PAPER BEATS PLASTIC

Catherine Kerninon, EUROSAC, and Elin Gordon, CEPI Eurokraft, present the results of a study by RISE, which compared typical paper cement sacks and form-fill-seal polyethylene cement sacks.

Introduction

The EU climate debate and discussions on the cement industry's contribution to reducing global warming emissions affect the criteria for packaging decisions: besides filling speed, pack cost, product protection, and cleanliness, the environmental aspects of packaging are becoming increasingly important to cement producers. But which packaging solution offers it all and combines state-of-the-art performance with strong environmental credentials?

In Europe, two systems are widely used for packaging cement: paper sacks and form-fill-seal (FFS) polyethylene sacks. A comprehensive study among the fillers and retailers of cement and other building materials by the Swedish research institute, RISE (formerly Innventia), has revealed that modern paper sacks provide innovative and reliable solutions that satisfy the industry's high expectations and requirements. In particular, fillers profit from lower packing costs and higher filling speeds when using paper sacks.[1]

Concerning environmental impact, several life cycle assessment (LCA) studies have been published by stakeholders, claiming environmental benefits for polyethylene FFS sacks for cement. However, these studies have lacked transparency, especially in terms of the data applied and the assumptions made. Subsequently, CEPI Eurokraft and EUROSAC requested RISE to conduct a transparent comparative study, calculating important emissions to air and water, as well as the carbon footprint of the two solutions. Its key result concerning climate change, the most important challenge today: the paper sack is clearly the favourable option. This article will first describe the study design and then present the results in detail.

***Table 1.* Specifications of the two compared sack systems.**

Typical 25 kg paper cement sack	**Typical 25 kg polyethylene FFS cement sack**
45 g outer ply (bleached)	67.8 g PE (85% LDPE, 15% LLDPE)
4 g HDPE poly liner	2.2 g ink
42 g inner ply (unbleached)	Total sack weight of 70 g
3.7 g starch glue	
1.1 g ink	
Total sack weight of 95.8 g	

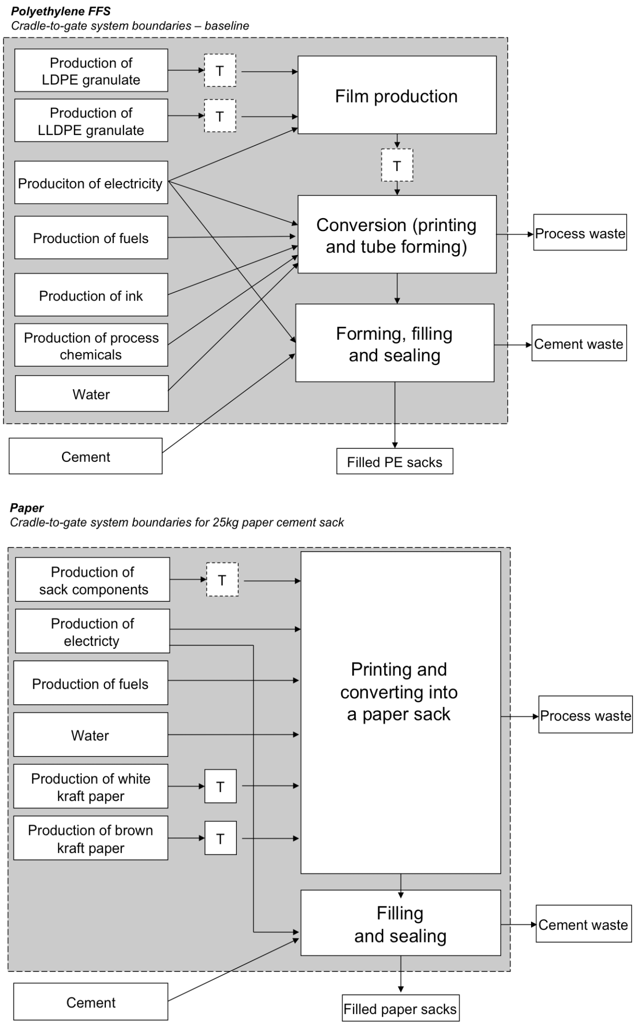

Figure 1. The system boundaries from cradle to gate.

The research

The study compared the life cycle inventories (LCI) of a typical European 25 kg cement paper sack with a typical European 25 kg FFS polyethylene cement sack. It considered various environmental interventions for both packaging solutions, for example overall carbon footprint and fossil energy consumption. These were deemed to be indicators of climate change and other emissions to air and fresh water, encompassing a wider range of environmental effects. The carbon footprint calculations conducted are based on the Ten Toes Framework for the development of carbon footprints for paper and board products, which was developed by CEPI, and the CITPA calculation tool. The two sack systems have also been modelled in the LCA software tool GaBi, with secondary data from GaBi and Ecoinvent databases, to enable an analysis of important emissions other than greenhouse gases. The study has been peer reviewed by the sustainability team at Intertek, a leading total quality assurance provider to industries worldwide.

