Newspaper waste management – a combined assessment of ecological and economic aspects

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Content

Summary

We combined life cycle impact assessment (LCIA) with economic analysis of social life cycle costs (SLCC) to investigate five alternatives for newspaper waste management. The alternatives consisted of various recovery and treatment methods applicable to newspaper in a separately collected paper fraction and to newspaper in mixed waste. The methods considered for the separately collected paper fraction were 1) material recycling, 2) gasification and co-combustion, and 3) incineration. The methods considered for newspaper in the mixed waste were 1) landfilling, 2) mechanical-biological pre-treatment followed by gasification and co-combustion of SRF (solid recovered fuel), and 3) incineration. The boundaries of the commodity and its production process were defined within the LCA approach. The analysis of the recovery and other related costs followed closely these boundaries. We linked LCIA and SLCC to each other in different ways. First, we used LCIA to rank our alternatives and asked how this ranking relates to the SLCC associated with each alternative. Second, we solved the cost minimizing problem and asked how this purely economic ranking relates to our LCIA ranking. Third, we included in the costs the external costs from the use of fossil fuels and then compared the solution to the LCIA results. Many useful features emerged. Tying economic analysis firmly to the steps of LCA helps to produce consistent SLCCs. Given that environmental policies usually involve trade-offs between environmental and economic factors, economic analysis conducted consistently with LCA complements LCA in a way that can be expected to make the results of the analysis more useful for policy making.

Introduction

It has been increasingly recognized that while life cycle assessment (LCA) is useful for identifying environmental attributes of a product of service, communicating the results to decision makers is sometimes a problem. Namely, in addition to their concern for environmental impacts, societal decision makers and company managers must also focus on the economic costs and benefits associated with products or services. These can, however, differ greatly with respect to the alternatives assessed with LCA. For instance, one may encounter situations in which two product or service alternatives are close to each other in terms of their environmental impacts, but differ greatly in terms of their associated life cycle costs. Making a final decision requires the ability to link environmental impacts with associated costs and benefits.

When analyzing the life cycle impacts of waste policy alternatives that are available to a society, the need for a concept of social costs and benefits over the life cycle of a product becomes evident. Here, the analysis must combine life cycle costs (and benefits) accruing to multiple actors, firms and consumers. Hence, the viewpoint of an enterprise or of a consumer is not enough; instead, one has to apply a consistent strategy to treat the flows of payments between actors. Parallel to an LCA analysis we developed one approach that takes all socially relevant cost items into account. We call this the social life cycle costs (SLCC) approach.

In this paper we present some results of our approach for combining the results of an LCA to the SLCC.

Materials and methods

The case study analyzed

In the case study reported in this paper, an LCA was performed on newspaper with particular attention paid to waste management practices in the Helsinki Metropolitan Area (HMA). The product system studied consisted of all the sub-processes within the life cycle of newspaper, i.e., production and transportation of raw materials; energy generation; the manufacturing of newsprint and the printing of newspaper; the delivery of newspaper to consumers; the collection, transportation, recovery and treatment of discarded newspapers; and the external processes avoided by energy recovery from newspaper waste. The functional unit of the study was one tonne of newspapers delivered to consumers. All in all five waste recovery and treatment alternatives (Cases 1, 2a, 2b, 3a and 3b), i.e., product systems, were studied.

Case 1 describes the current system in the HMA:
Separately collected paper: material recycling.
Mixed waste: landfilling without pre-treatment.

Cases 2a and 2b are based on energy recovery of SRF (solid recovered fuel):
a) Separately collected paper: material recycling.
Mixed waste: gasification and co-combustion of SRF (solid recovered fuel) containing newspaper and various other materials sorted from the mixed waste by mechanical-biological (MB) pre-treatment.
b) Identical to Case 2a except that 50% of the separately collected newspaper is gasified and co-combusted.

Cases 3a and 3b include incineration of mixed waste:
a) Separately collected paper: material recycling.
Mixed waste: incineration with energy recovery.
b) Identical to Case 3a except that 50% of the separately collected newspaper is incinerated.

