# WASTE2ROAD

Biofuels from WASTE TO ROAD transport

LC-SC3-RES-21-2018 (818120)

# Deliverable Report

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# Description of the deliverable content and purpose

Deliverable 2.4 *'Inventory on optimal waste fraction availability'* is linked with Task 2.4 *'European perspective and deployment'*. The main aim of Task 2.4 is to establish an inventory of optimal waste fraction availability in the waste categories of contaminated wood, food residues and black liquor, which are studied in WASTE2ROAD, by quantifying the volumes available and the continuity of feedstock supply for production of advanced biofuels in Europe.

The purpose of D2.4 is to provide an example of an effective waste management strategy by analyzing operational data from the last 3 years of collection, sorting and treatment of biological waste in the City of Oslo. Oslo collects pre-sorted waste from households in different categories (paper, metal, organic, plastic, glass, etc.). The waste is treated in various recycling operations. The report focuses especially on collection, sorting and biological treatment of the organic fraction of the household waste which is utilized in the city of Oslo for biogas and biofertilizer production.

# Table of Contents

# 1 Introduction

This report describes waste collection methods used in the City of Oslo, with focus on household food waste and its treatment. Operational data from the years 2016-2019 are provided. The waste fractions from REG that were tested in WAST2ROAD include pre-treatment reject and digestate. The process, of how these waste fractions are obtained, is described in the report.

# 2 Organic waste in City of Oslo

REG (Renovasjons- og gjenvinningsetaten) is responsible for collection, sorting and treatment of waste in the City of Oslo. It collects waste from about 670 000 inhabitants, representing about 12 % of the total Norwegian population. Collection and separation of household food waste, its biological treatment and operational data from the waste sorting facility (in Oslo) and the associated biogas plant (in Romerike) are described in the following sub-chapters.

## 2.1 Collection and separation

The Oslo inhabitants sort their waste in three fractions in differently colored plastic bags in their homes (Figure 1). Besides these three waste categories, the inhabitants also collect separately paper/cardboard/drinking cartons, glass/metal and dangerous toxic waste (e.g., batteries). The plastic bags containing plastic, food and residual waste are collected in the same container and transported by trucks to one of the waste management facilities where the waste is optically sorted. The plastic waste is sent for material recovery (not described in this report). The residual mixed waste is incinerated, and the recovered heat is delivered to the city's district heating system. The food waste collected in the green bags is transported to a nearby biogas plant at Romerike where it is further processed.


Figure 1: Waste sorting system in households in the City of Oslo: a) sorting at homes, b) garbage collecting truck, c) and d) optical sorting of bags.

## 2.2 Biological treatment

The Romerike biogas plant receives household food waste in the green bags, as well as liquid food waste from industrial production and food waste from commercial activities and other industries that are not covered by the municipal waste collection system. The food waste from Oslo's households represents about half of all the food waste received at the Romerike biogas plant. To produce biogas, the liquid waste can be pumped directly into the buffer tanks but the solid waste needs to undergo a multi-step pre-treatment process [1]. The whole process is illustrated in Figure 2 and described below.

In steps 1-3, **'Preparation and removal of unwanted adverse elements'**, a grinder opens up the bags and reduces the size of the raw material. The waste is transported on a belt and unwanted pieces of metal misplaced with the food waste are removed by a magnetic separator. After removal of metals, the waste continues into a bio-separator, where water is added, and plastic, packaging and other unwanted larger objects are sorted out. The size of the particles is reduced and a liquid substrate is formed which passes through a sieve before it is pumped further into a screw press where the remaining unwanted materials are removed. The materials removed in the screw press can be for example larger pieces of vegetables and fibrous materials[1]. Finally, the liquid substrate, free of all unwanted materials, is pressed through a sieve with 10 mm holes.

In step 4, **'Intermediate in storage tanks'**, the liquid substrate is further transferred to temporary storage in three buffer tanks. The purpose of intermediate storage in the buffers is to ensure an even compositional distribution of waste, regardless of the quality of waste deliveries and irregularities in the pre-treatment steps.

