PRODUCT LIFE CYCLE AND ENVIRONMENTAL IMPACT ASSESSMENT OF 7UP BOTTLE

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A THESIS SUBMITTED TO SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY, ZARIA IN PARTIAL FULFILLMENT OF THE REQUIRMENTS FOR THE AWARD OF MASTER DEGREE IN GLASS TECHNOLOGY,

DEPARTMENT OF INDUSTRIAL DESIGN,
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CERTIFICATION

The dissertation entitled "PRODUCT LIFE CYCLE ANALYSIS AND ENVIRONMENTAL IMPACT ASSESSMENT OF 7 UP BOTTLE BY HALIMAT IBRAHIM ABDULLATEEF" meets the regulations governing the award of the degree of MSc Glass Technology of Ahmadu Bello University, and approved for its contribution to knowledge and literary presentation.

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DEDICATION

This work is dedicated to Almighty Allah, my husband Geologist Abdulsalam Ibrahim Yusuf and my sons; Mohammed –Yasir and Sheik-Ibrahim.

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ABSTRACT

Studying the life cycle of 7up bottle is of great importance not only to the producers but to the users and the entire environment.The work broadly covers the entire life of the bottle from raw materials, production phase to the end of its life. The environmental impacts include those from emissions into the environment and through the consumption of resources, as well as associated with producing the bottle that occur when extracting resources, producing materials, manufacturing the products, during consumption/use, and at the products' end-of-life (collection/sorting, reuse, recycling, waste disposal). These emissions and consumptions contribute to a wide range of impacts, the depletion of resources, water use, land use, and noise—among others. A clear need, therefore, exists to provide complimentary insights, to help reduce such impacts. The raw materials are readily available except for soda ash sodium sulphate and iron chromate which are supplied from outside the Country and are very expensive.

Energy is most utilized at the melting stage, the furnace alone accounts for 70% of the total plant demand, while the batch stage and transportation has the least of energy consumption. A few of the total bottle produced for the batch under review were unrecovered from the consumers and most of the recovered bottles after being reused two times for the period of two and half years ,were crushed and used for recycle for further production. The greenhouse gases were emitted greatly at melting stage due to the fuel type LPFO (low pour flow oil) used in running the furnace .It is a by-product of crude oil which burn slowly. Dust particulates were also observed at the point of unloading of the raw materials and batch house.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Glass Life-Cycle Assessment

The product Life Cycle Assessment (LCA) allows toquantify a product's environmental footprint, in accordance with international standards, It studies two major aspects:

i. The whole product Life Cycle: from the raw materials and production phase to the end of the product life.

ii. All environmental impacts: water consumption, air pollution, resource utilization, and energy.

While a project life cycle assessment establishes an important quantitative benchmark, the full sustainable benefits of glass packaging include additional environmental, health, social and economic dimensions that reach above and beyond what can be measured in an LCA. These include health and safety, recycling, reuse and resource efficiency; the full benefits of glass social, environmental and technical recycling and reuse. Glass recycling and reuse contribute significantly to reducing glass packaging's carbon footprint (Abrahams, and John 2002). The use of recycled glass or cullet in batch materials has the following beneficial impacts:

1. Every 1 kg of cullet used replaces 1.2kg of virgin raw materials that would otherwise need to be extracted.
2. Every 10 percent of recycled glass or cullet used in the production results in an approximate 5 percent reduction in carbon emission and energy savings of about 3 percent.

3. Glass is resource efficient; it can be reused in its original form more than other packaging materials. Additionally, several initiatives currently underway in the glass industry that will further increase the efficiency of glass packaging. Such efforts include including ; to improve recovery and recycling of glass containers, help eliminate the diversion of glass to landfill; leading to a decrease in energy use and global warming potential (Andreola, *et.al*., 2005).
4. Light weighting glass containers reduces raw material usage, emissions, energy use and the overall weight.
5. Packaging's most important function is product preservation and no other packaging material does this better than glass.

1.2 Life History of Glass

According to Chang, (2008), glass dates back to the Stone Age when naturally occurring glass (especially the volcanic glass obsidian) was used globally by many Stone Age societies for the production of sharp cutting tools and jewelry. Another rare form of naturally occurring glass is called *fulgurite* (commonly called 'petrified lightning') which occurs when lightning strikes sand and the resultant heat sometimes fuses the sand into long slender glass tubes. The scarcity and selective source areas of these naturally occurring glasses made them valuable materials for trade. Archaeological evidence however suggests that the first true glass was made in coastal North Syria, Mesopotamia or Ancient Egypt, (Douglas, 1972).

Early glass production relied on grinding techniques borrowed from stone working. This meant that glass was ground and carved at a cold state. The disasters that overtook the Late Bronze Age civilizations brought glass-making to a halt and it only picked up again in

its former sites, in Syria and Cyprus, in the 9th century BCE, when the techniques for making colorless glass were discovered. In Egypt however, glass-making did not revive until it was reintroduced in Ptolemaic Alexandria, (Helmenstine, 2012).

1.3 Statement of the Research Problem

When you buy a bottle of 7up drink, most of the cost is for the liquid and the bottle. But what about the environmental cost? Manufacturing, filling, labeling, shipping, storing and recycling of the bottles is expensive. In responding to the imperative to reduce greenhouse gases, life cycle modeling tool is used to measures the environmental impact of every stage in the bottle life cycle.Each of these life cycle stages yields carbon emissions that contribute to the total carbon footprint. As a result, customers and consumers get a clear picture of 7up bottle packaging which provides insight into the bottle quality and the bottle's positive or negative environmental impacts.

1.4 Aim of the Study

The aim of this research is to assess the life cycle of 7up bottle production and the associated environmental impacts generated at every stage, using Sunglass as a case study.

1.5 Objective of the Study

The objectives of this study are to:

i. Study the stages in the life cycle of the 7up container glass, with consideration to a particular batch.

ii. Assess the impacts associated with every stage in the life of a the bottle

iii. Study the span of the bottles with 7up bottling Company, its end users and back to the Sunglass Company

1.6 Research Questions

This research work tends to ask the following questions:

i. What are the stages in the life cycles of the 7up container bottle?

ii. What are the impacts associated with every stage in the life of a bottle?

iii. How long does the 7up Bottling Company use the bottles before they are returned to Sunglass for recycling?

1.7 Significance of The Study.

To evaluate the environmental profile of 7 up bottle, through its life cycle stages and determining its improvement opportunities., towards having more sustainable and more environment friendly 7up bottle**.**The outcome of the study will help us to understand the requirement and potentiality of 7up bottle packaging industry.

1.8 Basic Assumption

The basic assumptions of this study are:

i. There are adverse environmental impacts in the life cycle of 7up container glasses that need to be addressed.

ii. There will be possible solutions to minimize the adverse environmental impacts by 75%.

1.9 Delimitation of the Study

The delimitation of this study is to work with data collected from Sunglass Nigeria Ltd,Kaduna on a particular batch of feed consisting 50% of Virgin materials for glass and 50% Cullet.

1.10 Scope of the Study

The study covers raw materials extraction and processing, heating and melting stage of the raw materials, bottle formation, distribution, usage and end of life.

CHAPTER TWO

LITERATURE REVIEW

A growing number of businesses commission independent audits that help set environmental performance targets, particularly regarding waste disposal and energy use. The term environmental audit is applied to the voluntary regulation of an organization's practices in relation to its environmental impact. An Environment Impact Statement (EIS) usually involves a sequence of steps, (European Commission, 2010): (1) screening to decide if a project requires assessment and to what level of detail; (2) preliminary assessment to identify key impacts, their magnitude, significance, and importance; (3) scoping to ensure the EIS focuses on key issues and to determine where more detailed information is needed; (4) implementing the main EIS study, which involves detailed investigations to predict impacts, assess their consequences, or both. After a project is completed a *post audit* is sometimes done to determine how close the EIS's predictions were to the actual impacts, (GEPVP, 2005).

