Ecological Economics 135 (2017) 22–28

Contents lists available at ScienceDirect

Ecological Economics

journal homepage: www.elsevier.com/locate/ecolecon

A Cost-effectiveness Analysis for Incineration or Recycling of Dutch Household Plastic Waste☆

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ARTICLE INFO

Article history:
Received 30 May 2016
Received in revised form 19 October 2016
Accepted 7 December 2016
Available online xxxx

JEL Classification:
H43
Q38
Q42

Keywords:
Recycling
Incineration
Plastic waste
Cost-effectiveness analysis

ABSTRACT

The cost-effectiveness of two different plastic waste treatment options is compared. This paper evaluates the recycling of plastic waste with the more conventional incineration of plastic waste, using data for the Netherlands. Both options have specific revenues and costs. The main benefit from plastic recycling is the avoidance of CO_2 emissions that otherwise would occur during incineration and from the production of virgin (new) plastic material. At the same time, there are significant costs involved, such as collection, separation, sorting, and recycling. The benefit from plastic waste incineration is the energy that can be recovered, which reduces emissions in the regular energy production sector by displacing production. The main cost associated with incineration is that this requires a waste-to-energy plant with the associated capital investments. Summing the costs and revenues from both plastic waste treatment options and comparing the results, leads to an implicit CO_2 abatement price of 178 €/t of CO_2 in case of plastic recycling. In general, this implicit price is much higher than current (or historic) ETS prices, the estimated external costs of CO_2 emissions, or alternatives to reduce CO_2 emissions (e.g. renewable energy). A sensitivity analysis shows that this conclusion is robust.

1. Introduction

Lack of space and growing public environmental awareness forced subsequent Dutch governments to take measures from the early eighties to reduce the landfilling of household waste and to stimulate incineration and recycling (see Dijkgraaf, 2004). The percentage of Dutch municipal waste that was either recycled or composed in 2014 was 24% and 27% respectively. The remaining half was incinerated to recover energy (electricity and heat). The Dutch incineration facilities are amongst the most efficient in the world, with high energy recovery and competitive gate fees. Although there was some discussion at the beginning of this century whether the waste incineration should be considered from a cost-benefit perspective (see Dijkgraaf and Vollebergh, 2004), the Dutch government remains committed to its strict policy to stimulate waste recycling and incineration. In other countries, e.g. Germany and the USA, waste incineration has not been undisputed (for USA see for example Seltenrich, 2013). In the Netherlands some environmental groups even advocate a zero-waste policy (i.e. full recycling/re-use) without any form of incineration. The advocates of more recycling point to Germany, which has less waste incineration and a recycling rate (without composting) of 48% - two times the Dutch rate.

In the past decade, Dutch efforts to stimulate the collection of recyclable waste, especially at the source, have been intensified. Similar to most EU countries, Dutch municipalities are in charge of collecting and sorting household waste. Municipalities are thus, from an execution perspective, responsible for implementing national and European waste policies. Dijkgraaf and Gradus (2016a) show that between 1998 and 2012 there was an increase in municipally-run facilities to collect different valuable waste streams such as paper, glass and textiles. In addition, many municipalities introduced curbside collection of specific waste streams, and unit-based pricing for mixed waste to encourage recycling. In Ferreira et al. (2016) the costs (including opportunity costs) and revenues of different waste collection and sorting systems in Portugal, Italy (in particular, the Lombardia region), and Belgium are compared. The three countries differ in their collection systems. Some countries put emphasis on a drop-off system using centrally-located containers, whilst others focus on curbside systems (door-to-door source collection) and collection frequency. They further differ whether packaging material is collected as a mono-material stream (e.g. solely plastics) or as a multi-material stream. The authors conclude, for all three countries analysed, that re-routing packaging waste for recycling is better for the environment than other waste treatment

☆ The authors would like to thank two (anonymous) referees for their helpful comments, any remaining errors remain the responsibility of the authors.

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http://dx.doi.org/10.1016/j.ecolecon.2016.12.021
0921-8009/

options, such as incineration and landfilling. Given recent Dutch policy initiatives that specifically focus on plastic packaging waste, this article has a more specific focus.

Dutch recycling of plastic waste has drawn significant political and public attention. Since 2009 most Dutch municipalities separately collect plastic packaging at the source, and are financially compensated by the packaging industry – similar to other European countries (see da Cruz et al., 2014). Dutch municipalities are free in the plastic waste collection methodology. Both curbside door-to-door collection and central drop-off facilities are common, although the number of municipalities collecting household plastic waste at the curbside has substantially increased in recent years.

As a result, more Dutch plastic waste is recycled, contributing to a reduction in CO_2 emissions – as less plastic waste is incinerated and less virgin material is needed. However, the costs for the collection, separation, sorting and recycling of household plastic waste (funded by the packaging industry) substantially outweigh the revenues that are generated from the sale of recycled plastic. Therefore, municipalities are compensated for this deficit by the packaging industry and get a net contribution of 677 €/t of collected household plastic waste. In other words, the total cost of recycling of plastic waste is 677 €/t. In addition, recycling costs depend on the quality of the final secondary plastic material delivered. Producing plastics for high quality industrial purposes will require further separation and processing to meet required standards.

On the other hand, the incineration of plastic waste generates revenues from an energy perspective. Plastic waste produces more than three times more energy when compared to other materials (see also Morris, 1996). A decrease in the plastic content of municipal waste lowers the energy output per unit of input, and thus increases overall incineration costs (by reducing effectiveness and energy return). The difference in costs and benefits between the two different waste treatment options for plastic packaging in the Netherlands provide for an interesting analysis of relative costs and benefits from an economic and environmental perspective.

