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A proposed framework of food waste collection and recycling for renewable biogas fuel production in Hong Kong

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ABSTRACT

Hong Kong is experiencing a pressing need for food waste management. Currently, approximately 3600 tonnes of food waste are disposed of at landfills in Hong Kong daily. The landfills in Hong Kong are expected to be exhausted by 2020. In the long run, unavoidable food waste should be sorted out from the other municipal solid waste (MSW) and then valorized into valuable resources. A simple sorting process involving less behavioural change of residents is, therefore, of paramount importance in order to encourage residents to sort the food waste from other MSW. In this paper, a sustainable framework of food waste collection and recycling for renewable biogas fuel production is proposed. For an efficient separation and collection system, an optic bag (i.e. green bag) can be used to pack the food waste, while the residual MSW can be packed in a common plastic bag. All the wastes are then sent to the refuse transfer stations in the conventional way (i.e. refuse collection vehicles). At the refuse transfer stations, the food waste is separated from the residual MSW using optic sensors which recognize the colours of the bags. The food waste in the optic bags is then delivered to the proposed Organic Waste Treatment Facilities, in which biogas is generated following the anaerobic digestion technology. The biogas can be further upgraded via gas upgrading units to a quality suitable for use as a vehicle biogas fuel. The use of biogas fuel from food waste has been widely practiced by some countries such as Sweden, France, and Norway. Hopefully, the proposed framework can provide the epitome of the waste-to-wealth concept for the sustainable collection and recycling of food waste in Hong Kong.

1. Introduction

The disposal of mounting municipal solid waste (MSW) is an imminent problem for Hong Kong society. Currently, Hong Kong relies mainly on landfills for MSW disposal. In 2012, approximately 9000 tonnes of MSW were disposed of in the landfills every day. It is anticipated that the current three strategic landfills in Hong Kong, namely South East New Territories, North East New Territories, and West New Territories, will reach their maximum capacities by 2020 (HKEPD, 2013a). Of the 9000 tonnes of MSW disposed of at landfills, about 3600 tonnes is food waste, representing the largest waste component of MSW in Hong Kong. Food waste in Hong Kong generally refers to the organic waste generated during food production and processing, wholesale and retail preparation, after meal leftovers, and expired foods. The food waste per capita in Hong Kong is comparatively higher than those of other Asian cities of similar economic status. For example, the food waste per capita in Hong Kong is about 2 times higher than those in Singapore and South Korea. In addition, the food waste recycling rate is low in Hong Kong (0.6%), which is far below compared to other urban cities in Asia such as South Korea (95%), Taiwan (31%) and Japan (25%) (MOE, 2012; LegCo, 2013; EPA, 2014a,b).

The current practice of disposing food waste at landfills is not a sustainable approach in Hong Kong, as it incurs fast depletion of landfill space, generates odour nuisance, and produces greenhouse gases and leachates, thus causing severe adverse environmental problems. A landfill ban on organic waste has been practiced by a few countries. In South Korea and Sweden, a banning disposal of food waste at landfills has been imposed since 2005. In Germany, zero disposal of biodegradable municipal waste at landfills has been reported since 2006. Similarly in Norway, a landfill ban on biodegradable waste was enforced in 2009. Meanwhile, the accelerating human population growth and growing global energy demand in the society have stimulated rigorous research efforts to valorize waste to resource in order to meet such global targets. The security of supply energy may likely become an increasingly important aspect of decision making for developing a sustainable city. Due to these circumstances, unavoidable food

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waste should be collected systematically and valorized to a value-added product for advancing environmental sustainability and economic development.

2. Proposed framework of food waste collection and recycling for renewable biogas fuel in Hong Kong

Among the 3600 tonnes of food waste generated daily, domestic households give rise to about 2500 tonnes, while around 1100 tonnes come from food associated with commercial and industrial (C&I) sources (HKEB, 2014). Assuming that the food waste collection rates of domestic household and C&I sectors are 50% in the future, the total food waste collection rate in Hong Kong is about 1800 tonnes per day (tpd). This amount renders a massive challenge to society if the collected food waste is not recycled and valorized to a value-added product, as far as possible. A systematic food waste separation and collection system, together with environmentally friendly food waste valorization technologies is, therefore, imperative in order to form a sustainable food waste management framework in Hong Kong.

In light of this need, a sustainable framework of food waste collection and recycling for valorizing the food waste to renewable biogas fuel is proposed in this study. The proposed framework is established in consideration of the food waste collection and recycling systems in certain cities such as Oslo in Norway, Linköping in Sweden, and Lille in France, as well as with reference to the food waste management environment and community needs in Hong Kong. The proposed framework of the food waste collection and recycling for the food waste valorization in Hong Kong is shown in Fig. 1, and consists of three parts: (i) food waste separation at source and collection; (ii) food waste valorization to value-added products; and (iii) other MSW treatment. It is hoped that the proposed framework can also act as a reference for other urban cities that face a food waste disposal dilemma similar to Hong Kong's environmental conditions.