2.0 The Sunglass Nigeria Limited

Sunglass Nig Ltd (Plate 1) is located at Plot H8, Kudenda Industrial Area, off Nnamdi Azikiwe Expressway, in Kaduna, Nigeria. It is a manufacturer of high quality 7up glass bottle containers products. Sunglass bought over the Ballarpur assets in 1992 and became incorporated that year. It started production in November 1995 and is the only manufacturer of 7up container products in West Africa..



Plate I: Sunglass company.

Sunglass energy cost has increased steadily over the past decade, with the most rapid increase occurring from 2001.

Figure 2.1.Shows the Sunglass Co. energy costs as a percentage of value added, and the rapid increase in energy cost occurring since 2009 can be attributed to step increase in the price of fuel over the same period.

Energy costs as a percentage of production decrease steadily throughout 2009 but tended upward along with total energy cost since 2009 due to uncontrolled charges in fuel prices increases.

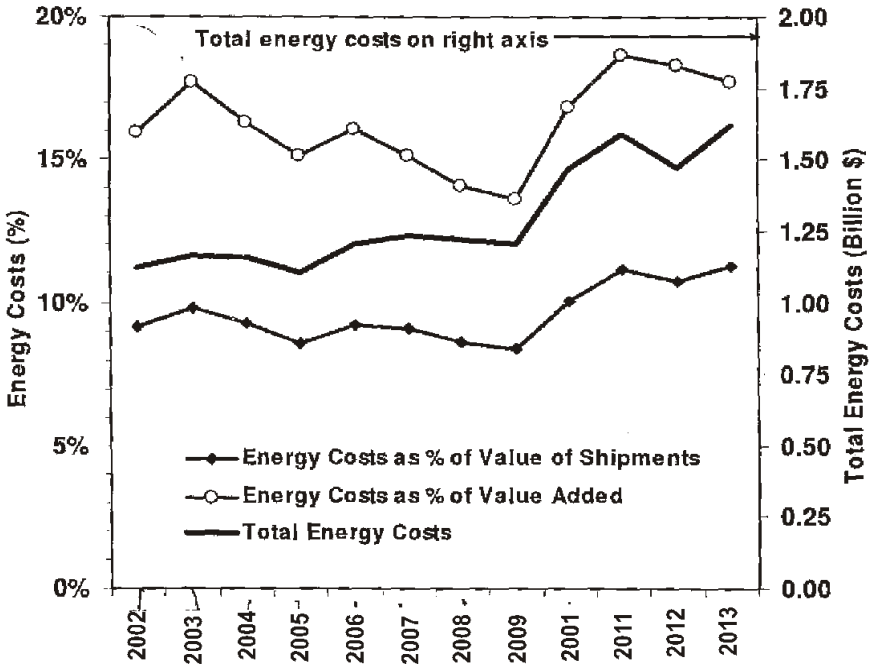


Figure 2.1 Historical Trends in energy cost for Sunglass industry

2.1 Container Glass

Container glass is manufactured by combining quantities of minerals to obtain a feedstock rich in silica (SiO_2), soda (Na_2O) and lime (CaO). Whilst a wide range of minerals can be used, the most common ingredients are high purity silica sand, soda ash (Na_2CO_3) and limestone ($CaCO_3$). The mixture is heated to temperatures between 1300°C and 1650°C where it is melted. During its time in the glassmaking furnace, the molten material is 'fined' (allowed to release all gas bubbles within its volume) and homogenised via mechanical stirring and convection mixing. It is then brought to a suitable temperature for forming, and released from the furnace. Forming is carried out automatically, usually by a combination of blowing and pressing, (Abrahams, and John 2002).

Most glass (89 percent) that is discarded is container glass. The glass container industry is also the largest segment of the glass industry, shipping $4.5 billion dollars worth of glass containers in 1996 and employing about 432, 008 workers in U.S. In 1998, glass containers represented 44 percent of the value of primary glass shipments in the United States. Glass containers are used in a variety of product industries, including food and beverages, medicine and health, toiletries and cosmetics, and chemicals, (GEPVP, 2005).

The decline in the amount of container glass discarded (dropping from 13.2 million tons in 1996 to 9.9 million tons in 1998) is largely attributable to a decrease in the shipment of new glass containers, from 46.7 billion units in 1999 to 40.5 billion units in 1999. The decreased shipments reflect the industry's loss of market share to other container types. According to the Glass Packaging Institute, the trend toward making lighter bottles also contributed to a decrease in the weight of glass in the solid waste stream, (Abrahams, and John 2002).

In 1999, however, product shipments of glass containers grew slightly for the first time since 1996, to 40.9 billion units. Growth in 1999 shipments is attributed to various factors, including the conversion from plastic soft drink bottles back to glass in a few markets, increases in sales of beer and food containers, and deceleration in the movement to plastic bottles for liquor products. Throughout this same period, the recycling of glass containers has increased. In 2000, 5.7 percent of glass containers were recycled. By 2001, this rate had increased to 13.3 percent of glass containers, representing an increase of 133 percent, (GEPVP, 2005).

2.2 Glass Containers versus Aluminum and Plastic containers

Since the introduction of plastic beverage containers back in the late 1970s, the glass share of the beverage container market, as well as the non–beverage container market, has dropped consistently. Prior to that, glass was also losing market share to aluminum cans. In the soft drink market, for example, glass containers accounted for 80 percent of packaged soft drink sales in 1970. By 1980, the glass share had fallen to 45 percent and in 1989 it was 22 percent due to market factors have favored growth for aluminum and plastic. Both materials are lighter than glass and both are shatterproof. Aluminum cans have captured a large share of the convenience market while the larger plastic containers have taken a substantial market for at-home consumption, (Molisch, *et al*., 2009).

2.3 Manufacture of Glass.

The main manufacturing processing activities taking place at the manufacturing site are the batch preparation, the melting of the raw materials in the furnace, the formation of

glass containers, the conditioning in the annealing lehr, the quality control, automatic neck forming and storage.

Glass container is primarily made of raw materials like sand and soda ash, but also from recycled glass i.e. 'cullet'. Mixing recycled glass with raw materials allows a reduction of CO_2 emissions from production and contributes to greater product sustainability. The stages in glass production include:

1. Sand, limestone, soda ash, dolomite, iron oxide and salt cake are mixed together with cullet in the batch plant.
2. The raw materials are then charged into a large furnace and melted at 1600°C. They combine in a process of physical transformation to form molten glass.
3. A continuous gob of molten glass is fed out of the melting furnace onto a mould of an enclosed former of molten glass at 1100°C.
4. Compressed air is then blown into the mould and the molten glass takes the shape of the former.
5. The glass is then released from the mould onto conveying belt or rollers to theannealing lehr to be cooled down. At this stage the internal stresses are released ensuring perfect glass ware.

Depending on the type of content of the product, the glass is labeled in various styles ranging from enameling to screen printing, (Abrahams, and John. 2002).

2.4 Environmental Impact

The major environmental impact of glass production is caused by atmospheric emissions from melting activities:

- The combustion of natural gas/fuel oil and the decomposition of raw materials during the melting lead to the emission of CO_2. This is the only greenhouse gas emitted during the production of glass.

- Sulphur dioxide (SO_2) from the fuel and/or from decomposition of sulphate in the batch materials can contribute to acidification and formation of SMOG.

- Nitrogen oxides (NO_x) due to the high melting temperatures and in some cases due to decomposition of nitrogen compounds in the batch materials also contribute to acidification.

Other environmental issues are water pollution, the use of non renewable natural raw materials such as sand and minerals, production of solid waste and emission of volatile organic compounds (used in production of mirrors and coatings).

Although a lot has already been achieved, further reductions in emissions of SO_2, dust particles, NO_x and CO_2 are still the main environmental objectives for our flat glass activities. Minimising and controlling these emissions in an integrated way is a complex matter. The development of environmental techniques is still ongoing, and AGC Glass Europe actively participates in the dynamic process of developing new techniques. Most of these technologies, however, have disadvantages as well as advantages. For example:

- Switching from heavy fuel to natural gas reduces CO_2 and SO_2, but increases NO_x.

