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# Food waste disposal units in UK households: The need for policy intervention

Eleni Iacovidou, Dieudonne-Guy Ohandja, Nikolaos Voulvoulis *

*Centre for Environmental Policy, Imperial College London, London SW7 2AZ, UK*

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ABSTRACT

The EU Landfill Directive requires Member States to reduce the amount of biodegradable waste disposed of to landfill. This has been a key driver for the establishment of new waste management options, particularly in the UK, which in the past relied heavily on landfill for the disposal of municipal solid waste (MSW). MSW in the UK is managed by Local Authorities, some of which in a less conventional way have been encouraging the installation and use of household food waste disposal units (FWDs) as an option to divert food waste from landfill. This study aimed to evaluate the additional burden to water industry operations in the UK associated with this option, compared with the benefits and related savings from the subsequent reductions in MSW collection and disposal. A simple economic analysis was undertaken for different FWD uptake scenarios, using the Anglian Region as a case study. Results demonstrated that the significant savings from waste collection arising from a large-scale uptake of FWDs would outweigh the costs associated with the impacts to the water industry. However, in the case of a low uptake, such savings would not be enough to cover the increased costs associated with the wastewater provision. As a result, this study highlights the need for policy intervention in terms of regulating the use of FWDs, either promoting them as an alternative to landfill to increase savings from waste management, or banning them as a threat to wastewater operations to reduce potential costs to the water industry.



## 1. Introduction

The disposal of biodegradable waste to landfill can lead to the formation of landfill gas and leachate which can result in adverse environmental impacts. To control these impacts, the European Union (EU) Landfill Directive (1999/31/EC) came into force and requires all EU member states to reduce the amount of biodegradable waste going to landfill to 75% by 2006, 50% by 2009 and 35% by 2016, based on the waste production levels of 1995 (European Council, 1999). Countries which have been heavily reliant on landfill, such as the UK, have an additional four years to comply with the targets set in this Directive. Therefore, in order to reduce the amount of biodegradable waste going to landfill to 75% by 2010, 50% by 2013 and 35% by 2020, alternatives to landfill are increasingly being considered across the UK (European Council, 1999).

In the UK, Local Authorities (LAs) have the responsibility for managing municipal solid waste, of which a high proportion is biodegradable. To deliver the required landfill diversion targets they have promoted and implemented a wide range of waste management options including kerbside collection and recycling, home and centralised composting, centralised incineration, anaerobic digestion, and the use of food waste disposal units (FWDs) (Defra, 2007).

The use of FWDs foresees the diversion of food waste from the solid waste stream through grinding with the addition of water for direct discharge as wastewater in the sewers (Evans, 2007; Galil and Shpiner, 2001). Although most LAs would treat household food waste collected as part of the biodegradable fraction or separately, some (LAs) have been encouraging the installation and use of FWDs. As a result, in order to tie up with the recommendations set by LAs, FWDs have recently been installed in new housing developments.

In 2008, in the UK, 5% of households had FWDs (MTP, 2008), an installation rate considered to be the highest amongst the EU member states (EPA, 2008). Although their use is controlled in European countries, being banned in Austria, Belgium and Germany, and regulated locally by municipalities in Italy, France and Sweden, the story is very different outside the EU. The highest installation rate is found in the USA, where 50% of households have FWDs, whereas in Canada, Australia and New Zealand the installation rate of FWDs is about 10%, 12% and 30% of households, respectively (EPA, 2008).

This diversity in installation rates of FWDs is mainly attributed to the belief that the use of these units can be associated with a number of technical and environmental limitations. For that purpose available studies have recently been reviewed to examine the feasibility of their use (Iacovidou et al., in press). In these studies, recommendations on the use of FWDs as a waste management option differ widely and there is widespread uncertainty regarding their potential benefits and impacts to wastewater treatment works. This is mainly because different area-specific characteristics such as water resources, household

* Corresponding author. Tel.: +44 2075947459.
*E-mail address:* n.voulvoulis@imperial.ac.uk (N. Voulvoulis).

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practices, the condition of the sewerage system and different wastewater treatment processes can affect the viability of FWDs as a waste management option. These characteristics are important factors that must be taken into account before the adoption of FWDs as a wide scale waste management option (Iacovidou et al., in press).

In the UK, waste collection and disposal are not under the same authority as water industry operations and thus the use of FWDs becomes more complicated. This is because the use of FWDs would transfer the responsibility for food waste management from LAs to the water industry. As such, whilst LAs could benefit by reductions in the amount of waste collected, the water industry would be left to deal with the additional costs related to water treatment and distribution, wastewater treatment, and sludge treatment and disposal, without the transfer of the associated revenues.