In steps 5-7, **'Thermal hydrolysis'**, the substrate is pumped from the buffers into several pressure tanks (thermal hydrolysis process – THP) where it undergoes sterilization. In the pulper, the substrate is pre-heated to between 80-100 °C and then sent to a reactor tank where the temperature and pressure are elevated to 130 °C and 4,5 bar, respectively, to kill pathogens and other noxious bacteria/fungi. The flash tank is used to damage the cell walls, due to a rapid change of pressures, which makes the material more accessible to the bacteria in the bio-reactor.

In step 8, **'Rotting in the bio-reactors'**, the pre-heated substrate then enters the bio-reactors where it disintegrates by a bacterial culture in anaerobic conditions (anaerobic digestion). The temperature in the bio-reactor is at 38 °C and the retention is about 24 days. The biogas generated in this process consists of approx. 60 % $CH_4$ and 40 % $CO_2$. After 24 days, the material is strongly degraded and a digestate remains[2] The digestate is further treated to produce a bio-fertilizer which can be sold in Norway to farmers.

[1] This type of reject contains a significant organic fraction and in WASTE2ROAD, it is defined as pre-treatment reject, which was tested as a feedstock in fast pyrolysis (more information available in D2.2 Waste sorting matrix).
[2] Digestate is also one of the feedstocks tested in WASTE2ROAD by both HTL and fast pyrolysis.

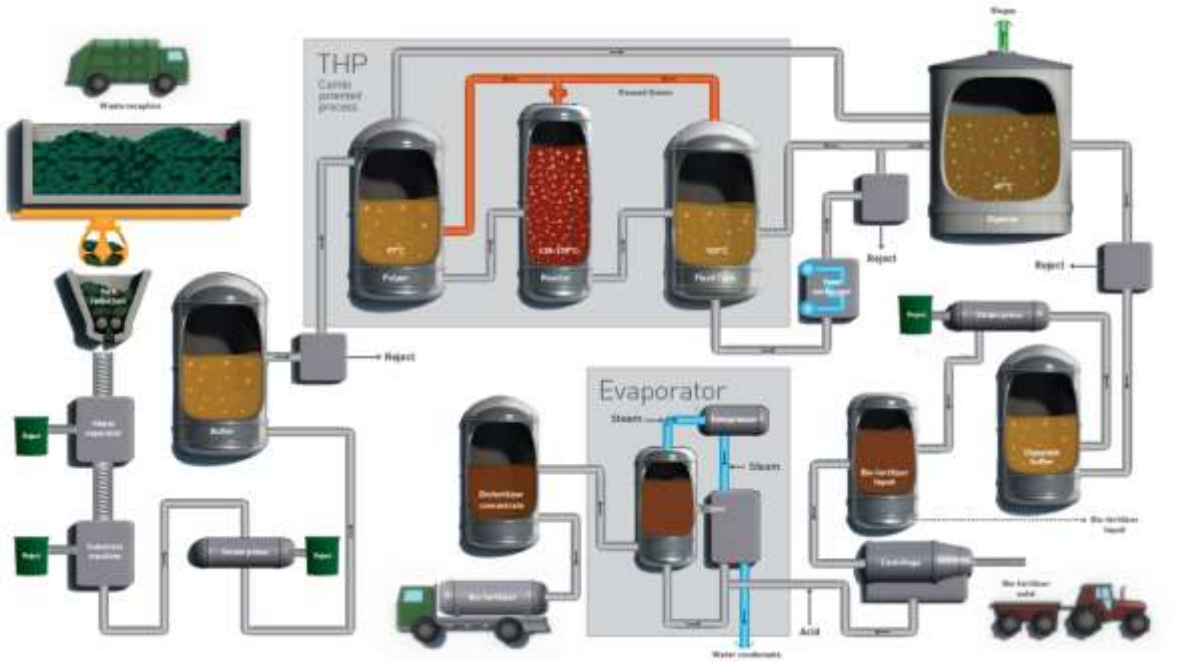

Figure 2: Biological treatment of organic waste collected in Oslo.