- Some technologies that reduce NO_x can cause an increase in CO_2 when extra energy input is needed.

- Technologies that reduce SO_2 can produce non-recyclable waste.

- Some technologies can affect the lifetime of the furnace or the quality of the glass.

A glass furnace runs 24/7 and cannot be stopped and cooled down during its lifetime (15-18 years). Most technologies can therefore only be installed during a furnace rebuild. At that moment we have to look beyond and make decisions for a long period.

The Building and Industrial Glass divisions (Primary Operations) and the Automotive division.
The environmental impacts of these divisions are different, because the Automotive and Building divisions have lower atmospheric emissions than the Industrial Glass division. Similarly, the quantities of waste are lower than in plants producing flat glass, but a constant recycling effort reduces the amount of waste sent to landfill.

The North American glass container industry has taken a pioneering step in producing the first complete and thorough cradle-to-cradle life cycle assessment (LCA) ever conducted for the industry.

The LCA, coordinated by the Glass Packaging Institute (GPI), reaffirms the benefits of glass container recycling for the environment. The use of recycled glass (cullet) in manufacturing results in a decrease in primary energy demand and reduces carbon emissions. A “cradle-to-cradle” LCA includes the entire cradle-to-grave life cycle of a product while factoring in the recycling of the used product back to its original purpose.

The LCA confirms the industry is on the right track with the goal to use 50 percent recycled glass in the manufacture of new glass bottles and jars by the end of 2013,” says

Joseph Cattaneo, president of the Glass Packaging Institute. “In creating more recycling awareness and working to improve recycled glass collection, the industry is helping boost the cullet content in manufacturing. The study shows increased cullet helps to reduce energy emissions, conserve raw materials, extend the life of glass manufacturing furnaces, and save energy.”

While other industries claim that the transportation of glass bottles has more of an environmental impact because of the weight of the containers, a key finding of the LCA dismisses this claim. The transportation of raw materials and cullet used in glass production represents less than four to five per cent of the total energy used in the production of container glass.

While each glass container has its own carbon profile, on average, existing recycle rates offset the CO_2 burden when shipping foods and beverages across America. The 50 per cent content rate will only serve to further reduce carbon emissions.

Therefore, when examining the entire life cycle of a packaging material, one must also consider the environmental impact of raw material extraction, production, transportation and end use treatment. The conclusion: when looked at it in its entirety, the environmental benefits stemming from the recycling of glass containers more than offset any increased impact generated by slightly heavier containers.

“The North American glass container industry purposely conducted a cradle-to-cradle LCA to obtain a total picture of our industry’s environmental impact,” says Cattaneo. “We knew that for an LCA to be useful and to serve as an appropriate benchmark, it had to be cradle-to-cradle. For consumers and retailers to be able to compare the environmental

impact of one packaging material to another, all industries should consider conducting complete life cycle analyses. Only then will we have clarity."

Glass containers are endlessly recyclable, made from all-natural ingredients (sand, soda ash, limestone, and recycled glass), and glass is the only packaging material accepted by the U.S. Food and Drug Administration (FDA) as GRAS (generally recognized as safe) for food and beverage contact.

A leading sustainability consulting firm, PE Americas, conducted the study examining each step from raw material extraction to end-use. The closed-looped cradle-to-cradle LCA collected data from 105 furnaces representing 75 per cent of North American glass container production.

There are areas that an LCA is not designed to study where glass excels for both the consumer and the environment. Recent surveys continue to show that most consumers say glass maintains the flavor and shelf life of foods and beverages longer than any other commercial container and is least likely to leach toxins into the packaged products. The trust and premium image glass bottles and jars maintains with consumers is only reinforced by the standard-setting methodology and results of the glass container LCA.

2.5 Environmental Impact Statement (EIS)

Environmental Impact Statement (EIS) is a formal process used to predict how a development project or proposed legislation will affect such natural resources as water, air, land, and wildlife. The environmental impact statement was first introduced in 1969 in the United States as a requirement of the National Environmental Policy Act. Since then, an increasing number of countries have adopted the process, introducing legislation and

establishing agencies with responsibility for its implementation, (European Commission, 2010).

Environmental impact statements have mostly been applied to individual projects and have led to various offshoot techniques, such as health impact assessments, social impact assessments, cumulative effects assessments, and strategic environmental assessments (environmental assessments of proposed policies, programs, and plans). In some cases, social and economic impacts are assessed as part of the environmental impact statements, and in other cases, they are considered separately, (European Commission, 2010).

2.6 Life Cycle Impact of Energy Efficient Glass

The process of manufacturing flat glass for building applications inevitably has a cost in terms of CO_2 emitted. However this is more than compensated for by the CO_2 savedbyreplacing single glazing with energy efficient glazing. According to a detailed study undertaken in 2005,the manufacture of $1m^2$ of low-E double glazing leads to the emissionof 25 kg ofCO_2**,** and this has subsequently been further reduced by the introduction of new manufacturing technologies in recent years. On the other hand, 91 kg of CO_2 per year are saved by replacing one square metre of single glazing with low-E double glazing. TheCO_2 emitted during production is thus offset after only 3.5 months' use, (TNO, 2007).

At the level of the European Union (EU 25), the total CO_2emitted by buildings is 765 million tonnes CO_2 per year. By comparison, the manufacture of architectural glass only releases 4.6 million tonnes per year. Considering the potential savings of 100 million tonnes of CO_2 per year through the use of energy-saving glass, CO_2 linked to glass production would quickly be outweighed even if additional production was required. Glass is also a recycle

product. Even at the end of the lifecycle of the window this valuable resource is not lost and can be recycled. This recycled glass, when melted again to produce new glass products, helps further reduce the CO_2 emitted by manufacturing facilities, (TNO, 2007).

Glass manufacturing requires energy since glass furnaces need to be heated to temperatures of 1600C° at which point raw materials melt to become glass. Because of this rule of material physics, energy accounts for the largest share of manufacturing costs. In this context, reducing energy consumption is an economic imperative and constant goal of all glass manufacturers. In fact, studies have shown that the glass industry has been able to reduce energy consumption by 55% between 1970 and 2000 while production was on the rise,(Waterman, 2007).

Today, glass manufacturers continue to invest and apply best available techniques in all installations. They carry energy audits and have taken commitments to reduce energy consumption even further. That being said, without major technological breakthrough, improvements will remain limited hence glass manufacturers' investments in extensive research programmes.

The carbon content of final glass products is also heavily affected by the geographical location of manufacturing installations. Glass is a relatively heavy product, which is not convenient to transport over long distances. For this reason, importing glass from outside Europe inherently means importing glass with much higher carbon content. Maintaining energy-efficient glass manufacturing installations in Europe is thus to the benefit ofEurope**.** It is all the more important that installations can then recycle glass, which contributes to further lowering energy consumption in manufacturing and to preserving

natural resources. The glass industry is committed to energy-efficiency of its products and their manufacturing for one obvious reason: through out its lifecycle,(Waterman, 2007).

The study also found that where energy savings are cost effective, the result is that consumers divert expenditure from energy into the general consumption sector. Improving the energy efficiency of residential property can also help address fuel poverty. Those with the lowest incomes are increasingly vulnerable to rising energy prices due to the bad energy performance of housing. Promoting energy efficiency upgrades can help to ease this social burden on society, (Samtur, 1997).

More globally, Europe's investments in energy-efficient buildings will boost investment in Research and Development and in manufacturing capacities of energy-efficiency industries. It will contribute to maintaining Europe's industrial lead in the worldwide race for sustainable production and green product development.