Based on this supposition and with limited research undertaken in the UK on the potential impacts of the use of FWDs, this paper has evaluated the additional burden to water industry operations in the UK, compared with the benefits and related savings from the reduction in cost of waste collection and disposal to Local Authorities, using the Anglian Region as a case study. Although the methodology can be applied to any region, the Anglian Region was selected because of the availability of data that were provided or adopted from the literature.

## 2. Methods

The Anglian Region, one of the areas with the fastest growing population in the UK, was chosen as a case study. This region was identified by the Environment Agency as the driest region in the UK, with an average of 600 mm of rainfall each year, in contrast to the average 900 mm for the rest of England and Wales (Anglian Water, 2008). Anglian Water is the main provider for water and/or wastewater treatment services in this area (East of England) (Anglian Water, 2008). Based on the latest available data provided by the LAs and Anglian Water, year 2008 was chosen as the base year for calculations and 2035 as the projection year.

To evaluate the additional burden of the use of FWDs from year 2008 to year 2035, three scenarios were investigated. In these scenarios a current, future and hypothetical market installation rate was used to project the FWD penetration in 2035, based on the 2008 average FWD installation rate of 5% (MTP, 2008). The purpose of having these three scenarios was to show the magnitude of large-scale use of FWDs over the current penetration rates (Table 1).

In order to evaluate the benefits resulting from the use of FWDs, a simple economic analysis was undertaken. Cost elements borne by LAs included the collection and disposal of household residual waste. Household residual waste includes the waste that has not been separated for reuse or recycling. Food waste is a fraction of household residual waste and accounts for approximately 36.7% of it. Therefore this type of waste was considered in the analysis. For the water industry, cost elements such as water and wastewater treatment, sewer cleanse and sludge management were considered (Fig. 1).

The cost of household residual waste collection is largely dependent on the number of households in the Anglian region, whereas the cost of household waste disposal depends on the amount of household residual waste collected. According to that, changes in the fraction of food waste would not create any changes in the cost of waste collection. A reduction in the amount of food waste due to the use of FWD would reduce the amount of household residual waste for disposal, and therefore the associated cost. To calculate this cost, both the amount of household residual waste generated in the Anglian region and the fraction of food waste within it were first calculated. For each FWD penetration rate scenario, the food waste fraction in residual waste was changed and so, as a result, was the amount of household residual waste. The calculated amount of household residual waste collected and the cost value of household residual waste disposal (Table 2) were used to project the cost of household residual waste disposal to LAs in 2035. To calculate the cost of household residual waste collection, the number of households in the Anglian region was first calculated. This number, together with the cost value of household residual waste collection (Table 2), was used to calculate the cost of waste collection in the region. The cost values of household residual waste collection and disposal were based on the 2008 average costs, as estimated on the basis of data collected from LAs in the Anglian region. Increases in the landfill tax and inflation rates in these costs by 2035 were not included in the calculations not only to exclude the inherent uncertainties in these, but also to ensure that all costs are directly comparable. As the UK government has put landfill tax on an escalator from 2008 to 09 until 2014, these calculations provide a conservative estimate. With the annual increase in landfill tax set at £8 per tonne of waste, by 2014 landfill tax will be £80 per tonne in comparison to the £32 per tonne in 2008 that was used as the base year.

The costs of water treatment and distribution, wastewater collection and treatment, and sludge treatment and disposal, were calculated based on water consumption, tonnage of biochemical oxygen demand (BOD), and dry solids (DS) treated in the whole area, respectively (Table 2). Thus, increases in these parameters due to FWDs were used to estimate the additional costs. However, the marginal cost to treat an additional tonne of BOD or DS can be very different, depending on the method used. That is because some wastewater treatment plants can incur relatively small additional costs from BOD increase, whereas others have BOD, suspended solids (SS) or even heavy metal limits that disproportionally affect the marginal costs of an additional volume. In addition, costs associated with sewer cleansing and maintenance, although they constitute a cost to the water industry, were not calculated in the analysis mainly because there are no direct costs associated with the disposal of food waste in the sewer. Therefore it was difficult to accurately estimate how the disposal of food waste would increase these

**Table 1**
Scenarios of FWDs penetration rate.

| Scenario | FWDs penetration rate | | Assumption |
|---|---|---|---|
| | Increase per year (%) | Projected in 2035 (%) | |
| Low | 0.3 | 10 | Market penetration remains stable at current rates (MTP, 2008) |
| Medium | 1 | 24 | Market penetration increases as predicted by MTP (MTP, 2008) |
| High | 15 | 96 | Hypothetical case where FWD are promoted as 'the' waste management option |