3. Proposed optic bag system for food waste separation and collection at source in Hong Kong

Source separation is a critical step in dealing with the increasing problem of food waste in society prior to transporting the food waste to various recycling facilities. In Hong Kong, most of the food waste, particularly the food waste from domestic households, is not sorted out from other types of MSW prior to discarding in the three strategic landfills. Residents, nevertheless, are responsible for separating the food waste from the other MSW produced in their home. If the residents fail to sort the food waste at source, the food waste will be contaminated and cannot then be recycled. A complicated sorting process in households, however, can discourage the residents from sorting their waste. A less behavioural change of the public is needed for the collection and separation of food waste. This is important to reduce any changes that might affect the lifestyle of the public and minimise potential impacts on the livelihoods of the public. In addition, the food waste collection system should be reasonably practicable built based upon the existing waste management system. By doing so, the public will not be required to travel to a new place or change their daily routine substantially for the sorting of food waste, and thus be more willing to take part in separating food waste at source. As such, a simple sorting process needing less behavioural change by residents is a key part in order to motivate the residents to sort the food waste from the other MSW. In order to achieve this objective, food waste and other types of MSW can be efficiently separated via an optic bag system.

By introducing the optic bag system, food waste will be packed in an optic bag (e.g. a bag in green colour), while the residual MSW will be packed in a common plastic bag or a pre-paid designated bag if MSW charging scheme is implemented by the Hong Kong Special Administration Region (HKSAR) Government. The optic bag comes in two sizes, which are 10 l size with 270 mm width × 130 mm depth × 480 mm height and 30 l size with 300 mm width × 220 mm depth × 640 mm height (Mepex, 2014). All the packed wastes will still be disposed of at the existing collection bins or rubbish chutes. By doing so, it will avoid the need for the households and C&I sectors to reconfigure the waste storage space in their properties. All the wastes will then be collected by the refuse collection vehicles and transported to the respective refuse transfer stations in Hong Kong. As such, no changes to collection routines are required. It is observed that the optic bag is comparatively thicker than the common plastic bag used in Hong Kong. In Oslo, Norway, the optic bag remains intact in the optical sorting plant after it is transported via refuse transfer vehicles. The refuse transfer vehicles used in Oslo are of similar configuration (i.e. with rear compactor) to those in Hong Kong. Hence, it is believed that the optic bag will not be damaged when it arrives at the refuse transfer stations in Hong Kong.

Upon arrival at the refuse transfer stations, all the waste bags will be unloaded into a receiving pit. At this point, the optic bags have yet to be separated from the other bags. All the bags will then be sent to a main conveyor belt, in which an optic sensor technology will be used to sort the bags. The green colour of the optic bag allows the optical camera in the sorting plant to identify and sort the optic bag from the other plastic bags automatically. When an optic bag of green colour (i.e. food waste) is detected, a signal will be sent to push the green bag off the main conveyor belt to a second belt. An Enviflex system (i.e. an automatic bag-opener and breaker of food waste) can be employed to separate the collected food waste from the optic bag. In the system, a hydraulically driven roller will be used to open the optic bag. The optic bag will be pulled in a long strip and the food waste will be broken into pieces of approximately 35–50 mm. The food waste and the optic bag will then be screened for separation. Finally, the food waste will be compacted and containerized in purposely built containers and then transported to various food waste recycling facilities for further treatment. Meanwhile, the other residual MSWs such as plastics and papers, which are packed in common plastic bags, will be sent to a proposed advanced incineration facility. After combustion, the heat generated will be used in a steam turbine for generating electricity.

The HKSAR Government is going to launch the MSW charging scheme based on a quantity-based system. According to this system, the waste charge could be introduced through the mandatory use of pre-paid designated garbage bags. The optic bag can be assigned as one of the pre-paid designated garbage bags for packaging food waste (the cost of an optic bag is about 0.1 Swedish Krona (SEK) or 0.1 Hong Kong Dollar (HKD) based on Swedish case), while the other pre-paid designated garbage bags can be used for the disposal of other types of MSW. To promote the implementation of optic bag system in Hong Kong, the HKSAR Government should work hand-in-hand with local industry, consumers and communities. It can be done through education by fostering positive behaviour change along with legislation, such as mandatory use of optic bag for packaging food waste or food waste disposal ban in strategic landfills.

3.1. Applications of optic bag system in other countries

The optic bag system has been applied in several countries especially in European countries such as Sweden and Norway. An optical sorting plant can be constructed in many different forms