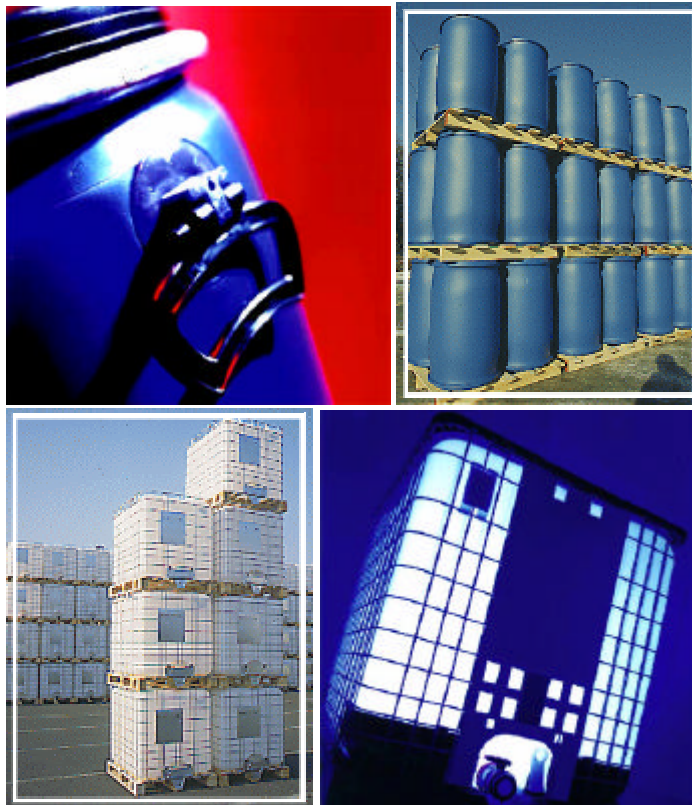




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EXECUTIVE SUMMARY



LIFE CYCLE ASSESSMENT OF INDUSTRIAL PACKAGING FOR CHEMICALS

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Abstract

This report is a cradle to grave study of four types of packaging used at Akzo Nobel, Stenungsund. All stages are included, from the extraction of raw materials to the final waste management. Emphasis was made on the reuse and recycling. Data have been compiled concerning use of natural resources, energy consumption and emissions emitted.

The study is resulted in a number of conclusions and recommendations. The use of steel drums is currently the best option due to the high steel collection and recycling rate worldwide. Intermediate bulk containers are a good alternative as supplier is handle collection and recycling. The composite drums should be used as less as possible due to the difficulties with recycling of this type of packaging. In countries with a high recycling rate such as Sweden all packaging alternatives can be used. Carbon dioxide emissions from the whole life cycle of packaging contribute to 1-7% (depending on the type of packaging and scenario applied) of the carbon dioxide emissions from the life cycle of the product (for example surfactant).

This report complements the series of studies performed by Akzo Nobel Surface Chemistry: "Transport and Environment. Site Stenungsund" and "Risk Analysis. Transportation of hazardous goods to and from Akzo Nobel site Stenungsund".

1. Introduction

Packaging of materials, goods and products is an essential feature in the demand-supply chain. It has both beneficial and harmful effect to the environment. Packaging protects goods from contamination during transportation and storage. However, during production of packaging, natural resources are depleted and energy is required. The emissions from the packaging production processes pollute the environment.

Akzo Nobel Surface Chemistry in Stenungsund, Sweden has decided as a part of their environmental concern and commitment to carry out a Life Cycle Assessment (LCA) of steel and plastic packaging used at the site in order to evaluate the potential environmental effects of these materials over the entire life cycle with emphasis on reuse and recycling.

The aim of this study is to compare different types of packaging and answer the following questions:

1. Which packaging has less environmental impact?
2. What happen to the packaging after delivery to the end user?
3. What are the differences between recycling of packaging in Sweden and the rest of the world?
4. Is recycling worth the effort?