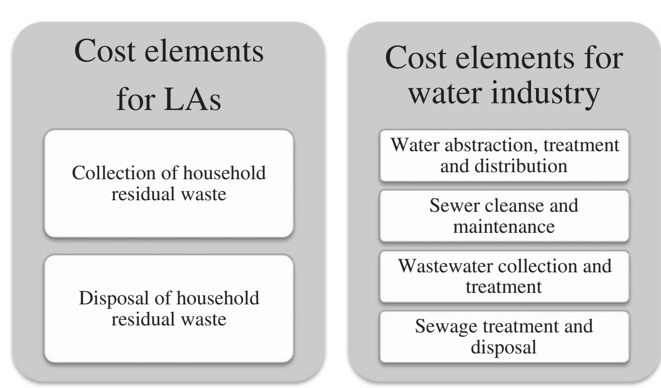


**Fig. 1.** Cost elements used for comparing the LAs savings to the water industry costs.

**Table 2**
Average costs to LAs and water and wastewater services.

| Parameters | Description | Value | Reference |
|---|---|---|---|
| Average cost of water consumption | Provided | £191.22/Ml | Ofwat (2008) |
| Average cost of wastewater treatment | Provided | £486.21/ tonneBOD | Ofwat (2008) |
| Average cost of sludge treatment and disposal | Provided | £217.43/tonneDS | Ofwat (2008) |
| Average cost of household residual waste collection | Adopted | £50.20/household | Audit Commission (2011) |
| Average cost of residual waste disposal | Adopted | £53.70/tonne residual waste | Audit Commission (2011) |

costs in the future. Although treatment of sewage sludge is costly, there are inherent benefits such as the increased generation of biogas, through the anaerobic digestion. Various treatment processes are currently used to stabilise sludge, ranging from simple mesophilic anaerobic to advanced treatment methods such as enzymic or thermal hydrolysis. Biogas production and energy consumption by these processes are highly variable and as such, these benefits could not be reliably estimated in this study (Caldwell, 2009; Jolly and Gillard, 2009).

In addition, inflation rates by 2035 for cost associated with water treatment and distribution, and wastewater collection and treatment, were again not included in the calculations due to related uncertainties, and in an attempt to ensure that the costs are directly comparable.

To calculate the costs to LAs and the water industry, certain parameters such as the number of households, the amount of household residual waste generated, the fraction of food waste diverted from residual waste, the amount of water consumed, the amount of wastewater, BOD, SS and DS generated in the whole region due to the use of FWDs, had to first be calculated. For calculating these parameters a number of equations were formulated. These equations were formulated based on a number of other parameters that have been either provided by the appropriate bodies, or adopted from the literature (Table 3). The methodology followed to calculate the aforementioned parameters, is analytically described below.

The first step was to calculate the amount of total household food waste generated and the quantity diverted from landfill to the sewer. Total household food waste generation ($FW_{gnr}$) was estimated based on the amount of food waste generated per household ($FW_{gnr/hh}$), and the number of households in any given year ($HH_{n+1}$) from the base year (when n = 0) in the Anglian Region as follows:

$$FW_{gnr} = FW_{gnr/hh} * HH_{n+1} \tag{1}$$

Knowing the amount of total household food waste generated in the region, it was then possible to estimate the fraction diverted from landfill, through the use of FWDs, based on food waste penetration rate ($FWD_{p.r}$) and the number of households that have a FWD ($HH_{FWD}$). This was calculated in each year, as follows:

$$HH_{FWD} = HH_{nFWD} + \left[(HH_{n+1} - HH_{nFWD}) * FWD_{p.r}\right] \tag{2}$$

Because not all food waste can be ground by a FWD, three main parameters were used to quantify the amount of food waste disposed of to the sewer: the amount of food waste generated per household, the number of households that have a FWD, and the fraction of food waste that could be ground by a FWD ($FW_{grd}$) as shown in Eq. (3).

$$FW_{FWD} = FW_{gnr/hh} * HH_{FWD} * FW_{grd} \tag{3}$$

Then, the following equation was used to calculate the percentage reduction of food waste landfilled:

$$\%FW_{DL} = \left(\frac{FW_{FWD}}{FW_{gnr}}\right) * 100 \tag{4}$$

The percentage increase in water consumption was calculated based on the amount of household food waste disposed to the sewer through the use of FWDs ($FW_{FWD}$), the volume of water needed