2.7 Reduction of Air Pollutants

The aim is to gradually reduce air emissions, which mainly come from the glass-melting furnaces. The primary measures (optimization of the combustion and/or glass batch) are applied as a priority by Glass factories. In this way, the direct emissions of nitrogen oxides released during the melting of 1 tonne of SGG PLANILUX glass were reduced by 28% over a worldwide perimeter, between 2007 and 2010. In addition, systems for treating gas emitted at the chimney stacks have been installed to reduce dust, sulfur oxides, heavy metals and acid gas (HF and HCl) emissions. 8 new gas filtration systems have been installed since 2007, bringing the total number of sites equipped to 19 in 2010. In this way, the amount of

dust emitted during the melting of one tonne of glass was reduced by 40% in 2010 compared to 2007, over a worldwide perimeter, (European Commission, 2010).

2.8 Waste Glass and Cullet

There are 3 types of cullet, depending on their origin:

1. Internal cullet: broken glass coming from manufacturing glass, reintroduced into the original process
2. Pre-customer cullet: broken glass coming from processing, before implementing the finished product.
3. Post-consumer cullet: broken glass coming from the end-of-life stage, after collection, sorting and treatment, (Selvaduray, 1995).

Currently, on average 30% of the total weight of container glass made by Saint-Gobain Glass comes from recycled internal cullet and pre-customer cullet. More than 1 500 000 tonnes of cullet are melted each year in 36 furnaces. This enables:

1. A reduction of 1 800 000 tons of raw materials (natural resources) consumed.
2. A reduction of at least 375 000 tonnes of CO_2 emitted, which results in significantly capping the greenhouse effect caused by greenhouse gas emissions. The technical limit to incorporating cullet into glass manufacturing has by no means been reached. There is an unquestionable market opportunity if the collection and treatment channels were set up to collect glass from demolition sites, treat it and recycle it in flat glass furnaces, (Samtur, 1997).

2.9 Product Marketing

Annual growth in total industry sales generally follows population growth. Glass container manufacture is also a geographical business; the product is heavy and large in volume, and the major raw materials (sand, soda ash and limestone) are generally readily available, therefore production facilities need to be located close to their markets. A typical glass furnace holds hundreds of tonnes of molten glass, and so it is simply not practical to shut it down every night, or in fact in any period short of a month. Factories therefore run 24 hours a day 7 days a week. This means that there is little opportunity to either increase or decrease production rates by more than a few percent. New furnaces and forming machines cost tens of millions of dollars and require at least 18 months of planning. Given this fact, and the fact that there are usually more products than machine lines means that products are sold from stock. The marketing/production challenge is therefore to be able to predict demand both in the short 4–12 week term and over the 24–48 month long term. Factories are generally sized to service the requirements of a city; in developed countries there is usually a factory per 1–2 million people. A typical factory will produce 1–3 million containers a day. Despite its positioning as a mature market product, glass does enjoy a high level of consumer acceptance and is perceived as a "premium" quality packaging format.

2.10 Life cycle impact

Glass containers are wholly recyclable and the glass industries in many countries retain a policy, sometimes required by government regulations, to maintain a high price on cullet to ensure high return rates. Return rates of 95% are not uncommon in the Nordic countries (Sweden, Norway, Denmark and Finland). Return rates of less than 50% are usual

in other countries. Of course glass containers can also be reused, and in developing countries this is common, however the environmental impact of washing the container as against remelting them is uncertain. Factors to consider here are the chemicals and fresh water used in the washing, and the fact that a single-use container can be made much lighter, using less than half the glass (and therefore energy content) of a multiuse container. Also, a significant factor in the developed world's consideration of reuse is producer concerns over the risk and consequential product liability of using a component (the reused container) of unknown and unqualified safety. How glass containers compare to other packaging types (plastic, cardboard, aluminum) is hard to say; conclusive lifecycle studies are yet to be produced.

CHAPTER THREE

METHODOLOGY

3.1 Data Collection

The data on the subject inventories(materials and energy usage) and processes were collected at Sunglass limited while the data regarding the use of the produced bottles from Sunglass i.e. filling of the content with the liquor, packaging and distribution to consumers were gathered at 7up company in Kakuri, Kaduna,. Secondary sources such as bibliography, inventories data and literature were also utilized.

3.2 Materials

The materials used in the study were classically obtained from Sunglass limited on a particular batch (SG-130716B) of raw materials (Silica sand, Soda Ash, Limestone, etc.), Energy, fuel usage and other input. Data were also obtained on all the stages in the lifecycle of the 7UP bottle and the impact at each stage such as batch preparation, melting conditioning, forming finishing, final product, recycle and reuse. The obtained data were analyzed and the Composite Environmental Impact was calculated and result was compared to the industry benchmark, graphs were also plotted to show the trend in the energy usage at Sunglass ltd over the last decade and the benefit of high usage of cullet as it reduces the Global Warming Potential (GWP) and Primary Energy Demand (PED).

3.3 Method and Procedure

Quantitative and analytic techniques were adopted in this research work. Sunglass Company limited was used as a case study. The journey of the study of the life cycle of 7UP

bottle began with the consideration of a particular batch (SG-130716B), right from processing of raw materials to the end users then back to the company for the period of two and half years

7UP Container glass production requires four major processing steps: batchpreparation, melting and refining, forming, and post forming.

Batch preparation is the step where the raw materials for glass are blended to achieve the desired final glass product. Once mixed the batch is charged to a melting furnace.Melting of the batch may be accomplished in many different types and sizes of furnaces, depending upon the quantity and type of glass to be produced. The melting step is completed once the glass is free of any crystalline materials. Refining is the combined physical and chemical process occurring in the melting chamber during which the batch and molten glass are freed of bubbles, homogenized, and heat conditioned. After refining, the molten glass is sent to forming operations. Forming is the step in which the final product begins to take shape. The main stages in the life cycle of a bottle that were studied are as follows:

3.4 Extraction and Processing of raw Materials

The raw materials that constitute the batch (SG-130716B) which gave output products of 660,000 units of bottles on 2nd of June, 2013 are categorized below inTable 3.1 into former, stabilizer, flux and colorant, their origins are also shown on the table. The former is the subject raw material, sand while fluxes are there to reduce the melting temperature. The off-loaded Silica Sand and a view of the crushed cullet are shown in Plate II and III.

Table 3.1 7up Bottle Raw Materials

S/N	RAW MATERIAL	ORIGIN	FUNCTION
1	Silica Sand	Baba Muttum(Kano)	Subject Material(Former)
2	Feldspar	Katsina	Former
3	Limestone	Edo	Enhance Durability(Stabilizer)
4	Dolomite	Nasarawa	Stabilizer
5	Soda ash	China	Reduces Melting Temperature(flux)
6	Sodium Sulphate	China	Act as Catalyst(flux)
7	Iron Chromate	United Kingdom	Gives The Green Colour(colorants).

SOURCE: Sunglass Laboratory Data



Plate II: Off-loaded Silica Sand.



Plate III:Veiw of Crushed and purified cullet.

The raw materials arrived at the plant by truck, and in drums and packages. They were unloaded using drag shovels, vacuum systems and gravity systems, and conveyed to and from storage by belts, screws and bucket elevators Raw materials were crushed, ground, and sieved prior to receipt at the glass plant, and were stored in separate elevated bins

The raw materials were conveyed to the weigher and mixer. 50% of treated cullet (to the ratio of virgin material) which weigh 750kg was introduced alongside with the raw materials. The cullet is to increase the output and reduce the energy level that would have been used if the same quantity of raw materials were substituted for the cullet Efficient blending of the raw materials is critically important to the quality of the glass product. If the batch is not properly blended, in-homogeneities may increase melting time and lead to product quality problems. For example, if not mixed properly, the molten glass may not have uniform viscosity, and when delivered to the forming machine will not flow evenly. The result could be a glass product of variable thickness. The equipment used for crushing and handling the raw materials was kept separate from the furnace in the batch plant (Figure 3.2). The final mixture was conveyed to a batch storage bin called bunker where it was held for 24hrs before it was fed into the melting furnace.