## 2.3 Amounts of food waste collected in 2016-2019

The City of Oslo collects and treats between 16-19 ktonnes of food waste from households every year (Table 1). This corresponds to about 8-9 % of all the food and wet organic waste collected in Norway. Taking into account the number of inhabitants, the amount of generated household food waste is about 28 kg/capita/year. According to [1], this represents about 50 % of all the food waste generated by households. The other 50 % end up in mixed municipal waste due to lack of sorting by the consumers at home. The City of Oslo aims to increase the sorting rate for food waste up to 60 % by 2025 while reducing the food waste generation by 30 %.

During the treatment process, food waste from households is mixed with food waste generated from industrial and commercial activities, including minor amounts of food waste occasionally accepted from other waste management facilities (outside Oslo) and animal manure (not received on regular basis, in the past years mainly for testing purposes). In total, about 30 ktonnes of food and other wet organic waste per year is sent to biogas production in Oslo, the food waste from households representing the share of about 55 – 63 %. This is the maximum amount of waste that can be treated by the biogas plant in Romerike, since its capacity is 30 ktonnes/year.

Table 1: Amount of food waste (FW) collected from households, industrial and commercial activity, and other types of organic waste sent to biogas production in Oslo.

| Year | FW Oslo households (tonnes) | FW Oslo industrial/commercial (tonnes) | FW other than Oslo (tonnes) | Animal manure (tonnes) | Total (tonnes) |
|---|---|---|---|---|---|
| 2016 | 16635 | 11505 | 2055 | | 30196 |
| 2017 | 17578 | 10041 | 885 | 43 | 28546 |
| 2018 | 16853 | 8612 | 1490 | 53 | 27008 |
| 2019 | 18936 | 7725 | 3488 | 122 | 30272 |

The amount of food waste collected in households on weekly basis in the years 2016 – 2019 is shown in Figure 3. The figure shows that the amount of food waste received throughout the years is quite consistent (on average approx. 320-360 tonnes/week), with a distinct drop around week 30, which corresponds to the summer holidays (July, August). Also, somewhat higher values than average are typically observed in the beginning and at the end of the year, due to Christmas holidays, when the disposal of food waste is higher.