Specifications of the compared systems

The functional unit considered in the comparisons is a single, filled 25 kg cement sack. The specifications of a 25 kg paper cement sack vary between sack suppliers. Therefore, a typical construction has been estimated for the comparison, based on primary information provided by several suppliers. The specification considered for the 25 kg FFS polyethylene cement sack has been based on sampling sacks that are available on the market and discussions with industry stakeholders. The underlying specifications for both sacks are shown in Table 1.

System boundaries: from cradle to gate

In the first step, the study investigated the system boundaries from cradle to gate. For the

FFS polyethylene cement sack this covers the following:

- Polymer production (LDPE and LLDPE granulate).
- Film production.
- Flexo printing of the film.
- Converting process into a tube.
- Delivery of the tube as a reel to the filler.
- Forming of the tube into a bag, filling, and sealing in one operation.

The system boundaries for the paper cement sack include the following:

- Production of sack kraft paper.
- Printing and converting into a paper sack.
- Distribution to a filler.
- Filling and sealing process.

Figure 1 shows the system boundaries from cradle to gate of both sack systems in detail. The impact of cement production was excluded from the analysis, as its goal is to compare the environmental impacts of the two alternative packaging solutions.

System boundaries: from cradle to grave

In the second step, the system boundaries were extended to include the distribution and retail of the filled sacks, as well as end-of-life management. As far as distribution and retail are concerned, a structured evaluation by RISE on behalf of the European Paper Sack Research Group in 2015 delivered the data basis. The evaluation investigated the distribution chains for cement in both paper sacks and FFS polyethylene cement sacks, concluding that damage rates and losses from point-of-fill to point-of-sale at the retailer are likely to be less than 1% for both. As a result, for this analysis losses in distribution of 0.5% have been considered for both systems. It is further assumed that these losses (both product and packaging) are disposed of into landfill. Due to a lack of available data, no consideration has been made for losses incurred once the cement has been purchased by the final consumer. As long as cement in either paper or FFS polyethylene sacks is stored appropriately by the consumer, then there is no reason to believe that losses are any different in paper sacks compared to FFS polyethylene sacks.

Concerning end-of-life management, the following three scenarios have been investigated for both packaging alternatives:

- 100% landfill.
- 100% incineration with energy recovery.
- 100% recycling.

For the recycling scenario, the cut-off method has been applied in both cases. To investigate the potential influence of this approach, for the FFS polyethylene sack, a scenario has also been modelled in which the emissions associated with recycling, as well as a credit for offset virgin polyethylene production are included. Despite reducing the overall footprint of the FFS polyethylene sack, the paper sack still shows better results.

Data sources

The figures used for evaluating paper sack production are mainly primary data from representative European paper mills, paper converters, and machinery manufacturers. Secondary data is used from GaBi and Ecoinvent databases.

The analysis of the production of LDPE and LLDPE granulates and film production are based on life cycle inventory data published by PlasticsEurope. Primary data on the filling and sealing process has been provided by a machinery manufacturer.

Why paper sacks are better for the climate

The results of the comparative study clearly show that paper sacks are the better choice for the climate. They have a smaller overall carbon footprint, no matter which end-of-life scenario is considered, be it landfill, incineration, or recycling. In addition, regarding the input of energy resources, the paper sack is the more environmentally-friendly packaging; it uses a greater amount of renewable energy resources to cover its production energy than the FFS polyethylene sack. Concerning emissions to air and freshwater, the two solutions cannot be directly compared: in some emissions, the paper sack showed better results, whereas in other emissions it was the FFS polyethylene sack.

This convincing environmental balance validates the European sack kraft paper and paper sack industry in the continuing efforts to reduce its greenhouse gas emissions, improve energy efficiency, and increase the share of renewable energies. This is simultaneous to enhancing product protection and efficiency on the production lines.

2.5 times smaller carbon footprint

With 71 g of carbon dioxide equivalent (CO_2e) emissions from cradle to gate, paper cement sacks have significantly lower fossil greenhouse gas emissions than FFS polyethylene cement sacks (which total to 192 g CO_2e). In other words, emissions from paper cement sacks are 2.5 times smaller and therefore have a lower climate change impact. The difference in the higher amount of fossil CO_2e from the FFS polyethylene sack is comparable to the emissions of a laptop with a power consumption of 25 W running for nine hours. Furthermore, when extending the boundaries to consider the end-of-life scenarios – whether landfill, incineration, or recycling – the relative standing of emissions for

Figure 2. Infographic showing the most important results of the study.

the two different packaging alternatives remains unchanged: the paper sack's carbon footprint is smaller.