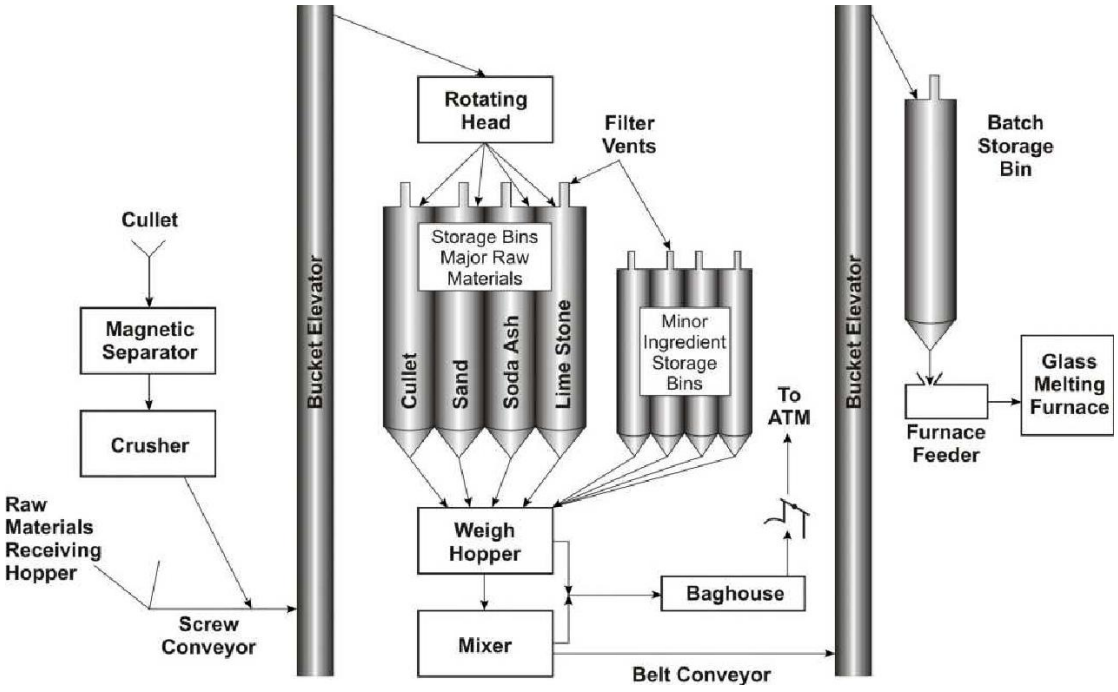


Figure 3.2. Batch Plant [Sunglass Nig Ltd]

3.5 Heating and Melting of the Raw Materials

The raw materials are conveyed from the bunker to the furnace, the melting Chamber(fig 3.3) and are heated up to the temperature of 1,500°c which through a sequence of chemical reactions causes the materials to be transformed to a molten glass.

The furnace has the capacity of 100 metric tons hence could not contain the total output of 200 Metric tons from the bunker at once. The batch was fed into the furnace twice.

The high temperature required to melt the glass requires a lot of fuel this is why furnace is the main energy centre in the industry accounting for around 70% of the total plant demand, the furnace used 1100kwh of energy for each metric ton of glass melted, hence used total of 220,000kwh to melt the batch (SG-130716B) of 200 Metric tons .The whole melting process took a day and used 33,000ltrs (l truck load) of fuel,LPFO(low pour flow oil) a by-product of crude oil.

The type of furnace used by Sunglass is a Regenerative Furnace where the latent heat in the furnace is collected in a regenerator and then used to preheat combustion air and achieve higher efficiency.As the batch passes through the melting furnace, it went through four phases: melting, refining, homogenizing, and heat conditioning. This is illustrated in Figure 3.3 **.**Melting began when the batch entered the furnace, and was complete when the glass was free of crystalline materials.

During refining, gas bubbles were eliminated from the batch and molten glass. Refining occurs throughout the melting chamber, beginning with the batch charge to the furnace and continuing until the complete dissolution of crystalline materials.

During thermal conditioning, glass was stabilized and brought to a uniform temperature Thermal conditioning began immediately after the glass melt reaches its highest

average temperature in the furnace, after this time it began cooling to the working temperature for forming.

As shown in Figure 3.3, thermal conditioning occurs in the melting and refining sections of the furnace, and in the forehearth. The glass melt flowed to the forehearth, where the glass was then transferred to the forming process. The forehearth cools the molten glass to a working temperature for forming.

The melting furnace contributes 80% of the total pollutant emission to the air this includes SO_2,NO_2, Greenhouse gases (GHG). The emission from the furnace also contain particulate matter (PM) the main source include low level of metals and the combination of volatile component from the batch and melt with sulfur oxides to produce compounds that condense in furnace waste gases.

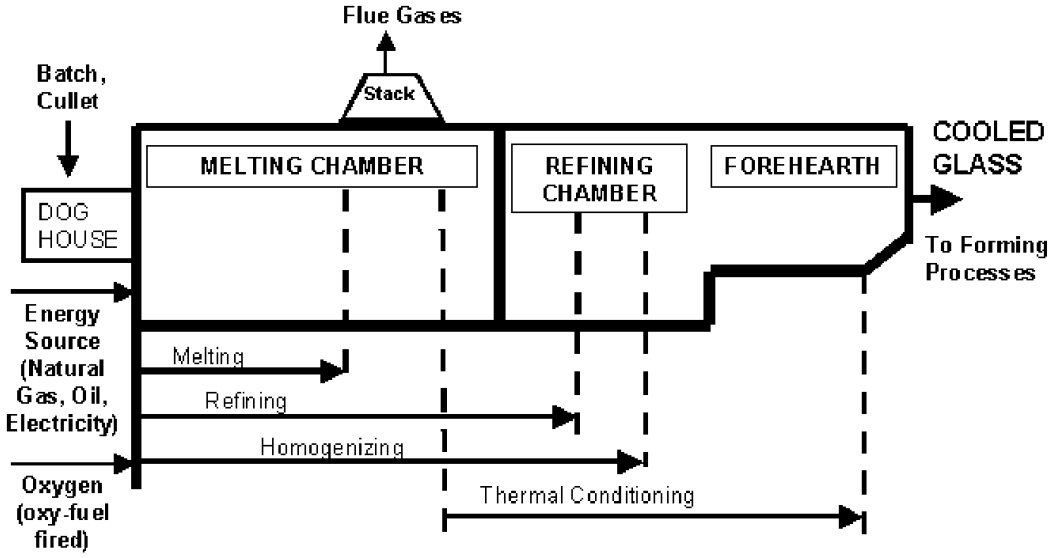


Figure 3.3 Melting and Refining Processes [Sunglass Nig Ltd}

3.5.1 Forming and finishing

At this stage the float glass from the furnace was further preheated at the forehearth(Fig 3.3) (conditioning) to maintain the viscosity and flow to the production side where was blown and moulded. Press-and-blow formation takes place in an individual section (IS) machine (Fig 3.4).The machine has between five and 20 sections, all identical, which can each carry out the glass-container forming process simultaneously and completely. The result was that five to 20 containers can be produced with one machine at the same time. A shearing blade was used to cut and shape the glass into a cylindrical shape, called a gob.The cut gob falls, and using gravitational force, rolls through the appropriate passage to reach the moulds. A metal plunger presses the gob into the blank mold where it assumes the mould's shape. from here, it moves to the annealing lehr where they were cooled, and the , bottles undergo internal treatment, a process which makes the inside of the bottle more chemically-resistant, two tanks of water are used in cooling process. The bottles were further conveyed to ACL (Applied Ceramic Label) Department for labeling. The process of the labeling is so fast that over 100 bottles are labeled in every 10 minutes.