The life cycle impact assessment (LCIA) methodology

The life cycle inventory data of each waste recovery and treatment option were interpreted with three impact assessment methods, namely DAIA (Decision Analysis Impact Assessment) (Seppälä 2003), Eco-indicator 99 (Goedkoop and Spriensma 2001) and EPS 2000 (Steen 1999). The assessment is reported in detail in Dahlbo et al. 2005. For presenting the impact assessment results in this paper we use the overall results (that is results including weights) in order to ease the comparison between the environmental and the economic impacts. We recognize, however, that this is not fully compatible with the ISO standard 14042 (ISO 2000), which does not approve of using weighting for comparative assertions disclosed to the public.

The economic impact assessment methodology: SLCC

Because waste management alternatives are a matter of public policy, we apply the concept of social life cycle costs. SLCC refers to all social costs associated with the entire life cycle of a product or a service within the boundaries defined in the LCA. Three basic cost items are useful to mention. First, the most conventional costs are direct costs, that is, costs of investments, labour, energy, and so on. There are also indirect costs, not allocated to production as such but for instance to capital. Third, there are all external costs associated with environmental impacts of the product's or service's life cycle.

The concept of social implies that the costs are defined from the viewpoint of the whole society. This means, e.g., that all taxes levied on agents operating in the economic sphere covered by the life cycle of the product and obtained by the society will cancel out when summing up the costs. Moreover, payments between two agents will cancel out too, because payment from one agent to another represents income received. Hence, SLCC includes real social life cycle costs of a physical product.

Basically, SLCC was worked out as follows. We defined the SLCC for material recycling, landfilling, production of SRF (solid recovered fuel) followed by gasification and co-combustion and incineration as a function of collection and recovery rate. This yielded social life cycle cost functions as a function of the recovery rate of discarded newspaper over the range (0, 1) (Fig. 2). Specific cases 1; 2a & 2b: 3a & 3b were then combined by using these SLCC functions. The cost assessment is reported in more details in Dahlbo et al. 2006.

Results and discussion

First, we present the ranking of our alternatives given by the three LCIA models, and ask how this ranking relates to SLCC associated with each alternative (Table 1). From the comparison we see that the environmentally best waste management alternative (Case 2b) entails the second highest costs; they are two times higher than costs in the cheapest Case 1. Furthermore, when comparing recycling of newspaper with energy recovery (that is Case 2a to 2b and Case 3a to 3b), it can be noticed that energy recovery of separately collected newspaper is always more expensive than its material recycling into newsprint manufacturing. This reflects the fact that using recycled paper in paper production is more profitable than using virgin timber.

Table 1. The ranking of the waste management options given by the three LCIA models used and the total SLCC cost for each option. Rankings: I = lowest cost or lowest environmental impacts, V = highest cost or highest environmental impacts.

Case	**Cost, million € (ranking)**	**Life cycle impact results, ranking**		
		DAIA	**Eco-indicator 99**	**EPS 2000**
Case 1	2.55 (I)	V	V	V
Case 2a	3.54 (III)	III	III	II
Case 2b	5.11 (IV)	I	I	I
Case 3a	3.49 (II)	IV	IV	III
Case 3b	7.16 (V)	II	II	IV

Energy recovery performed well in our LCIA, when waste was assumed to substitute coal. If it substituted biofuels, energy recovery would not perform as well. We must also keep in mind, that all the three LCIA models used have a common potentially significant limitation. None of them assesses the biodiversity impacts from the use of forests in a satisfactory way. The biodiversity impacts of forestry are, however, of fundamental importance when considering what to do with discarded paper and newspaper. The less paper is recycled, the more cutting is needed.

Second, the social cost minimizing solution in the absence of external costs was solved (Dahlbo et al. 2006) and is compared with the LCIA results in Table 2. The absence of external costs reflects a policy where no weight is given to environmental impacts in the social decision making. Hence, this represents the extreme solution as compared with LCIA, and helps us to trace out how far neglect of environmental aspects can bring societal decision making from LCIA.