More efficient fossil energy consumption

Regarding the consumption of fossil energy in the production process, the study concludes that the paper sack is the more climate-friendly solution. The production of a cement FFS polyethylene sack uses 4.72 MJ of fossil energy per sack as fuel input. This is approximately five times more than is consumed to produce a cement paper sack (0.97 MJ of fossil energy per sack). This means that almost five paper sacks can be produced with the same amount of fossil energy that is consumed in the production of only one plastic sack.

The study also shows that the paper sack system uses more renewable energy sources (0.19 MJ of renewable energy per sack) to fulfil its production energy needs, compared to the plastic sack (0 MJ of renewable energy per sack). Considering the fossil resources consumed as feedstock within the product itself, as would be expected the FFS polyethylene sack has a significantly higher consumption, using 18 times more fossil resources (3.19 MJ of fossil resources per sack) than the paper sack (0.18 MJ of fossil resources per sack). This fossil energy consumption is still higher, even with credit for offset virgin polyethylene production in the system boundaries of the recycling scenario.

Mixed picture for other environmental parameters

When looking at the study results of other emissions to air and freshwater during the production process, a conclusion as to which of the two packaging choices is better for the environment cannot be drawn. In some respects, the paper sack shows better results, where in others it is vice versa. Due to the higher consumption of fossil fuels, FFS polyethylene cement sacks produce higher nitrogen oxide (NO_x) and sulphur oxide (SO_x) emissions, as well as higher emissions into the air of the heavy metals lead and mercury. In contrast, paper cement sacks produce higher emissions of ammonia, non-methane volatile organic compounds, and particulates into air. Regarding emissions into freshwater, the production of FFS polyethylene sacks emits more heavy metals, while paper sack production emits more organic substances into freshwater. These results cannot be directly compared in all aspects because paper and FFS polyethylene sacks have different emission profiles, due to their use of different raw materials, processes, energy requirements, and mixes. Figure 2 displays the key results of the comparative study.

Continuous improvements in carbon footprint

Aside from this LCI for a typical European paper cement sack, RISE regularly conducts carbon footprint analyses of the value chain of an average European paper sack. The outcome is convincing: between 2007 and 2015 alone, CO_2e emissions from this process have improved by 22%. This exceeds one of the EU climate targets for 2020, five years before this date – namely that of reducing greenhouse gas emissions by 20% compared with 1990. The total annual improvement in terms of CO_2e equates to around 27 200 circumnavigations around the globe by car. If the carbon sequestered by forests, end-of-life, and avoided emissions were considered in the calculation of the carbon footprint, it would actually come to less than zero.

Strong environmental arguments

As a cornerstone of the bio-based economy, the European sack kraft paper and paper sack industry contributes to sustainable development, meeting the requirements of modern packaging, conserving natural resources, and protecting the environment. Inspired by nature's organic packaging solutions, the industry creates high-performance paper sacks that are based on natural resources. The fibres used to produce sack kraft paper are 100% natural, renewable, and biodegradable. This also makes paper sacks an excellent source of fibre for the recycling industry after their use, as their long, strong fibres can be recycled several times. Moreover, the material efficiency of paper sacks has been greatly enhanced over the past two decades: the paper weight per sack has been reduced by 25%, while the strength of sack kraft paper has been improved by 45%. This results in considerable reductions in natural resources and costs for fillers.

The sustainable management of forest areas is a central element of the value chain for paper sacks. The fibres for sack kraft paper are extracted from tree thinnings and from process waste from the timber industry, originating from sustainably managed European forests. Thanks to the continuous replanting of trees, the amount of state-owned forest in Europe is growing by 200 million m^3/year, according to Eustafor. These living forests provide habitats for wildlife and recreational areas for people. Furthermore, they act as a carbon sink when they grow and therefore play a key role in climate change mitigation.

Conclusion

The comparative study of paper cement sacks and FFS polyethylene cement sacks has concluded that paper cement sacks are the better option for the climate. Their overall carbon footprint is smaller and they are more energy efficient. Cement fillers using paper sacks not only profit from high performance, especially in terms of lower packing costs and high filling speeds when using paper sacks, but they can also reduce CO_2e emissions and contribute to the mitigation of climate change with their choice of packaging.

Reference

1. KERNINON, C., and FLORESJÖ, E., "Paper Sacks Meet High Demands", *World Cement* (April 2016), pp. 71 - 75.

About the authors

Elin Gordon has been Secretary General of CEPI Eurokraft since September 2014 and became Chairman of CEPI Eurokraft in March 2018.

Catherine Kerninon has been General Delegate of EUROSAC since 2011 and has spent most of her career working in the paper sack industry.