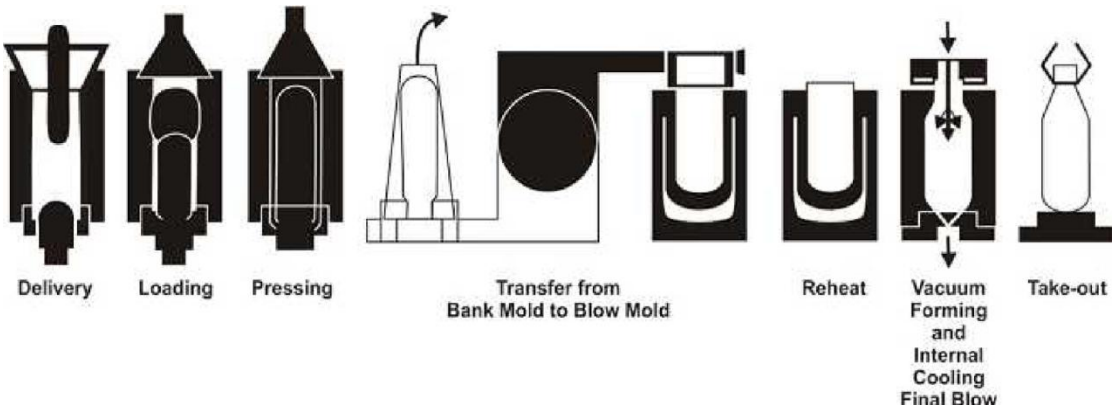


Figure 3.4. Container Glass Forming Press &Blow{Sunglass Nig Ltd}

3.6 Filling and Distribution

Sunglass Nigeria Ltd distributes packaged bottles to different outlets within Nigeria and outside the country as well depending on the demand. The product from batch (SG-130716B) with an output product of 660,000 units were all purchased by 7up bottling company at Kakuri in Kaduna .The new bottles, together with existing ones were further washed and sterilized after which they were filled already prepared liquor These were packaged and distributed to different retail outlets. The products were purchased by consumers and consumed. Containers were collected through curbside drop-off centers and commercial no-premises locations.

After three months, 80% of the bottles were recovered ,the recovered bottles were further washed sterilized, filled, packaged and distributed, 82% were collected after another 3 months . The turnover of the bottle collection was high enough that the bottles were reused for about 7 times within the span of, 2.5years before 90% of the bottles recovered were send back to Sunglass for recycling.

3.7 End of life/Recycle

As the bottles were collected from consumers the 7up bottling company subjected each bottle to the following physical and mechanical test before they are reused:

- Internal Pressure: This mechanical test was done on the bottle to determine whether the bottle meets applicable specifications and is fit for the intended use. The testing was carried out using a ramp internal pressure tester. The bottles were filled using water and the pressure is automatically increased until the bottle

breaks; the location of the failure origin was then determined. The standard internal pressure for 7UP Bottle is 300Psi from production point (Sunglass ltd) while 250Psi is set by the bottling company. Any bottle that fall short of this point is sent back to Sunglass for recycle.

- Vertical Load Resistance: It was carried out to determine the bottle's resistance to vertical load forces.
- Capacity and Headspace: the assessment calculates the volume of liquid held by the container and the volume of space left at the top of the packaging. The assessment determine whether the correct volume of product can be held whilst still maintaining the sufficient headspace in order to withstand any change in pressure that may occur during the bottle's life cycle.

Any bottle that failed the above tests including those physically damaged, are all put together and sent to Sunglass for recycle. They are crushed into cullet and used alongside with virgin raw materials and mixed for the new glass 7up packaging.

3.8 Data Analysis

From the data collected at each stage of the life cycle of the bottle from Sunglass Company Ltd. The figures for each pollutant were computed for 7UP bottle life cycle and results were compared to the industrial standard and other packaging products. From the result deduced from the data analysis and findings, recommendations were given.

CHAPTER FOUR

4.0 Results

4.1 Results of Feedstock Analysis

The information regarding the raw materials that constitute Batch No: (SG-130716B) was obtained the batch constitute of the following raw material: Silica Sand, Feldspar, Lime Stone, Dolomite, Soba Ash, Sodium Sulphate and Iron Chromate. Sunglass obtains silica sand which is the major raw material from Babban Mutum because of the riches in the sand. Table 4.1 below present the component of the sand and the weight of each.

Table 4.1 shows, SiO_2 remains the major component of the silica sand, it has total weight of 98.83%. Feldspar is also an inherent part of the raw material for 7 up bottle as it acts as flux Table 4.2 and 4.3 present the Feldspar and Dolomite content of the raw sample and percentage weight of raw material.

Table 4.1 Raw Materials for production of 7up bottles

Analyte	**Silica Sand (Babban Mutum)**
	Weight%
Na_2O	<0.05
MgO	<0.05
AI_2O_3	0.41
SIO_2	98.83
P_2O_5	<0.05
K_2O	<0.05
CaO	0.14
TiO_2	0.11
Cr_2O_3	<0.05
Mn_3O_4	<0.05
Fe_2O_3	0.12
ZnO	<0.05
SrO	<0.05
ZrO_2	0.05
BaO	<0.05
LOl @ 1000°c	0.34

Table 4.2 Analyte of both Feldspar and Dolomite.

Analyto	Timsul Dolomite	Feldspar Lumps I	Feldspar Lumps II (WHT)	Feldspar Lumps III (WZR)
Na_2O	0.04	7.25	10.23	2.71
MgO	18.68	0.03	0.04	0.03
AI_2O_3	0.07	20.49	21.02	18.88
SiO_2	1.51	65.16	65.77	65.01
K_2O	<0.01	5.34	0.81	12.71
CaO	33.87	0.97	1.67	0.10
TiO_2	<0.01	<0.01	<0.01	<0.01
Cr_2O_3	<0.01	<0.01	<0.01	<0.01
Mn_3O_4	<0.01	<0.01	<0.01	<0.01
Fe_2O_3	0.05	0.10	0.09	0.09
SrO	0.01	<0.01	<0.01	<0.01
ZrO_2	0.01	<0.01	0.01	0.01
BaO	0.02	0.01	0.01	0.01
LOI @ 1000°c for 30 mins	45.74	0.66	0.35	0.45
Total	100.00	100.01	100.00	100.00

Table 4.3 Percentage Weight of raw materials in 7up bottle.

Analyte	200ml flat bottle Weight %
SiO_2	71.34
AI_2O_3	1.80
Fe_2O_3	0.137
CaO	9.81
MgO	1.67
Na_2O	13.93
K_2O	0.89
TiO_2	0.08
ZrO_2	0.036
SO_3	0.30
Cr_2O_3	0.001
Total	100.00
Density (gcm -3)*	2.5032 +/-0.0001

Table 4.3 shows the major resources to be SiO_2, 71.34% N_2O 13.93% and CaO 9.81% other materials are in minimal value. Both CaO and Na_2Oacts as flux that makes the process faster and smoother.

A sand with very high percentage of SiO_2 like that gotten from Babban mutum can actually be used alone to make the bottle, but the environmental impact will be so high as more energy and time will be required to melts it and it depreciate the furnace faster.

4.2 Notable impacts Associated with Extraction and Processing of Raw Materials

The observed impacts at this stage are

(a) **Energy usage in batch preparation**: Electricity was used in batch preparation for bucket elevators pneumatic conveyors, batch mixers or blenders, and agglomeration of materials. The batch mixer accounts for the greatest share of electricity. In general electricity use in batch preparation was only 4 percent of a glass plant total energy demand. Electric consumption for batch preparation is summarized in Table 4.4. A total of 0.5 mmbtu/ton of energy was used for batch preparation

(b) **Air Emission:** the air emissions observed in batch preparation were mostly particulates in the form of dust. Table 4.5 presents the quantity of filterable particulates at each stage of batch preparation. Unloading and conveying happens to give the highest dust generation. The quantity is high enough to affect to affect the neighborhood and the employees of the company if not well managed.

Table 4.4 Energy Usage in batch Preparation

Energy	Air Emissions	Effluents	Byproducts/Wastes
Energy use per net ton of glass: 0.5 Btu/ton	Particulates in the form of dust (raw material particles)	not applicable	Unusable raw materials, baghouse or filter dust residues (recycled)

Table 4.5 Air Emission Factors Batch Preparation

Batch Plant Source	Filterable Particulates (lb/ton of materialProcessed)
Unloading and conveying	3.0
Storage bins	0.2
Mixing and weighing	0.6
Crushing and batch charging	Negligible

Mixing and weighing stage has a reduced dust emission compared to unloading because the process is done in an enclosure; most of the dusts are trapped in. Crushing and batch charging has a negligible air emission.