**Table 3**
Parameters used in the equations.

| Parameters | Description | Value | Reference |
|---|---|---|---|
| Food waste generation ($FW_{gnr}$) | Calculated | – | This study |
| Kerbside household residual waste generation | Adopted | 653 kg/household/year (12.6 kg/household/week) | Defra (2009) |
| Food waste generation per household ($FW_{gnr/hh}$) | Adopted | 4.6 kg/week (0.66kg/d) | WRAP (2008) |
| Number of households in the area and household growth per year ($HH_{n+1}$) | Provided | 2347335 and 1.35% | (Anglian Water, 2007; Ofwat, 2008) |
| Increase in number of households that have a FWD ($HH_{FWD}$) | Calculated | – | This study |
| Number of households in previous year that have a FWD ($HH_{nFWD}$) | Calculated | – | This study |
| FWD penetration rate ($FWD_{p.r}$) | Adopted | Scenario based | (MTP, 2008) and this study |
| Food waste diversion from landfill though the use of FWDs ($FW_{FWD}$) | Calculated | – | This study |
| Food waste ground by a FWD ($FW_{grd}$) | Adopted | 95% | Marashlian and El-Fadel (2005) |
| Food waste diverted from landfill ($FW_{DL}$) | Calculated | – | This study |
| Increase in water consumption due to the use of FWDs ($W_{inc}$) | Calculated | – | This study |
| Water consumption per kg food waste ground ($W_{FW}$) | Adopted | 11.7l | Thomas (2010) |
| Daily water consumption per capita ($W_{cap}$) | Provided | 150l | Ofwat (2008) |
| Population in the area and population growth per year ($P_{n+1}$) | Provided | 5484400 and 0.55% | (Anglian Water, 2007; Ofwat, 2008) |
| Increase in wastewater flow due to the use of FWDs ($WW_{inc}$) | Calculated | – | This study |
| Daily wastewater generation per capita ($WW_{cap}$) | Provided | 167.5l | Ofwat (2008) |
| Moisture content of food waste ($FW_{m.c}$) | Adopted | 70% | De Koning and van der Graaf (1996) |
| BOD/SS increase due to the use of FWDs ($X^{1,2}_{inc}$) | Calculated | – | This study |
| Daily BOD generation per capita ($X^{1}_{cap}$) | Provided | 60g | Thomas (2010) |
| BOD load in food waste ($X^{1}_{FW}$) | Adopted | 8.37 g/l | Thomas (2010) |
| Daily SS generation per capita ($X^{2}_{cap}$) | Provided | 80 g | Thomas (2010) |
| SS load in food waste ($X^{2}_{FW}$) | Adopted | 7.71 g/l | Thomas (2010) |
| DS increase due to the use of FWDs ($Y_{inc}$) | Calculated | – | This study |
| DS generation per cubic metre of wastewater ($Y_{WW}$) | Provided | 0.4 kg | Essex and Southend Waste (2010) |
| SS content per cubic of WW ($X^{2}_{WW}$) | Calculated | 0.418 kg | This study |

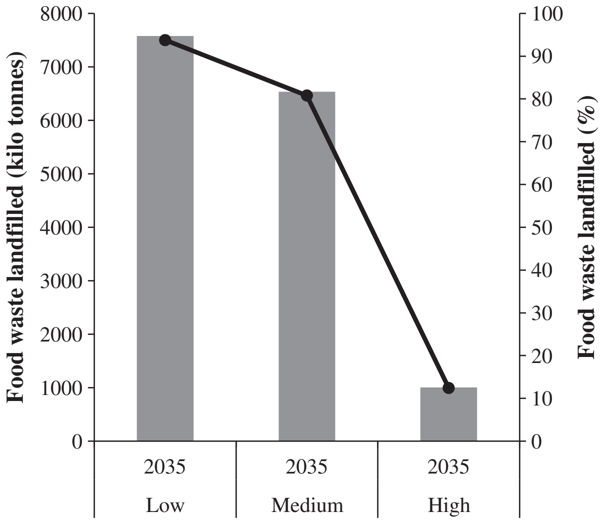


**Fig. 2.** Food waste disposed of to landfill in the Anglian Region based on the three scenarios at year 2035.

to grind food waste ($W_{FW}$), and the daily amount of water consumed ($W_{cap}$) due to population growth ($P_{n+1}$), as follows:

$$\%W_{inc} = \left[\frac{FW_{FWD} * W_{FW}}{W_{cap} * P_{n+1}}\right] * 100 \quad (5)$$

Similarly, the percentage increase in wastewater flow generation rate was calculated as shown in the following equation:

$$\%WW_{inc} = \left[\frac{FW_{FWD} * (W_{FW} * FW_{m.c})}{WW_{cap} * P_{n+1}}\right] * 100 \quad (6)$$

Besides the amount of food waste that is disposed to the sewer through the use of FWDs and the water needed to grind it, the moisture content of food waste ($FW_{m.c}$), was also used for calculating the additional wastewater generation rate due to the use of FWDs (Eq. (6)).