Four packaging were selected for the study: 3 drums (plastic, steel and composite) of 200 litres each, and 1000 litres plastic container. LCA considered energy use and emissions associated with the production, filling, reconditioning, recycling and disposal of these packaging.

2. What is Life Cycle Assessment

Life Cycle Assessment provides the methodology to evaluate the potential environmental burdens of a product system or activity over the entire period of life cycle. It involves collecting data on raw materials used, energy consumption and wastes released to the environment (air, water and land). Data is collected for every stage of the life cycle, from mining of raw materials through to processing, distribution, use, reuse, maintenance, recycling, final disposal and all transportation involved

Based on a relevant functional unit for the system under study, this data is then calculated and modelled into a Life Cycle Inventory (LCI), which in turn is classified, characterised and valued to determine the environmental impacts of the system.

As a last step, the improvement assessment can be performed to identify and evaluate the options for reducing the environmental and possibly the economical burdens of the system.

3. Packaging for chemicals

Six different plastic and steel packaging are used at the site Stenungsund:

1. Steel Drum, 1.2 mm steel, Tight Head (TH), 210 ltr.
2. Composite (“Combi”) Drum, Steel/High Density Polyethylene (HDPE), 200 ltr.
3. Plastic Drum, HDPE, (TH), 217 ltr.
4. Plastic Drum, HDPE, Open Head (OH), 213 ltr.
5. Intermediate Bulk Container (IBC), HDPE, Wooden Pallet, 1000 ltr.
6. IBC, HDPE, Metal Pallet, 1000 ltr.

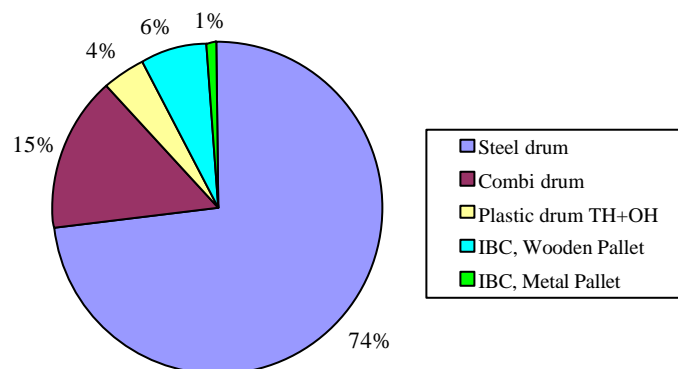


Figure 3-1. Types of packaging used at site Stenungsund (statistics for year 2001) [1]

As it is shown in Figure 3-1, the most widely used type of packaging is steel drums. The use of plastic drums became prominent in recent years due to the customers' demand. However, the percentage of plastic drums is still small in comparison to other types of drums. This is mainly connected to the technical problems posed by handling and filling of plastic drums at the site. [2]

The main characteristics of the packaging used are given in the Table 3-1.

All packaging are 100% recyclable except combi drums. The inner part of the combi drum is made of plastic and the outer of steel. This poses a problem for the material recycling process. Since the plastic and steel parts must be separated and sorted into different fractions to allow recycling.

Table 3-1. Characteristic features of packaging

Packaging	Material	Weight, kg	Comments	Useful life, years
<i>Combi drum</i>	Steel + HDPE	<i>Total: 24</i> Steel: 20,5 HDPE: 3,5	Partly recyclable	10
<i>Plastic Drum TH, OH¹</i>	HDPE	<i>Total: 9</i>	Recyclable	5
<i>Steel Drum</i>	Steel	<i>Total: 21,3</i>	Recyclable	10
<i>IBC, metal, wooden pallet²</i>	Container: HDPE Cage: steel Pallet: steel, wood	<i>Total: 75,81</i> Steel: 39,88 HDPE: 19,93 Wood: 16	Recyclable	5

4. Reuse and recovery of packaging worldwide

Nowadays, industrial packaging is increasingly being designed in ways that make them reconditionable, reusable or recyclable. But before they can be reconditioned or recycled, the packaging must be collected by or returned to a reconditioner, recycler or packaging manufacturer. Unfortunately, from a worldwide perspective, many users of packaging, especially small companies generating several empty drums or containers are not aware of this reverse distribution process or of the collection options available to them. The packaging in these companies are very often reused at the site or sold to their own workers for domestic use and, consequently, end up on landfills. Note: This is not the case in Sweden or other Nordic countries, where collection and recycling systems are well-developed.