The social cost minimizing solution was solved with the marginal cost curves produced for each recovery or treatment method for various rates of separate collection and recovery of discarded newspaper (Dahlbo et al. 2006). These curves indicated that recovery for material recycling in newsprint manufacturing is the best (cheapest) waste management option up to the recovery rate 80%. After this point it becomes too expensive to separate the last 16% from the mixed waste due to the high collection costs. The cheapest way of handling with this last 16% is to landfill it; thus, we have here a modified Case 1. Due to the European Union's legislation, however, this is no longer a feasible option. Hence, incineration will be the next cheapest feasible alternative. The crossing point of the marginal costs curves for recycling and incineration shows that 86% will be collected for material recycling in newsprint manufacturing and the rest, 10% should be incinerated with the mixed waste, which is modified Case 3a.

How do these modified Cases 1 and 3a relate to LCIA? From the economic point of view this suggests that Case 1 should be the best, and Case 3a would be the second best. The LCIA results (Table 2), however, show that with 80% recovery rate, Case 1 is environmentally the worst option and Case 3a the second worst. Thus, the purely cost minimizing solution would misguide us into selecting the environmentally worst solution.

Table 2. The cost minimizing waste management combinations and the LCIA results given by the three LCIA methods for the respective combinations. In parenthesis the ranking given by the LCIA results for the cost minimizing combinations (I = lowest impacts, V = highest impacts).

Cost minimizing alternatives	Life cycle impacts		
	DAIA impact value / t of np (ranking)	Eco-indicator 99 ecopoints / t of np (ranking)	EPS 2000 ELUs / t of np (ranking)
80% recycling & 16% landfill	7.4 (V)	34.5 (V)	295 (V)
86% recycling & 10% incineration	7.2 (IV)	35.5 (IV)	265 (III)

Third, we included in our assessment the external costs, that are costs associated with the environmental impacts of our product systems. Due to the observation that a large share of the differences in the environmental impacts of our cases originated from CO_2 emissions, the external costs were assessed by focusing on the fossil fuels. The external costs were measured by the expected price of CO_2 emission permits in the EU's emission trading scheme and by marginal exploration costs as a proxy for the scarcity prices of fossil fuels. (Dahlbo et al. 2006)

The external costs did not, however, crucially move the cost rankings towards the LCIA ranking. Case 1 remained the cheapest but ecologically the worst management alternative, while the ecologically best alternative, Case 2b, retained its position as the fourth most expensive management alternative (as in Table 1). This finding is natural, after all. As is well known from other economic studies, obtaining higher environmental quality usually entails higher costs. This is obviously true for social life cycle costs as well, thus stressing the need of the society to weigh the ecological life cycle impacts against the social life cycle costs.

One candidate for a reasonable compromise would be Case 2a, a combination of material recycling and gasification and co-combustion (SRF) of the remaining paper waste in the mixed waste. This case provides an environmental improvement with minimum costs (Table 1).

Generally, the weighting of ecological impacts and costs depends on the preferences of the society and any alternative is possible.

Conclusions

The presented comparisons between the environmental and economic impacts of our case study show that including both of these two dimensions in the assessment of waste management alternatives is crucial for making sustainable decisions. Concentrating solely on the economic aspects seems to lead directly to the environmentally worst alternatives. On the other hand again, the environmentally best solution gives the highest costs. How do we then make the compromise?

Our LCIA results support energy recovery only if the produced energy replaces energy from fossil fuels, thus obtaining credits from avoided impacts. Otherwise recycling newspaper for paper production outperforms energy recovery. The differences between energy recovery and material recycling turned out to be relatively small, however. Therefore, SLCC provides an important additional qualification: burning separately collected newspaper is always far more expensive than material recovery for paper production. Material recovery most probably also produce biodiversity benefits, which have not yet in our assessment been included satisfactorily.

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