To calculate the increases in BOD and SS, the concentration of BOD ($X^1_{FW}$) and SS ($X^2_{FW}$) in food waste and the average quantity of BOD ($X^1_{cap}$) and SS ($X^2_{cap}$) generated per capita were used, as follows:

$$\%X^{1,2}_{inc} = \left[\frac{FW_{FWD} * W_{FW} * X^{1,2}_{FW}}{X^{1,2}_{cap} * P_{n+1}}\right] * 100 \quad (7)$$

Based on SS concentration the increase in dry solids (DS) generated due both to the use of FWDs and population growth was calculated as follows:

$$\%Y_{inc} = \left[\frac{\left(X^2_{FW}/X^2_{WW}\right) * Y_{WW}}{\left[\left(X^2_{cap} * P_{n+1}\right)/X^2_{WW}\right] * Y_{WW}}\right] * 100 \quad (8)$$

Many of the parameters used in the above equations were provided from waste collection and disposal authorities and water industry operations in the Anglian Region, whereas others were adopted from literature or calculated as described above (Table 3).

## 3. Results

This study shows that in 2008 approximately 563 kilotonnes of food waste was generated in the Anglian Region, of which 27 kilotonnes was diverted from landfill through the use of FWDs. By 2035, it is predicted that 809 kilotonnes of food waste will be generated. The projected low, medium and high FWD uptake scenarios correspond to the diversion of 50, 155 and 708 kilotonnes, respectively, of food waste from landfill to the sewer, leaving 759, 654 and 101 kilotonnes to be landfilled. This corresponds to a significant reduction of 12%, 81% and 94% in landfilled food waste, for low, medium and high scenarios, respectively (Fig. 2).

This diversion is the main cause of increases in water consumption, wastewater flow and characteristics and sludge generation rates, and corresponding decreases in household residual waste collected and disposed, each with associated cost increases and decreases.

In 2008, a diversion of 27 kilotonnes of food waste from landfill to sewers through the use of FWDs resulted in an increase of 0.86Ml/d out of the total 621Ml/d in water consumption with a 0.14% increase in the total cost. In terms of wastewater flow and characteristics, 0.91Ml/d out of 920Ml/d of the wastewater generated was attributed to the use of FWDs, with BOD and SS increases being 7 and 6.6 tonnes/d out of a total of 329 and 439 tonnes/d, respectively. These increases were responsible for an increase of £1.3 million to associated costs. Sludge generation and disposal accounted for a cost increase of approximately 1.51%, attributable to the additional volume of 5.5 tonnes/d from the total of 368 tonnes/d. The total cost of these increases was estimated at £1.86 million, out of a total of £131 million water industry costs.

In the projection year 2035, food waste diversion to the sewer would result in higher increases in water consumption, wastewater flow and characteristics (Table 4).

In 2035, the projected increases in water consumption, wastewater flow and characteristics would account for a substantial increase in their associated costs (Table 5).

The increase in cost becomes more pronounced as we move from the low scenario to the high one. In all scenarios, the highest contribution

**Table 4**
Summary of the potential increases in water industry due to the use of FWDs, for all scenarios examined in year 2035.

| Parameter | Low | | Medium | | High | |
|---|---|---|---|---|---|---|
| | Additional load per day (year) | Increase (%) | Additional load per day (year) | Increase (%) | Additional load per day (year) | Increase (%) |
| Increase in water consumption in Ml ($W_{inc}$) | 1.6 (592) | 0.2 | 4.9 (1816) | 0.7 | 22.7 (8283) | 3.2 |
| Increase in waste-water flow in Ml ($WW_{inc}$) | 1.7 (627) | 0.1 | 5.3 (1925) | 0.4 | 24 (8778) | 1.8 |
| BOD increase in tonnes ($X^1_{inc}$) | 13.6 (4955) | 2.9 | 41.2 (15201) | 8.8 | 190 (69326) | 40.2 |
| SS increase in tonnes ($X^2_{inc}$) | 12.5 (4564) | 2 | 38.4 (14002) | 6 | 175 (63860) | 27.8 |
| DS increase in tonnes ($Y_{inc}$) | 10.5 tonnes (3823) | 2 | 32 tonnes (11729) | 6 | 146.5tonnes (53492) | 27.8 |

**Table 5**
Expected cost increases to the water industry due to the use of FWDs in year 2035 for all scenarios.

| Description | Low | | Medium | | High | |
|---|---|---|---|---|---|---|
| | Extra cost (£ million) | Increase (%) | Extra cost (£ million) | Increase (%) | Extra cost (£ million) | Increase (%) |
| Water treatment and distribution | 0.11 | 0.2 | 0.35 | 0.7 | 1.58 | 3 |
| Wastewater treatment | 2.41 | 3 | 7.39 | 9 | 33.71 | 40 |
| Sludge treatment and disposal | 0.83 | 2 | 2.55 | 6 | 11.63 | 28 |

to cost comes from the wastewater treatment, followed by sludge treatment and disposal, and finally water treatment and distribution (Table 5). The total cost that the water industry would incur in 2035 for the low to high scenario was estimated at between £179 and £223 million (Fig. 3). The £223 million is the cost the water industry would incur in the case of a high uptake of FWDs, of which the total extra cost due to the use of FWDs was estimated at £48 million. This extra cost corresponded to an increase of 27% over the total cost of £223 million.