The different waste management options vary from country to country and from company to company. The reuse and recycling of packaging in the customers' countries were studied through interviews and questionnaires. The customers' answers and recovery options in different regions (Asia, Eastern and Western Europe) are summarised in Table 4.1.

¹ In the analysis no distinction is made between these two types of drums.

² The use of IBCs on a metal pallet is insignificant (1% of all packaging) therefore, the analysis was made only on IBCs on a wooden pallet.

Table 4-1. Reuse and recycling of packaging in the different countries

Country	Plastic and steel packaging (recycling rate)	Answers of customers
<i>Japan</i>	<p>1. Plastic recycling³</p> <ul style="list-style-type: none"> - Coke substitute for pig iron production - Coal substitute for coke production - Material substitution - Synthetic oil production - Synthetic gas production [3] <p>2. Steel recycling</p> <ul style="list-style-type: none"> - 84,2% [4] 	Our steel drums are completely different from Japanese standards. Customers do not clean drums but send them for remelting. [5]
<i>Singapore</i>	<p>No pressure of recycling packaging for Asia Pacific, it is more up to the customer how they take care of it. Customer clean plastic drums and IBCs and use them for their ready made formulations. They dispose steel drums.</p> <p>Customers want to have more of the products in plastic drums. [6]</p>	
<i>UK</i>	<p>1. Plastic recycling</p> <ul style="list-style-type: none"> - 11% - recycled - 6% - incinerated for energy recovery [7] <p>2. Steel recycling</p> <ul style="list-style-type: none"> - 60% - overall steel recycling rate [8] - 37% - recycling rate of steel packaging 	<p>Steel and plastic drums and IBCs are sent for reprocessing.</p> <p>The majority of customers in the UK prefer plastic drums and IBCs as they are easy to handle and recycle. Steel drums are problems and composite drums are bigger problem. [9]</p>
<i>Germany</i>	<p>1. Plastic recycling</p> <ul style="list-style-type: none"> -51% - recycled (includes feedstock recycling) -19% - incinerated with energy recovery [7] <p>2. Steel recycling</p> <ul style="list-style-type: none"> -81% [10] 	Steel, plastic drums: Customers have special agreements with recyclers (VIV). IBCs are equipped with “recycling ticket” and recollected on this basis by the supplier and recycled. [11]
<i>Czech Republic</i>	46% of all packaging are recovered, from which 65% reused and 35% recycled. [12]	Customer has special agreement with the recycling company (EKO-KOM). [12]
<i>Sweden</i>	<p>1. Plastic recycling</p> <ul style="list-style-type: none"> - 17% - recycled - 62% - incinerated with energy recovery [7] <p>2. Steel recycling</p> <ul style="list-style-type: none"> - 70% [13] 	Customers clean packaging and reuse it for their products or send for reprocessing. IBCs are collected by the supplier and recycled.
<i>Former Soviet Union countries</i>	Recycling system is not developed. Used drums are cleaned and reused at the customer’s site or sold to their own workers for domestic use. Steel drums are usually collected and remelted. [14,15]	

³ The recycling rate for industrial plastic packaging is unknown.