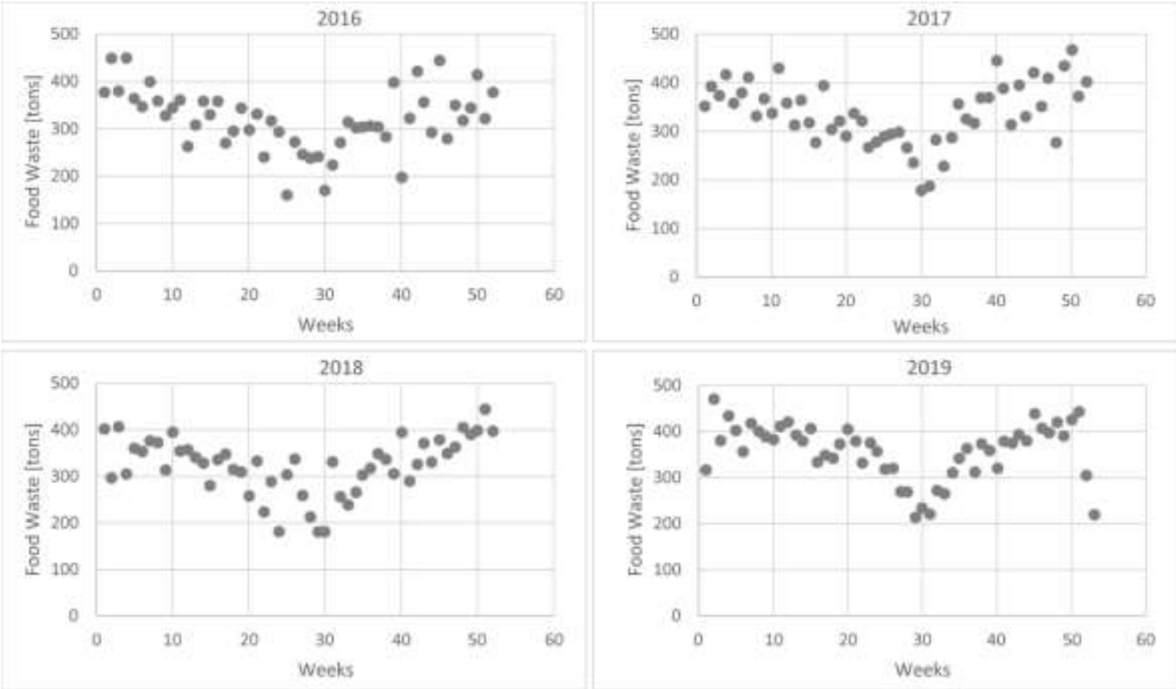


Figure 3: Food waste collected in Oslo's households on weekly basis in the years 2016-2019.

Figure 4 shows the data on the amounts of food waste generated by industrial and commercial activities in the City of Oslo in 2016-2019. This data seems to be much more scattered compared to the data in Figure 3. The average value of 221 tonnes of industrial food waste per week in 2016 declines throughout the years to 146 tonnes per week in 2019, consistent with the data in Table 1.

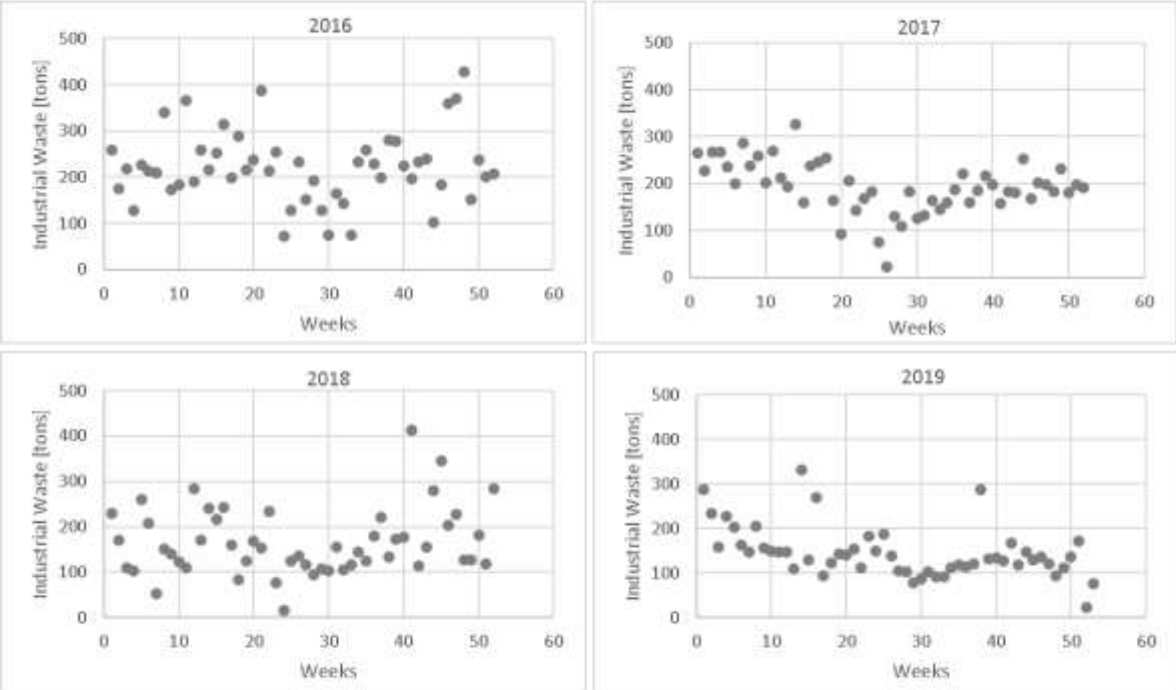


Figure 4: Food waste collected in industrial and commercial activities in the city of Oslo on weekly basis in the years 2016-2019.