Accordingly, in the low and medium scenarios the total cost was estimated at £179 million and £186 million, of which £3.4 million and £10.3 million, respectively, were credited to the use of FWDs. These extra costs would have corresponded to an increase of 2% and 6%, for low and medium scenarios, respectively.

For LAs, the cost of collection and disposal of household residual waste in 2008 was estimated at approximately £118 million and £81 million, respectively, adding up to a total of £199 million. In that year, the amount of residual waste generated in the Anglian Region was estimated at 1533 kilotonnes, but only 1506 kilotonnes was collected by LAs. The remaining 27 kilotonnes was the amount of food waste diverted to the sewer through the use of FWDs. The total amount of food waste generated in the same year was approximately 563 kilotonnes.

In 2035, the projected amount of household residual waste that would have been generated in the entire region was estimated at 2202 kilotonnes, of which 809 kilotonnes was food waste. Of the 36.7% of food waste in household residual waste, approximately 2%, 7% and 32% would have been diverted from kerbside collection to the sewer through the use of FWDs in low, medium and high scenarios, respectively (Fig. 4).

The cost of household waste collection in 2035 was estimated to be £169 million for all scenarios, whereas the cost of disposal varied

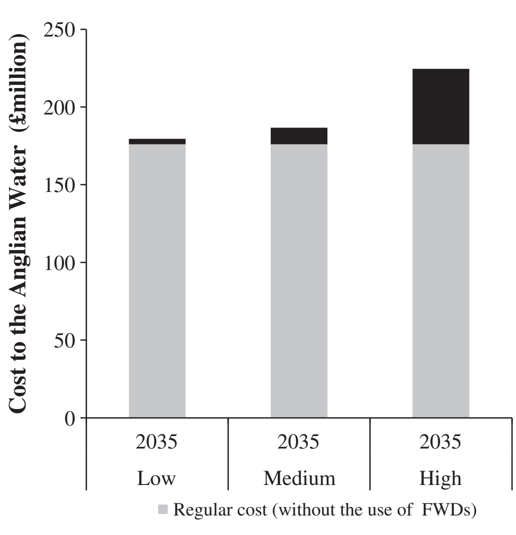


**Fig. 3.** Total cost to the water industry in year 2035 for all scenarios.

between £80 and £116 million (Fig. 5(a)). Savings to LAs resulting from the reduction of food waste fraction in household residual waste were estimated at £3 million, £8 million and £38 million, for the low, medium and high scenarios, corresponding to an increase in savings of 1%, 3% and 13% respectively (Fig. 5(a)).

As the food waste fraction in household residual waste decreases, a less frequent collection of household waste would be required. In such case, LAs could adopt a biweekly collection scheme in order to maximise their savings. The biweekly scheme could introduce flexibility in residual waste collection frequency. Based on calculations, biweekly collection could be implemented by year 2023, potentially saving £71.8 million to LAs. For every year since 2023 until 2035, savings to LAs from the biweekly collection increase by approximately £1 million per year. In our analysis, the assumption that a biweekly scheme, could only be applied to the high scenario, when the food waste fraction is considerably reduced was made. Based on this, LAs could obtain significant additional savings in waste collection under the high scenario (Fig. 5).

The cost of collection and disposal under the low and medium scenarios remains the same in both schemes with a noticeable decrease only in the high scenario. In that scenario the cost of waste collection was reduced to approximately £85 million, due to the adaptation of the biweekly scheme, presenting to LAs additional savings of approximately £84 million. These savings, added to the savings from household waste disposal, result in a total reduction in cost of £122 million in year 2035, which corresponded to a 43% increase in LA savings.

## 4. Discussion

The simple economic analysis undertaken in this study demonstrates that the use of FWDs can be an effective alternative waste management option that diverts food waste from landfill. This diversion of food waste from the solid waste stream to the sewer could be beneficial for LAs. Results demonstrate that there are two options by which LAs could benefit from this diversion. The first option is based on the current waste collection regime in which, as the fraction of food waste in the kerbside household residual waste decreases, the overall cost of household waste disposal also decreases. This decrease in cost becomes more significant in the high scenario in which the FWD penetration rate reaches 96% in the entire region. However, in the high scenario, the fraction of food waste in household residual waste is so small that the kerbside collection of household residual waste could become less frequent, potentially leading to the adoption of a biweekly waste collection scheme. Adoption of such a scheme could maximise the savings on waste collection and disposal for LAs.