Hopewell et al. (2009) show that incineration of plastic waste is less prevalent than the recycling of plastics at household level. They also point out that for highly mixed plastics energy-recovery may be the most suitable option. As far as we know a cost-effectiveness analysis comparing household plastic recycling, with plastic waste collected separately at source (i.e. curbside), to the recovery of energy through plastic waste incineration has not been performed. This paper attempts to fill that gap. Both options – plastic recycling and energy recovery from plastic – have specific revenues and costs.

The benefit of recycling is the avoided CO_2 that would otherwise be released during incineration and during the production of virgin plastics (as plastic is based on hydrocarbons). At the same time, there are significant costs involved with collection, separation, and sorting of plastic packaging waste by municipalities and the production of new (recycled) plastic raw materials. The revenues of incineration are energy recovery such as heat and electricity production. The associated costs relate to the capital and maintenance expenditure of a waste-to-energy facility. To determine the cost effectiveness of plastic recycling the revenues, costs and environmental impact - expressed in CO_2 emissions - are compared to the alternative, energy recovery from plastic incineration. The implicit cost of the CO_2 avoidance is calculated by comparing the difference in the net costs with the difference in net CO_2 emissions. This (implicit) price can then be compared with other options to achieve equivalent CO_2 reductions. We show that our derived implicit price is higher than both current and historic ETS prices, external costs, and other alternatives, such as renewable power production. We include a sensitivity analysis to test the robustness of our conclusions and we demonstrate that, in general, this implicit price is indeed relatively high in comparison.

The remainder of this paper is organized as follows. Section 2 describes the producer responsibility for plastic packaging in the Netherlands. Section 3 presents the cost effectiveness analysis, where we first present the chosen methodology and the data, followed by the analysis itself. Section 4 presents the sensitivity analysis, and finally Section 5 concludes, discusses policy implications, and makes suggestions for further research.

2. Dutch Extended Producer Responsibility

Based on the European directive on packaging and packaging waste, packaging producers are responsible to separate and recycle plastic packaging waste. In the Netherlands a so-called “green dot” company is in charge of meeting these legal obligations (Stichting Afvalfonds Verpakkingen, referred to as the *Afvalfonds*). It collects a financial contribution paid by the retail sector and the packaging industry (based on volumes of plastic waste) and compensates municipalities, which – in the Dutch system – have been mandated by the *Afvalfonds* to collect household plastic waste. Therefore, the *Afvalfonds* provides a clear structure to meet legislative requirements. In most European countries it is organized in this way (see Marques and da Cruz, 2015).

The Netherlands has implemented this European legislation strictly. In 2014, 50% of (packaging) plastics was recycled and in 2022 the goal is 52%, which is almost double when compared to current EU legislation and more in line with EU plans for 2030.[1] As the target has already been met, some environmental groups, such as *Natuur&Milieu*, are arguing to set the 52% target for 2017 instead of 2022 (see KiDV, 2016).

In order to comply with the ambitious recycling targets, the *Afvalfonds* was granted a license to manage the flow of household plastics. Its task is to promote, coordinate and finance the collection, separation, sorting and recycling of municipal (packaging) plastic. The (packaging) industry in the Netherlands is coordinated through this *Afvalfonds* and pays a fee to the fund according to the level of plastic production. Most companies pay a fixed contribution for products that require plastic packaging, such as body care, cleaning etc. In the Netherlands, municipalities are responsible for the collection and treatment of municipal waste. In return for collecting plastic packaging waste for the producers, the *Afvalfonds* compensates the associated costs. In 2015, there were 393 municipalities in the Netherlands, which received a financial contribution from the *Afvalfonds*.[2]

Based on 2010 data by Marques and da Cruz (2015), the green dot fees differ widely between countries. For Belgium and France this was respectively 220 and 245 €/t plastic, for Germany it was circa 1430 €/t (based on 2007 data).[3] Marques and da Cruz (2015) discuss that these differences are driven in part by the scope of recycling policies, and thus which plastics are recycled. In Germany, for example, mixed plastics are recycled, whereas in Belgium only plastic bottles and flasks, metallic packaging, and drink cartons are separated. In the case of Belgium only plastic of higher quality is separated, which increases the subsequent revenues from the sale of secondary plastic, and thus leads to lower tariffs. This suggests that if recent European plans become legislation, green dot fees in countries like Belgium will need to be raised, making our cost-effectiveness analysis of the Dutch market relevant for other European countries.

As mentioned, Dutch municipalities are responsible for the collection of plastic packaging waste, but are allowed to decide how they organize this. Dijkgraaf and Gradus (2016a) show that in 2007–2012 37% of municipalities collected plastic packaging waste at the curbside, whilst in the remaining municipalities citizens have to drop-off plastic waste at collection points nearby schools and shopping centres. Over half of the curbside municipalities (59%) collected plastic waste once a

[1] According to a recent proposal (20/04/2016), the Commission proposes a national target of 55% by 2030.

[2] Also other packaging material such as glass, paper and metal receive a contribution from the *Afvalfonds*, but the contribution for plastics is the most important.

[3] This is based on Table 3.3 for Belgium, Table 3.5 for France and Table 3.12 for Germany and taking into account that 1 t is 0.907 (metric) tonne. It should noticed that this fee is not mandatory for Germany as it is a private arrangement between industry and several green dot companies and is based on the last publicly-available list. For other countries discussed in this book, their system is less comparable.