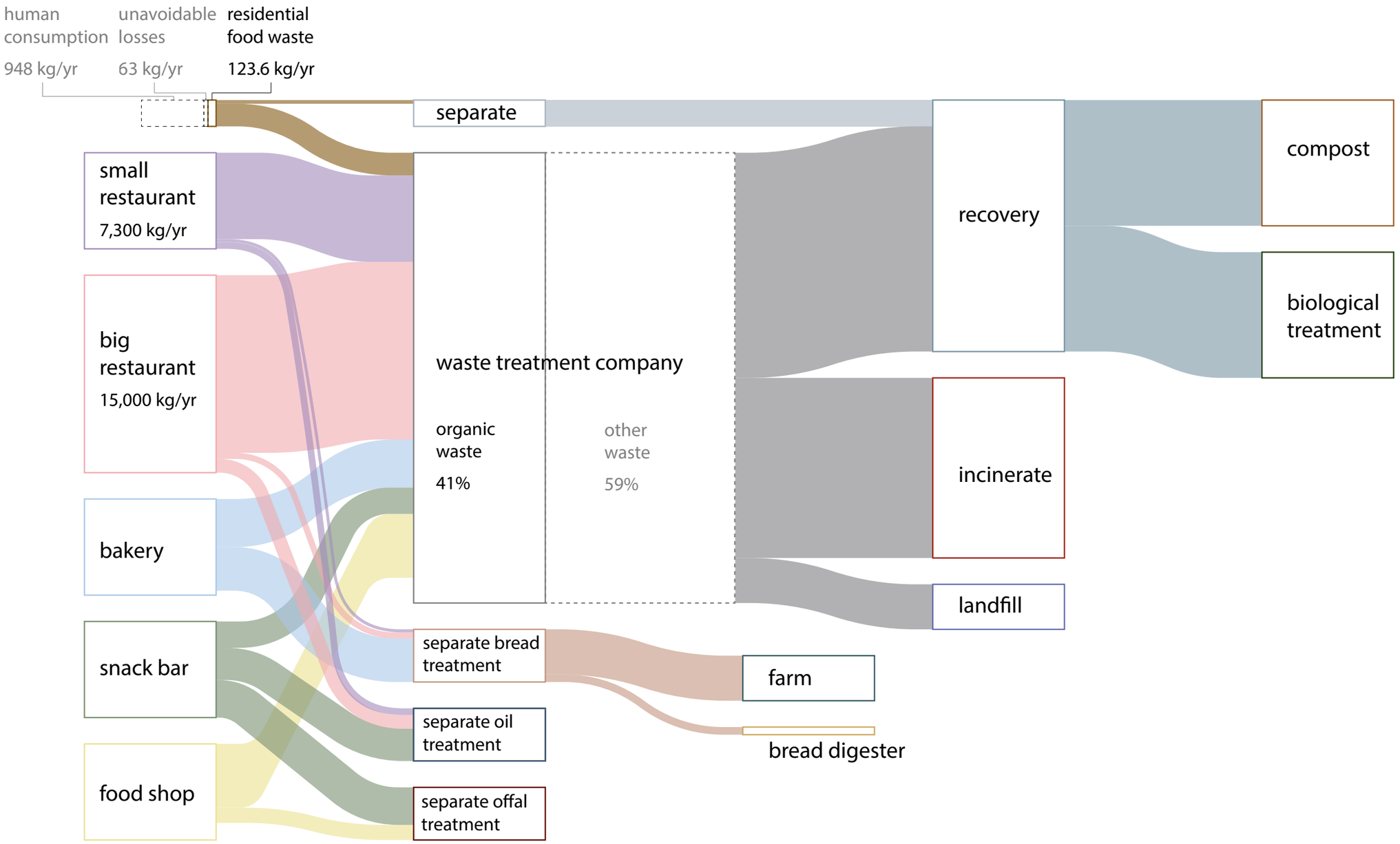
Collected waste (t)	Paper	Glass	Plastic	Scrap metal	Bio-waste	City Coverage
Door-to-door				10 t	519 t	< 18 %
Co-mingled						
Bring points	19 752 t	15 827 t	723 t			Paper: 3000 points (370 per 100 000 inhabitants) Glass: 3000 points (370 per 100 000 inhabitants) Plastic: 226 points (28 per 100 000 inhabitants)
Civic amenities				94 t	3 261 t	6 amenities (0.7 per 100 000 inhabitants)
Producer / Retailer take-back						
Total	**19 752 t**	**15 827 t**	**723 t**	**104 t**	**3 780 t**	