The cost to the water industry could be manifested by the increases in water consumption, and in tonnes of BOD and DS treated. Although increases in water consumption due to the use of FWDs were found to be not significant, the associated cost was found to be substantial both directly and environmentally. Environmentally, because even minor additional water consumption can be detrimental in the Anglian Region – which has been classified as an area of 'serious' water stress – and it is not clear whether the existing water resources would be enough to deliver the additional water demand in the future (Anglian Water, 2008). Directly because, the need for increased water

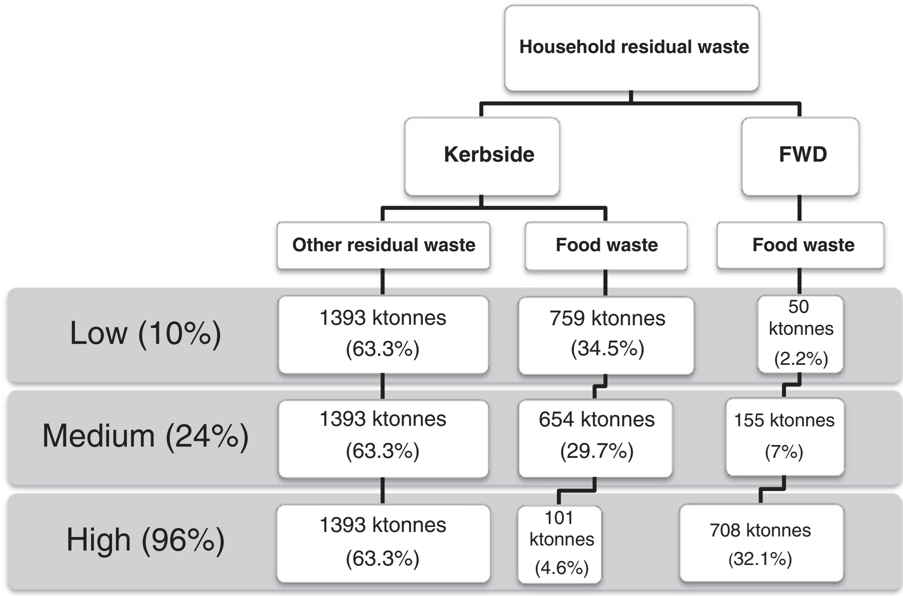


**Fig. 4.** Household residual waste distribution in 2035.

treatment and distribution, due to the use of FWDs in the Anglian Region, comes with additional cost. This cost was found to increase recognisably, but not substantially, as the FWD penetration rate was increased. However, increases in cost, even if small, can be of significant importance when it comes to the aggregate cost, although it should be acknowledged that FWD engineering and product design could have a positive impact on this, with new generation of FWDs, for example, taking less time to grind food waste and thus, using less water, or using alternative sources of water such as recycled water after dish cleaning or other uses in a household, in order to reduce the water demand.

Increases in cost due to the additional BOD and the resulting DS treated accounted for the major part of the extra cost associated with the use of FWDs. Although not included in this analysis, one of the main concerns of the water industry is also the increase in cost associated with sewer blockages (Perriam, 2007; Water UK, 2009). The use of FWDs increases SS and fat, oil and grease (FOG) concentrations