(c) **Transportation:** Transportation of the materials from the extraction point to Sunglass Limited is a costly process because of the location of the source of these raw materials; soda Ash, Sodium Sulphate are being supplied from China, Iron Chromate is supplied from United Kingdom. Other materials are found in Nigeria but distinct location from the company. With Solvay process, Sodium Sulphate can be produced from the cheaply available resources of sodium chloride and Aluminum Sulphate. Adopting the process will have a positive impact on the cost aspect.

4.3 Notable Impacts Associated with Heating and Melting of Raw Materials

Table 4.6 and 4.7 presents the emission load and Energy usage during production

(a) Air pollutant

Melting raw materials generate air emissions consisting of particulates, nitrogen oxides, and sulfur oxides.Sulphur oxide and Nitrogen oxides are the primary air pollutant produced during heating and melting. Sulphur dioxide or SO_x emissions, made up of SO_2 + SO_3, 1300mg/Nm3 of waste gas which is given off at the point of firing. A further environmental problem in the melting process the batch is posed by the NO_x loads occurring, 700mg/Nm3 of waste gas. The NOx content depends on the air preheating temperature. O_x content is believed can be reduced using catalysts with ammonia (NH_4)

Table 4.6 Emission load generation

Outputs per units of product	Unit	Batch Value	Industry Benchmark.
Particulate Matter	mg/Nm3	20	50
NOX	mg/Nm3	700	1000
SOX	mg/Nm3	1300	1500
COX	mg/Nm3	400	700
HCl	mg/Nm3	30	50
HF	mg/Nm3	20	40
Metals	mg/Nm3	20	50

Table 4.7 Resources and Energy Consumption

Inputs per unit of Product	Unit	Batch Value	Industry Benchmark
Fuels Specific fuel consumption for container glass regenerative end port furnaces with production 200 ton/day	GJ/tonne melted	2.2	3.9
Electricity Specific electricity use	kWh/tonne melted	98	110
Water Water consumption per unit of production	m3/tonne melted	3.2	4

(b) **Energy Usage and Water Consumption**

Table 4.7 provides the resource-consumption indicators for energy and water, the fuel, electricity and water consumed by the batch are all below the benchmark for container glass. The specific energy consumption (fuel and electricity) is below the benchmark as a result of the furnace capacity, age of the furnace and cullet utilization. Small furnaces and furnaces operating at less than nominal capacity are generally known with less energy efficient, since specific heat losses are high. The energy consumption is also dependent on glass quality (melt temperature), cullet percent, and furnace age. The lower value 2.2 GJ/tonne provided was as a result of the new furnace purchased three years back, cullet maximization (50%) and good insulation of the furnace, and good operating conditions (i.e., not excessive operating temperatures and good combustion control.).Electricity use figures similarly exclude direct use in melting, but do include use in combustion air fans

The amount of energy input in the bottle production is known as Primary Energy Demand (PED).Table 4.8 summarizes the average specific energy (i.e. energy use per ton of produce) use in the major process steps in the bottle production for each of the primary industrial segments.

Table 4.8 Specific energy consumption of major process step

Process Step	Average Specific Energy (mmbtu/ton)
Batch preparation	0.5
Melting and refining	5.8
Forming	0.4
Post farming/finishing	0.7

Source: - Sunglass Ltd (2014)

Melting and refining are the most energy – intensive process within each industrial segment, while batch preparation is usually the least energy – intensive process step.Overall, the increase of recovery and recycling result in a decrease of the primary energy demand and an even greater decrease of the Global Warming Potential (GWP). The greater benefit for GWP is generated by the lower energy numbers, the cut in CO_2 emission and from reduction of batch materials.

The 50 percent scenario shows nearly a 10 percent decrease in GWP. For GWP, the baseline is 1.26kg CO_2 per 1kg of the container glass production on the market and the 50 percent scenario result in a decrease to 1.11kg CO_2 equivalent. In order words the 50 percent metric tons of CO_2 from the environment, the equivalent of removing the CO_2 emissions of nearly 400,000 cars every year.

(c) Dust Emission

Dust emission (103mg) was observed in the melting furnaces which was believed to have been caused by the high temperatures, and the evaporation of the mixed components
The value indicated in the show that glass furnaces without filter systems have high dust concentrations in the waste gas. The prescribed limits of 50 mg/Nm^3 of dust in Germany (TA-Luft 1986) are difficult to achieve without dedusting plants. Electrostatic dust precipitation, fabric dust filters with sorption or wet scrubbing may be used.

(d) **Heat**

The heating chamber is generally very hot, in the event of stoppage or unexpected breakdown of furnace or faults in the preheating system ,very high temperatures may occur, since the furnaces are operated at temperatures in excess of 1500°C. Employees don't have

protective devices that could be used in such emergency situation such as thermal protective suits. Contingency plans were not available as the time of research such as drills plan to be carried out to ensure rapid, targeted intervention in emergency situations.

4.4 Notable Impacts Associated With Forming and Finishing

(a) Water Consumption

The wastewater produced in this sector is to be cooled and reused, but Sunglass has no facility for reuse yet. The company used about 4 m3/t in processing of the batch under consideration. The average water consumption in a glass works should be less than 1 m^3/t of glass produced. The cooling water of the cutting devices and moulding machines, the compressors, emergency power diesel generators used and also the water from the quenching basins underneath the production machines were contaminated by oil. These effluents were cleaned by oil separators. Circulating systems should have been installed so that only small quantities of additional fresh water are required.

(b) Noise Hazard

The noise generated is particularly significant in the industry during melting, moulding and cooling and in the chambers of the compressors, whilst hardly any problematic noise loads were generated in the areas of packing and finishing.

An extremely critical area in terms of noise emission, was moulding area with compressed-air-controlled machines; here the noise load generally exceeds 110 dB(A). In the furnaces noise levels of up to 90 dB(A) was reached during melting and in the feeder.

Whereas In principle no workplace within a plant should be exposed to a continuous noise level in excess of 85 dB(A); at this level hearing protection should be provided, and from 90 dB(A) protection must be worn in all cases, The employee of Sunglass at this locations do not wear hear protection. The large fans which produce the quantities of air required and the compressors also generate relatively high levels of noise. However, few houses are situated in the area of the company but the habitation is still being affected by noise nuisance,60 to 70 dB(A) during the day. So far, attempts to enclose the machines for soundproofing purposes have been unsuccessful because of the need for regular oil lubrication of the units and cleaning of the moulds. When the glasses are cooled, noises is generated by fans but were reduced by suitable designs and enclosures.

4.5 Notable Impacts Associated with End of Life/Recycle

Not all the supplied bottles were recovered from end users. Table 4.6 shows the analysis of quantity in use and quantity recovered within the span of two and half years from the day batch was produced while the pressure test result is shown in Table 4.10

As at 7th Dec.2015, out of the total 660,000 units of the produced bottles, only 11,000 Units were Unrecovered which was believed were either used for landfill or were converted for other purpose by the end users. The quantity still left of the batch that test satisfactory to the pressure test is 37,000 units which are currently used alongside with the new supplied bottles from Sunglass Company .A total of 612,000 units failed the pressure test (less than 250 psi) .These quantity were collected in bits throughout the period usually at the refilling stage which is done at every two months. Most of the bottles were used averagely two to

three times before they went below the standards (250Psi) set by the company. The bottles were crushed weighed (950kg) and sent to Sunglass for recycle.