Summary of waste collection systems in Amsterdam

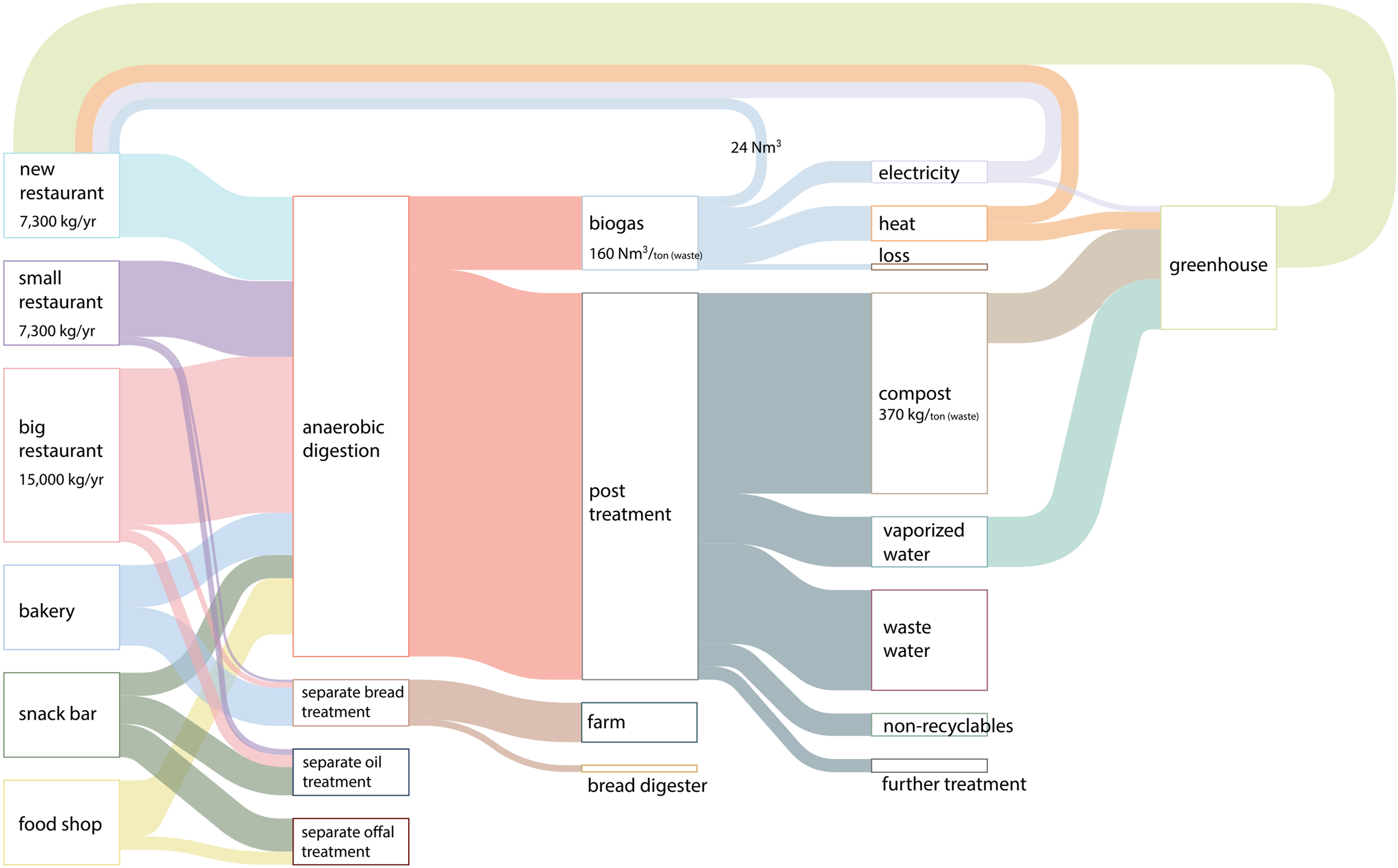
(Source: European Commission, 2014)

3.

Two big restaurants and one small bar at the Marineterrein



Sankey diagram of the existing food waste flow in Amsterdam



Sankey diagram of the potential food waste flow in Amsterdam, applying anaerobic digestion system with a greenhouse