5. Results

5.1 Scenarios

Three different scenarios (so-called optimistic, realistic and worst-case scenario) have been studied. The optimistic scenario can be applied to the countries where the collecting and recycling systems are well-developed and recovery rate is high, for example, Germany, Switzerland, Netherlands, and Nordic countries. The realistic scenario represents the current situation worldwide. Worst-case scenario is chosen to demonstrate the benefit of reuse and recycling of packaging.

Table 5-1. Scenarios

Scenario	Plastic drum	Steel drum	Combi drum	IBC
<i>Optimistic</i> (1)	reuse: 64% incineration: 16% landfill: 20%	reuse: 64% recycling: 16% landfill: 20%	reuse: 64% recycling: 16% landfill: 20%	reuse: 64% recycling: 16% landfill: 20%
<i>Realistic</i> (2)	reuse: 40% incineration: 20% landfill: 40%	reuse: 40% recycling: 40% landfill: 20%	reuse: 40% landfill: 60%	reuse: 64% recycling: 16% landfill: 20%
<i>Worst-case</i> (3)	landfill: 100%	landfill: 100%	landfill: 100%	landfill: 100%

5.2 Energy consumption

The energy consumption for the whole life cycle of packaging in MJ/1000 liters packed and delivered product is presented below.

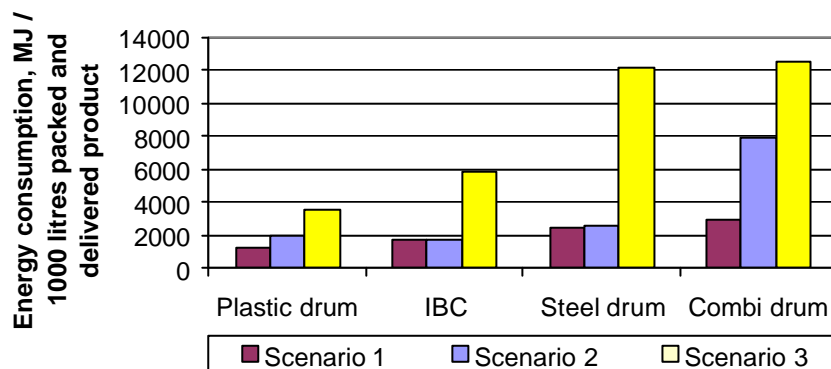


Figure 5-1. Energy consumption for the whole life cycle of different packaging. Comparison of scenarios.

From Figure 5-1 it is shown that the energy consumption for the whole life cycle of combi drums is higher than that of other packaging. In case of the realistic scenario (scenario 2), the high energy consumption for the combi drums is caused by the fact that the drums are considered to be partly recyclable.

A major part of the energy consumption concerning the life cycle of packaging (IBC, steel and combi drum) derives from the steel production process. If the reuse and recycling options are applied, the energy consumption would be reduced significantly (see the above Figure 5-1, scenarios 1,2).

5.3 Emissions to air

Carbon dioxide is one of the most important man-made emissions of greenhouse gases. Therefore, carbon dioxide emissions have been traced more carefully and compared for different types of packaging. Other emissions to air have been also studied. The result is presented below.

Scenario 1: optimistic

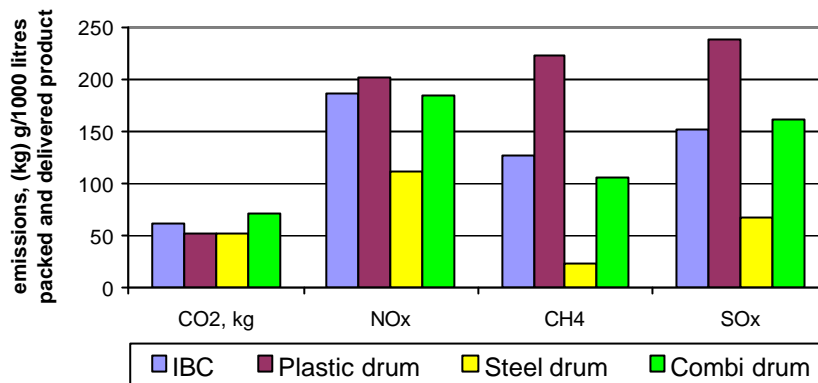


Figure 5-2. Emissions to air from the whole life cycle of different packaging. Scenario 1.