## 2.4 Pre-treatment reject collected in 2016-2019

Pre-treatment reject is a material removed from food waste during the multi-step biological treatment prior to biogas production. It contains a relatively high organic content (mainly fibrous residues rejected by screens in the waste size reduction process in Figure 2) but also contaminants such as pieces of glass, plastic from packaging or green bags as shown in Figure 5.

Figure 5: Pre-treatment reject.

The pre-treatment reject is today sent to incineration, however, due to the relatively high organic fraction, it could also be an interesting feedstock for bio-conversion, assuming the contaminants can be removed.

The amount of pre-treatment reject in the years 2016-2019 is given in Table 2. This, compared with the numbers in Table 1, represents about 20 % of the total food waste amount sent to biological treatment.

Table 2: Amount of pre-treatment reject in the years of 2016-2019.

| Year | Reject (tonnes) |
|---|---|
| 2016 | 5597 |
| 2017 | 5935 |
| 2018 | 5115 |
| 2019 | 5919 |

The data on pre-treatment reject collected on weekly basis is shown in Figure 6

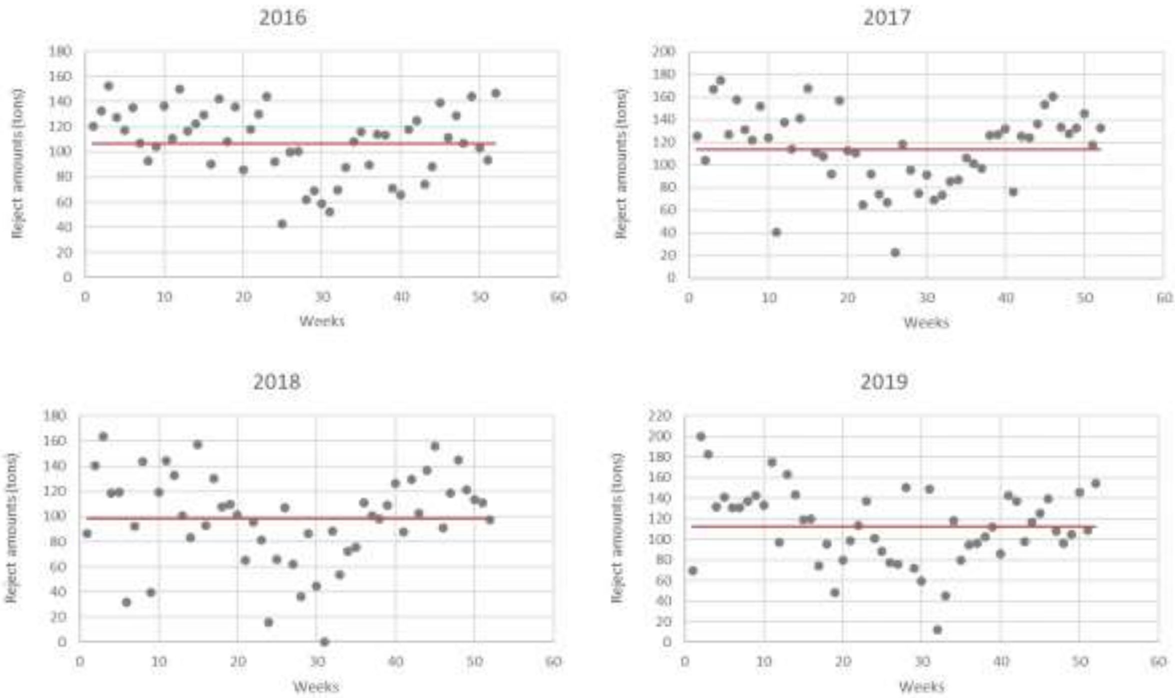


Figure 6: Pre-treatment reject collected on weekly basis.