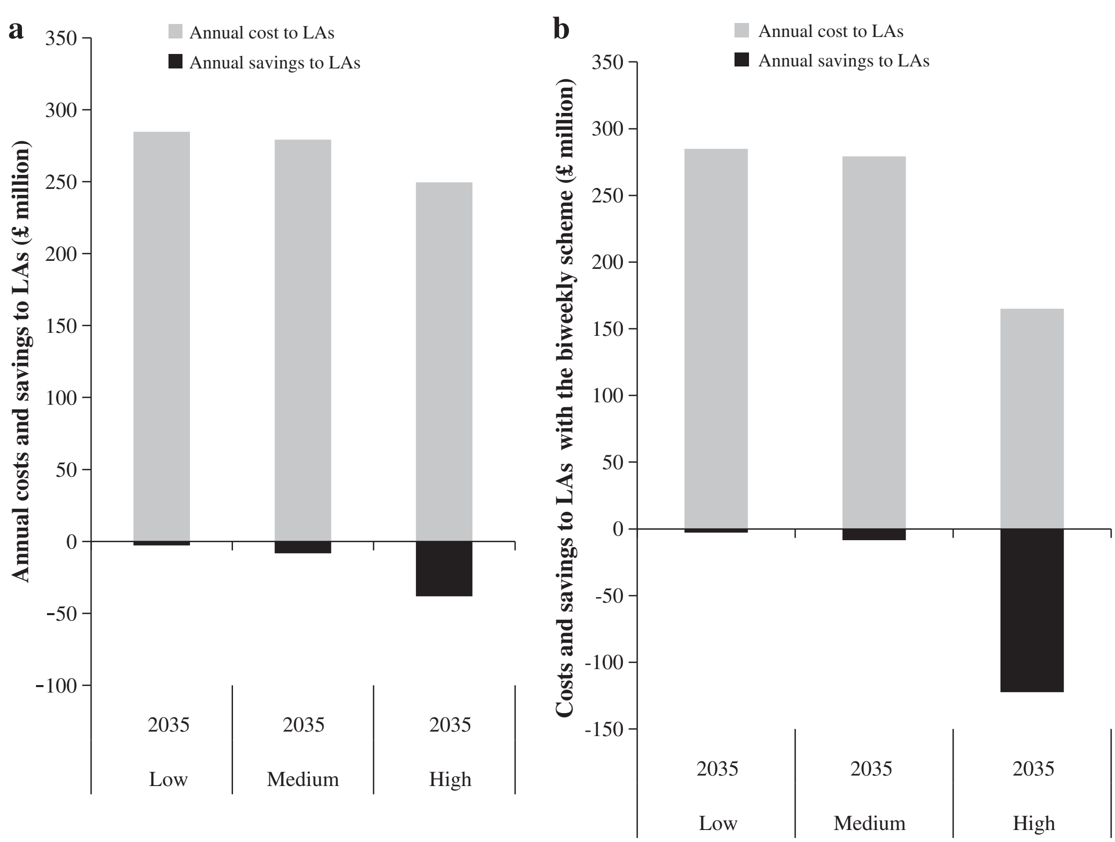


**Fig. 5.** Cost and savings to LAs for household waste collection and disposal due to the use of FWDs based on (a) the regular collection regime and (b) the biweekly scheme.

in the resulting wastewater, which are liable to settle in the sewer and cause sewer blockages. As thus, the costs that the use of FWDs could impose on the water industry are many and may become more pronounced as the FWD penetration rate increases. This is evidenced by the fact that in this study, as the FWD penetration rate increases, the total cost to the water industry increases notably.

Besides cost implications, there is also the cost to the environment and to social welfare. Food waste disposal into the residual waste stream drives collection frequency and contributes to hygiene-related issues associated with rotting food waste (Iacovidou et al., in press). Waste handling by trucks can be a major cause of carbon emissions, noise and nuisance and as thus, a reduction in the frequency of collection can reduce these negative environmental and social impacts. Thus, the use of FWDs can reduce the frequency of collection and hygienic impacts, offering a cleaner environment to household occupants. This has also been highlighted in an LCA study by Diggelman and Ham (2003), who evaluated FWDs to be an effective tool for food waste management in comparison to other options both for wastewater and waste managers (Diggelman and Ham 2003). Taking into account some evidence of the unwillingness of people to participate on food waste collection schemes reported by WRAP (2010), FWDs can be an attractive waste management option for both LAs and the water industry with regards to the environmental cost. However, the economic pressures associated with their use can be an important barrier to the water industry.

Therefore, for a sustainable use of FWDs, policy measures will have to be taken that enable the establishment of a platform within which savings from waste collection and disposal of food waste could be transferred to subsidise the water industry. However, based on the current waste collection scheme, savings made by LAs are not enough to compensate for the increased costs to the water industry. Consequently, whilst LAs would benefit from the diversion of food waste from the solid waste stream, the water industry would have to deal with the potential impacts of this diversion and its associated cost. In that case it is essential to either regulate the use of FWDs or to ban them completely in order to prevent their negative impacts to the water industry.

The adoption of the biweekly collection scheme would result in significant savings to LAs that could cover the increased cost of water and wastewater treatment. Switching to biweekly waste collection would depend on several factors including the environmental and health hazards that remaining food waste could pose to the surrounding environment.

## 5. Conclusions

Whereas the uptake of FWDs would lead to an additional cost to water industry operations, LAs could benefit from savings from the reduction in cost of waste collection and disposal. However, based on the current waste collection scheme, the simple economic analysis undertaken for the Anglian Region clearly demonstrates that savings to LAs are not significant enough to cover the increased cost to water industry operations. It also demonstrates that only a change in waste collection frequency would generate significant savings for LAs which could compensate for the increased costs to the water industry. This could be achieved by the adoption of a biweekly collection scheme in the region. The adoption of such a scheme would not only benefit the LAs economically but also socially and environmentally. The disposal of food waste into the sewer would minimise the hygiene-related issues as well as the environmental impacts associated with frequent collection and transportation. The paper therefore recommends the need for policy intervention in the region, to regulate the use of FWDs either promoting them as an alternative to landfill to increase savings from waste management or banning them as a threat to wastewater treatment provision to reduce costs to the water industry.

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