From the above Figure 5-2 it is shown that there is no significant difference regarding carbon dioxide emissions between the four types of packaging if the reuse and recycling rate is high. However, the carbon dioxide emissions to air from the life cycle of combi drums are slightly higher than for other packaging.

Scenario 2: realistic

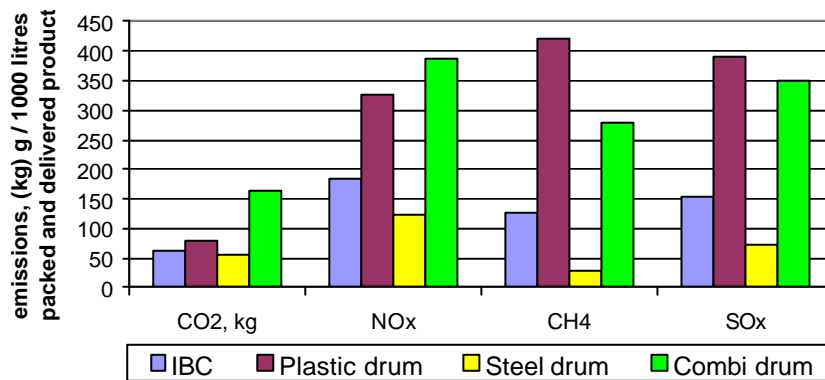


Figure 5-3. Emissions to air from the whole life cycle of different packaging. Scenario 2.

If the current reuse and recycling rates had been applied, the use of steel drums and IBCs would be the best option (see Figure 5-3). The use of plastic drums is also a good option. The carbon dioxide emissions to air from the life cycle of combi drums in the realistic scenario are higher than for other packaging. This is caused by the fact that only 40% of drums are considered to be reused and 60% disposed to the landfill (see Table 5-1).

Scenario 3: worst-case

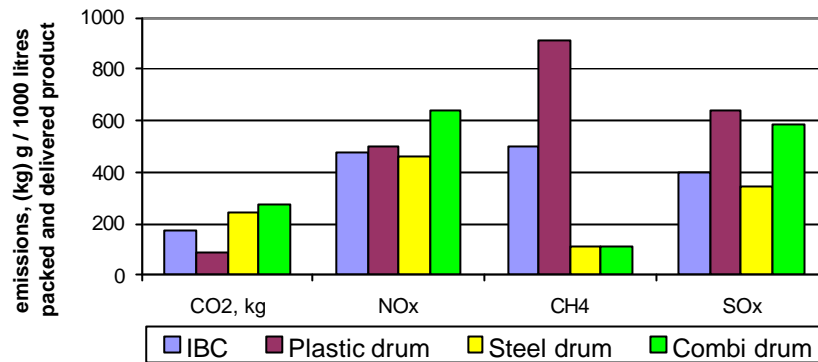


Figure 5-4. Emissions to air from the whole life cycle of different packaging. Scenario 3.

In case of worst-case scenario (100% landfill), the carbon dioxide emissions are higher for steel and combi drums than for IBCs and plastic drums as shown in Figure 5-4. The use of plastic drum is the best option. Note: The worst-case scenario has been chosen to estimate the benefit of recycling and the results cannot be applied for the current situation, since 100% disposal rate to landfill is impossible and not allowed by regulations.

Sources of emissions

The largest emissions of carbon dioxide come from steel and plastic production processes as well as from incineration of plastic wastes.

Methane is the second most important greenhouse gas. The study shows that the main part of methane is emitted during plastic waste disposal to landfill. The remaining part mainly originates from HDPE production.