There is some degree of fluctuation in the amount of reject on weekly basis. The amounts tend to be in general lower during the summer vacation period (around week 30) consistent with the trend observed in food waste generation in households.

## 2.5 Biogas and bio-fertilizer production

The food waste collected in the City of Oslo is primarily used for biogas and biofertilizer production. As shown in Figure 7, the produced biogas is partly flared (due to larger volumes of biogas produced than can be handled in the upgrading facility), partly used internally for energy and partly sent to upgrading to produce bio-methane which is used in the City of Oslo as transport fuel (buses and heavy vehicles). The amount of upgraded biogas has been increasing in the years of 2016-2019, reaching 57 % of the total biogas production in 2019. This is mainly due to improvements and optimization of the biogas plant infrastructure.

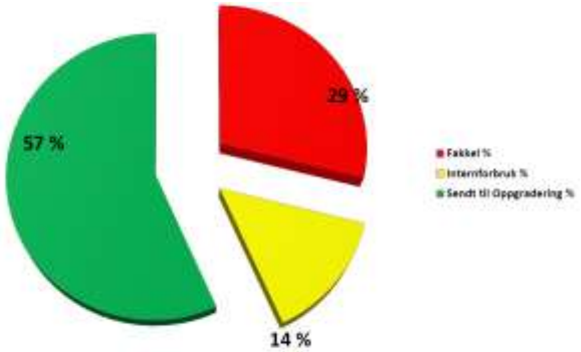


Figure 7: Distribution of the total biogas production in 2019: "Fakkel" means Flared, "Internforbruk" means Internal Use, "Sendt til oppgradring" means Sent to upgrading [4].

The remaining material remaining in the bio-reactors after digestion is called digestate. Digestate contains important nutrients, such as phosphorus, nitrogen potassium and organic material and in Norway, it can be used as bio-fertilizer. Digestate is in the Romerike biogas plant utilized to produced three forms of fertilizer:

- **Dewatered/liquid** – the digestate is transported from the reactor tank to the buffer tank, where it is filtered and then made into liquid biofertilizer.
- **Solid** – the liquid digestate is centrifuged, creating a solid organic material which is highly suitable for improving soil quality. The product is rich in phosphorous.
- **Bioconcentrate** – biowater after centrifugation is acidified, evaporated and accumulated. Concentrated biofertilizer is rich in potassium and nitrogen. The digestate is a sustainable alternative to chemical fertilizers. By recycling food waste and converting it to biofertilizer, we are creating a life cycle, whereby organic material and valuable nutrients from the food waste are used in the product of food. Products based on biofertilizer can be adapted to many different target groups, and used in agriculture, horticulture, gardens and for road construction [6].

The amount of produced biogas and bio-fertilizer in the years of 2016-2019 is shown in Table 3.

Table 3: Amounts of produced biogas and bio-fertilizer in the years 2016-2019 [4, 5].

| **Year** | **Produced biogas ($Nm^3$)** | **Sold bio-fertilizer (tonnes)** |
|---|---|---|
| 2016 | 2 907 955 | 44 849 |
| 2017 | 2 641 548 | 45 118 |
| 2018 | 3 031 923 | 33 775 |
| 2019 | 4 914 841 | 47 778 |

# 3 Conclusion

This report presents operational data on food waste handled by Oslo Municipality in years 2016-2019 and describes its treatment process. Information about how much food waste is generated in source sorted per inhabitant in the City of Oslo is provided. This gives an input to WP5 on feedstock amount available for potential production of advanced biofuels based on food residue value chain with hydrothermal liquefaction as the bio-conversion technology.

# References


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