E-CARGO BIKES IN WASTE MANAGEMENT: A CASE STUDY ON ALTERNATIVE FOOD WASTE COLLECTION

S. WALK[1], S. HERNANDEZ OSTOS[1], I. KÖRNER[1]
[1]*Hamburg University of Technology, Bioresource Management Group (BIEM), Hamburg, Germany.*

1. Keywords

Food waste, Circular Bioeconomy, Waste collection, E-cargo bike, Reverse logistics

2. Highlights

- Test of an electrically powered cargo bike for collecting food waste.
- Evaluation of logistical parameters related to collection and transport phase.
- The first tests indicate the suitability of the bike for food waste collection.
- Benefits related to traffic and emission reduction and specific applications.

3. Purpose

Waste management is increasingly becoming the focus of national and international goals to create an efficient circular economy. Food waste (FW), as one of the most important streams of household waste, still faces some major management issues. It is commonly the main cause for impurities in the biowaste bin and has a low source-separation efficiency. Only about 1/3 of FW of German households is sorted correctly (Dornbusch et al. 2020). This is partly due to the rigid German collection system, which offers low collection frequency and few financial incentives for better sorting. Sustainable Development Goal 12.3 aims to reduce FW by 50 % by 2030 and underlines the need for proper treatment of the part that is not reduced (European Commission 2015). Therefore, innovative means of collection are necessary. In addition, sustainable transport is needed to support clean urban development. The *Clean vehicles procurement act* requires a share of 38.5% of clean vehicles in the light vehicle sector (Bundesministerium der Justiz und für Verbraucherschutz 2021). Therefore, small e-vehicles are increasingly used in many logistics sectors, also due to government funding opportunities. Existing studies on services such as deliveries show the advantages of using small vehicles for the last mile (Gruber et al. 2019, Zacharias et al. 2015). This study examines the collection concept in relation to waste management, especially for FW. This is to demonstrate that the concept of first or last mile logistics can be beneficial for the overall improvement of waste management.

4. Materials and methods

The concept is tested in four steps. It aims to evaluate collection-related indicators to prove the technological usability of the e-cargo bike. Waste collection is divided into three stages, i) empty drive from origin to collection, ii) stop-and-go during collection and iii) loaded return to origin. In order to perform a full potential analysis, parameters such as average speed, average loading time per stop, average gradient of the distance travelled, average unloading time, total travel time, total electricity consumption and total travel distance per battery charge are examined. These parameters are analysed individually for the following scenarios of the logistical phases of waste collection:

1. Transportation phase: Driving of predefined route by different drivers at different conditions, empty to fully loaded. The goal is to measure the electricity use, maximum distance but also manoeuvrability.
2. Collection phase 1: Driving of predefined route in a dense urban neighbourhood. It simulates the drive until the bike is fully loaded and returns to the place of waste storage or treatment. The goal

is to measure the electricity use, maximum distance but also manoeuvrability during intense stop-and-go. As in scenario 1, both, empty and fully loaded, is evaluated.

3. Collection phase 2: Driving of predefined route and stops and simulated FW collection on the university campus. Stops include different amounts of small buckets filled with FW. Distance between stops correspond with distance between houses in a dense urban area. The goal is to measure the time it takes during the stops to collect FW.
4. Real case scenario: Collection of biodegradable waste is performed from real providers, such as a local farm, daily local market and a school canteen. The goal is to measure all parameters of 1 – 3 plus the influence of different types of biodegradable waste.

5. Results and discussion

With a loading capacity of up to 180 kg, the bike can theoretically serve between 600 and 1000 households depending on the FW generation and source-separation efficiency in households. In a flat environment, the average speed in the transport phase is 15.7 (± 0.8) km h^{-1}. The speed in the collection phase is estimated to be similar to that of conventional collection vehicles, at least in areas with high population density. However, small collection containers that can be lifted manually are needed. The evaluation of further parameters included in the methodology is currently in progress.

6. Conclusions and perspectives

Although the concept for using e-cargo bikes in municipal waste management is not well explored, its dynamics are comparable to other existing services such as grocery or mail delivery. E-cargo bikes, or small electric-powered vehicles in general, can provide a large impact in transitioning waste collection to a more sustainable approach. They can be an integrative part of reverse logistics in a decentralised management approach. Their application is seen in three different concepts: i) in central areas with narrow streets and lack of space, such as old towns, where waste collection with shared large bins, including navigation of large trucks, is a challenge, ii) newly built neighbourhoods which have the goal to be traffic-calmed and iii) in multi-family housing areas where waste separation is a problem. In addition to the environmental benefits of using e-cargo bikes, such as the reduction of exhaust gas during waste collection, they can also bring social benefits. On the one hand, they create a health-promoting activity within waste collection for the responsible worker and, on the other hand, new jobs related to future green bioeconomy.

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7. References

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