Emissions of sulfur and nitrogen oxides contribute to acidification. Nitrogen oxides emissions also contribute to eutrophication. The study shows that sulfur oxide emissions to air come mainly from HDPE production processes. Nitrogen oxides emissions originate from HDPE production, transportation and steel production processes.

5.4 Comparison to the product

In order to better understand the results from the LCA of packaging for industrial chemicals, a comparison with the LCA of a surfactant produced by Akzo Nobel Surface Chemistry in Stenungsund has been made. The LCA data for the product have been obtained from the report "Environmental Study of 2-Ethylhexanol Based Surfactants". [16]

Contribution of different types of packaging and the surfactant to the carbon dioxide emissions was compared. Carbon dioxide emissions from the whole life cycle of packaging contribute to 1-7% of the carbon dioxide emissions from the life cycle of the surfactant, depending on the type of packaging and scenario applied.

5.5 Treatment of packaging

Many customers treat used packaging at the site to use it for their products. The steam or hot water is used for this purpose.⁴ For instance, cleaning of IBCs is done at Akzo Nobel site in Stenungsund. Hot water is used for cleaning. Wastewater from the cleaning process is incinerated. The sources of carbon dioxide emissions to air from the whole life cycle of containers are shown in Figure 5-5.

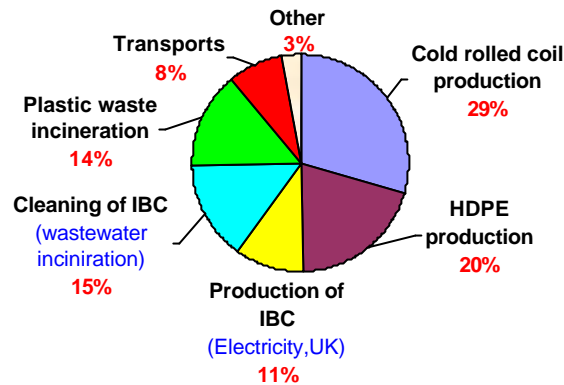


Figure 5-5. The sources of carbon dioxide emissions to air from the whole life cycle of IBC. Scenario 1.

The cleaning of containers (incineration stage) contributes to 15% of the total carbon dioxide emissions to air. However, the contribution is insignificant compared to savings of energy and resources and, consequently reduction of emissions, during the reuse and recycling as it is shown in Figures 5-2, 5-4.

6. Conclusions

Recycling gain. In order to reduce the energy input, resource consumption and emissions, the reuse and recycling options should be adopted and the recycling process should be made more efficient.

Presently, the use of steel drums is a better option. This is mainly due to the relatively high steel recycling rate worldwide. Based on the interviews with recyclers and customers it could be concluded that steel drums are usually collected and sent for recycling even if there is no regulations on recycling of packaging in the country.

Use of IBC is a good option, since the containers are equipped with so-called “recycling ticket” and recollected on this basis by the supplier and recycled. The “recycling ticket” is valid within Europe and US. Due to this option, reuse and recycling rates of IBCs are high and the use of this type of packaging is good from the environmental point of view.

With higher recycling rates the environmental effect of steel and plastic drums, and IBCs are almost the same. In the countries where the collection and recycling system is well-developed, for example Nordic countries, Germany, Switzerland, etc., all three types of packaging can be used.

⁴ Note that the treatment method depends on the previous contents of the packaging.

Use of plastic drums is reasonable in the countries with good plastic recycling technology. Feasibility studies should be carried out to know the packaging that customers want to buy the products and the reasons why they prefer it so as to reduce environmental effects.

Use as less composite drums as possible, only in cases where it is required by regulations. Composite drums contain two different materials and this poses a problem for the material recycling process, since the materials should be separated to allow recycling. In order to improve the recycling process, the materials should be easily separable or only one type of material should be used.

Plastic and steel drums are cheaper compared to other packaging. The IBCs on a metal pallet are more expensive than on a wooden pallet. The composite drums are the most expensive packaging.

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