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THE USE OF MULTICRITERIA ANALYSIS – LESSONS FROM SUSTAINABILITY ASSESSMENT OF HYGIENE PRODUCTS CONTAINING NEW WOOD-BASED MATERIALS

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ABSTRACT

This paper discusses the process of using multicriteria analysis (MCA) in sustainability assessment of absorbent hygiene products, comparing a reference product representing current technology, to product concepts containing new wood-based materials. The MCA required aggregation of qualitative and quantitative product performance indicators using different stakeholder value sets. The decision-makers in the MCA were drawn from different companies and from academia. The intent of the paper is to draw out some of the potential issues that may be encountered in similar assessments. The presentation also discusses different aggregation methods and provides results from the assessment and the aggregation.

INTRODUCTION

In sustainability assessments, an ever-present issue is how to compare seemingly incomparable aspects and how to manage trade-offs. Sometimes, weighting by the use of multicriteria analysis (MCA), sometimes called multicriteria decision analysis (MCDA), is applied (Mendoza and Martins, 2006). Weighting is based on the opinions of participants in the MCA, allowing integration of different aspects and providing structure and transparency to decision-making. MCA can thus be used in multi-stakeholder discussions within a company or project to derive weighting sets and also to illustrate the effects of applying different weighting sets.

The MCA work described here was performed as part of a larger four-year technical research and development project. It aimed to replace at least 50% of the absorbent porous structure in an incontinence product with new wood-based materials while maintaining performance and improving product sustainability. Sustainability assessment activities were performed throughout the research to guide material development towards sustainability. A final MCA was done in the last 6 months of the project to determine whether the project had fulfilled its goals. This paper describes the MCA procedure, and also reflects on the process.

MATERIALS AND METHODS

There are many ways to perform an MCA. We used our earlier experience and Rowley *et al*. (2012), which provided a practical methodological basis for this work. Additional methodological support was obtained from Brans and Mareschal (2005), Lundie *et al*. (2006),

Olson (2001) and Guitouni and Martel (1998). Briefly, the key elements of most MCA processes include: identification of the goals of the process, definition of decision criteria, definition of alternative choices, population of a performance matrix, weighting, and aggregation.

A project consortium workshop was held to bring together different stakeholders for the MCA. The reference product was based on a current market product and two hypothetical products with similar function were based on the new wood-based materials developed within the project. A list of 37 indicators was reduced to 31 when participants were asked to think critically about experiences with them and principles for the selection of indicators (see Rowley *et al*. 2012). Data for the different indicators had mainly been generated in different other activities earlier on in the project. Participants also provided some product evaluations at the workshop, adding to the life cycle assessment, materials testing and financial data.

The aggregation process had to cope with quantitative and non-quantitative data (not all schemes allow mixed data), avoidance of the requirement for stakeholders to generate trade-off weights using quantitative scales (necessary for single synthesising criterion schemes – see Rowley *et al*. 2012), and the expectations of the level of stakeholder interaction (interactive schemes were ruled out). Therefore, we chose PROMETHEE ("preference ranking organization method for enrichment of evaluations"), a European pairwise comparison method that has been in use since the 1980s. Details are available in Brans and Mareschal (2005). Briefly, the performance of two alternatives is compared and the differences are converted using a preference function chosen to reflect the information available to the decision-maker. The simplest "usual" function is sometimes called "strict preference", in which even a small difference in performance results in complete preference for the better alternative.

Workshop participants provided personal weighting factors by distributing a total of 100 points among the indicators. Demographics and previous practical experience with diapers were also noted to make it possible to check for potential biases. Additional weighting sets were collected in group evaluations of future scenarios, and individual company preferences. These did not change the MCA outcomes and are not discussed further here.

RESULTS AND DISCUSSION

Some results from the MCA exercises are reported in Table 1. The performances of the compared alternatives are here given only as a ranking with 1 being the one that performed the best in the assessment. Also for negative indicators, such as cost, 1 represents here the best performing alternative (e.g. lowest cost).

Considering the average individual weights (n=16), reported in Table 1, product price and global warming were priorities. If weights are grouped for aspects, product function achieved the highest weight. Using the average weights, the reference scenario outperformed the other two. The variation due to demographic parameters was generally not large and unlikely to exhibit statistically significant variation if subjected to formal tests. It is interesting, though, to note that having had practical experience with diapers had almost no bearing on how important the financial or product performance characteristics were weighted. The most distinct differences are the relative weighting of environmental plus resource issues versus product performance plus cost issues across the gender divide – the women slightly favoured

these particular "externalities" over the consumer and cost issues (43:39) compared with the men's strong opposite weighting (31:51). This ratio distinguished university panellists (43:36) from industrial panellists (34:49) even more strongly. There was also a continuous trend in increasing weight for product performance with age. However, neither of these differences influenced the preference of the reference product over the new concepts.

Table 1. Aspects and indicators applied in the MCA, performance ranking for the compared alternatives (1 contributes in the best way to sustainability, followed by 2 and 3) and the average weighting factor (WF) given to each indicator in a workshop with 16 participants.

Aspect	Indicator	Ref	New 1	New 2	WF
Environment	Acidification	2	1	3	2.0
	Eutrophication	1	2	3	2.4
	Smog formation	1	2	3	1.6
	Global warming	1	2	3	6.2
	Ecotoxicity; freshwater ecosystems	1	3	2	3.1
	Ecotoxicity; terrestrial ecosystems	3	1	1	3.0
Resources	Fossil primary energy	1	2	3	4.6
	Total primary energy	1	2	3	3.0
	Total secondary energy	1	2	3	3.6
	Water	1	2	3	1.4
	Process water	1	3	2	1.2
	Wood	2	1	3	2.4
	Oil	3	1	1	3.2
Health	Human toxicity	3	2	1	3.6
	Product safety	1	2	3	4.4
	Occupational safety	1	2	3	3.5
Product function	Preventing urine leakage	2	1	3	4.9
	Keeping the skin dry	1	2	2	3.2
	Dryness of surface material	1	1	1	1.9
	Absorption capacity	1	1	1	3.4
	Retention of urine	1	2	2	3.7
	Preventing faeces leakage	1	1	1	2.4
	Keeping the shape of the absorption area	1	1	1	1.5
	Thickness of the core	1	2	2	2.0
	Being comfortable to wear	1	1	3	4.0
	Looking clean	1	1	1	1.2
Social	Social equity in value chain	1	1	1	4.0
	Risks to brand	1	1	1	2.9
Economy	Product price	1	2	3	6.9
	Investments	1	2	2	4.7
	Avoidance of technical lock-in	2	1	1	4.1

We also examined two systemic variations in the input data: biasing the weights and introducing an indifference threshold. In the bias test, the weights were adjusted until a rank reversal of the first two options occurred; for criteria that favoured the New 1 over the reference product, the weights were increased and for those that favoured the reference product over the New 1, the weights were decreased by the same amount. In order for the New 1 product to be preferred, the model required that the weights be biased by 30%, i.e., the weights for indicators favouring the New 1 had to be multiplied by 1.3 and the others by 0.7. Another possible way in which the New 1 product could outperform the reference product

was if the criteria favouring the reference product were considered to only exhibit a small, insignificant outperformance, which can be referred to as an "indifference threshold". However, introducing a threshold could not alter the rank order due to the fact that only 7of the 20 indicators favour the New 1 over the reference product.

Although we hoped one of the new products would succeed, as analysts we were happy to arrive at a robust result - preference for the reference product over both new alternatives. The goal of the research project was not fulfilled but a satisfying level of certainty was. However, the project started to develop highly interesting materials that will likely prove more sustainable after further development efforts.

One of the key challenges faced by the research team was our conflicting roles as MCA workshop facilitators and environmental experts in the research project. Ideally, the workshop facilitators would be concerned only with the impartial fulfilment of the workshop aims, ensuring everyone understood the methodology and process. In practice, this requires elucidating the connections between the MCA process, the indicators and the products. For example, choosing an indicator involves an assessment of whether an indicator plays an important role – a value judgment the panellists should make but which they were at times more comfortable relying on our expert judgment. In retrospect, several hours might have usefully been directed earlier to general education of panellists about environmental and social performance indicators, had this time been available.

CONCLUSIONS

This MCA was performed to compare the sustainability of a reference and two conceptual absorbent hygiene products containing newly developed wood-based materials. The results robustly favour the reference product. Changing the rank order would require improved performance of the new products against several criteria. Key challenges experienced in this project were the need to educate decision-makers during an efficient evaluation process, and the conflict between the assessor roles of facilitator and expert.

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