Table 4.9 Batch life analysis

Batch (SG-130716B) weight(Metric tons)	**Quantity Generated(Units)**	**Quantity with Bottling/liquor CO.**	**Quantity returned to Sunglass Co for recycle(Units)**	**Quantity Unrecovered (Units)**	**Span(Months)**
200	660,000	37,000	612,000	11,000	30(2.5yrs)

Table 4.10 Pressure test analysis

Date	Total Quantity Used(Units)	Total Quantity Recovered(Units)	Average Pressure test value(Psi)	Standard (Psi) Value	Quantity below Standard(Units)
04/11/2013	660,000	605,000	220	250	136
25/03/2014	512,000	484,000	215	250	115
09/07/2014	421,000	392,000	212	250	104
15/11/2014	301,000	282,000	208	250	98
03/03/2015	254,000	185,000	205	250	85
26/07/2015	115,000	95	202	250	74
07/12/2015	37,000				

The standard Pressure value set by Sunglass Company is 300 Psi while that of the bottling company is 250 Psi.After use, some of the bottles fell below standard as shown in table 4.3.0 and the bottles were averagely used four to five times.

4.6 Major Findings

The following are the major findings in the course of the study:

(1) The effects of the bottle production on the environment and workplace are mostly caused by noise, dust, effluent and flue gases. Noise is mostly generated from forming and finishing stage, particularly when the bottles are been moulded.Most air emission in the process comes from melting stage .water is consumed highly at melting and cooling stage. The major impact of life – cycle assessment of 7-up bottle therefore comes from the melting of the glass in the furnace, followed by non-melting activities such as heating and cooling of plants compressors and finishing steps of the glass containers. This is followed by virgin maternal extraction and transportation of these materials. Melting contributes the largest percentage of each impact category considered.

(2) Cullet utilization plays a major role in impact minimization, The greater the percentage of cullet utilized alongside with virgin raw materials, the greater the overall impact which is also known as Composite Environmental Impact Index (CEII) can be greatly reduced.

(3) Sodium carbonate which is part of the raw materials is imported from United Kingdom. It's known to be very expensive even more than the major component. Sodium carbonate can cheaply be produced in Nigeria through Solvay process from sodium chloride, ammonia and carbon dioxide which are readily available.

(4) Sunglass Nig Ltd does not have waste water treatment plant, a facility that would have minimize the rate of water consumption in the process and impact caused by the waste water to the environment.

(5) The furnace has a small capacity of 200 tons compared to the benchmark of the industry; 350-400 tons .Acquiring furnace with greater capacity by the company will really enhance the process.

CHAPTER FIVE

DISCUSSION

5.0 Discussion

Waste generated in the 7 up industry can be categorized into the following three groups: materials handling waste, pollution control equipment waste and plant maintenance waste. Materials handling waste includes the waste generated during the receiving and transfer of raw materials at the facility for storage or processing, including raw materials that are rendered unusable when spilled during receiving and transfer.

Emissions control equipment at the bottle manufacturing plants generates waste residues from pollutants produced or captured during the melting, forming, and finishing steps. Theseare known to be hazardous .

The plant maintenance wastes include waste oil and solvents generated in the forming process, furnace slag, and refractory wastes. Furnace dust, grinding and polishing sludge, and refractory rubble from the demolition of glass furnaces may contain metals and other unsafe materials. During the forming process, oil is used in the forming machines and often contaminates the water that keeps the machines cool. Most of the industry's waste is managed on site via recycling, energy recovery, or treatment. The remaining waste is treated and released to the environment through direct discharges to air, land, and water, underground injection or offsite disposal.

5.1 Global climate change

The generation of greenhouse gases (carbon dioxide, methane, nitrous oxide) which trap heat in theatmosphere has been linked to global warming. These gases are transparent to solar radiation that enters the Earth's atmosphere, but strongly absorb the infrared thermal

radiation emitted bythe Earth.

Greenhouse gases are emitted from the combustion of fossil fuels and the incorporation of soda ash inglass. The amount of carbon released when fossil fuels are burned is dependent on the carbon content, density, and gross heat of combustion for the particular fuel.

Soda ash (sodium carbonate) is another source of carbon dioxide in bottle manufacture. As soda ash is processed into various products, additional carbon dioxide is emitted if the carbon is oxidized.Limestone (calcium carbonate), a glass batch material, is also a relatively small source of carbon dioxide.

5.2 7up bottle Lifecycle impact

Bottles are wholly recyclable and the glass industries in many countries retain a policy, sometimes required by government regulations, to maintain a high price on cullet to ensure high return rates. Return rates of 95% are not uncommon in the Nordic countries (Sweden, Norway, Denmark and Finland). Return rates of less than 50% is obtainable in Nigeria which i believe if such policies are introduced ,greater percentage of recyclable bottles will be recovered which will lead to impact reduction.However the environmental impact of washing the container as against remelting them is uncertain. Factors usually being considered here are the chemicals and fresh water used in the washing, and the fact that a single-use container can be made much lighter, using less than half the glass (and therefore energy content) of a multiuse container. Also, a significant factor in the developed world's consideration of reuse are producer concerns over the risk and consequentialproduct liability of using a component (the reused container) of unknown and unqualified safety. How glass

containers compare to other packaging types (plastic,cardboard, aluminium) is hard to say; conclusive lifecycle studies are yet to be produced.

CHAPTER SIX

SUMMARY,

6.1 Summary

One of the primary findings of the LCA is the relatively small energy impact resulting from transportation of glass packaging within the full scope of the environmental life cycle of glass. Transportation of raw materials and cullet used in the container production represents less than 10 percent of the total energy used in the production of container glass. Even at current industry recycled content rates, it is clear that the transportation emissions are offset by the energy savings gained from the use of recycled glass in the manufacturing process.

The CO_2 savings from glass recycling are as large, or larger, than the transportation emissions. Glass is nonporous and impermeable, so there are no interactions between the bottle and the contained products that could affect the flavor of the liquor.

Recycling glass containers provides for unmatched production efficiencies and significant environmental benefits: decreases the amount of raw materials used, lessens the demand for energy, cuts CO_2 emissions, extends furnace life without any processing by-products and saves on overall manufacturing costs. Much of glass container recycling is in a closed loop,

Which means that a glass container becomes the same product again and again. Though some glass containers are recycled into non-container products, the endless recycling of glass back to its original use without loss of quality or purity is the true definition of a recyclable material.

6.2 Conclusion

7UP container glass production is relatively energy-intensive, primarily due to the large amount of energy required to melt and refine glass, substantial amounts of energy are used in the manufacturing process. In general, the majority of energy used for these activities is derived from fossil fuels. Combustion of fossil fuels results in emissions of CO_2. In addition, the container manufacturing process also results in process non-energy CO_2 emissions from the heating of carbonates (soda ash and limestone).

The bottles are barely used four to five times before they are crushed and used as cullet this is due to frequency at which they failed the pressure test. More treatment should be given to the bottles by the Sunglass such that the Refillable bottles, can be used an average of 10 times, will greatly reduce carbon footprint.

Recycling and reuse glass contribute significantly to reducing carbon footprint. The use of recycled glass or cullet in batch materials has the following beneficial impacts: Every 1 kg of cullet used replaces 1.2 kg of virgin raw materials that would otherwise need to be extracted. Every 10 percent of recycled glass or cullet used in production results in an approximate 5 percent reduction in carbon emissions and energy savings of about 3 percent.

The Life cycle analysis is actually an effective tool that has helped shedding light on environmental impacts and identifying pathways in reducing the impacts of 7UP container bottle, from the analysis, energy consumption can actually be cut by 50 percent, reduce total CO_2 equivalent emissions by 65 percent, achieve a recycled content of 60 percent and achieve zero accidents.

6.3 Recommendations for Further Research

In order to reduce the Environmental Impacts to the minimal and making 7up container bottle more sustainable.

The following are recommended for Sunglass Co.

1. Air pollutants Reduction: particularly Sulphur and nitrogen oxides which are the primary pollutants produced during the heating and melting stage can be reduced. According to Technical instructions on Air Quality control of U.S, the sulphur oxides content can be reduced by feeding magnesium, calcium carbonate and soda into the flue gas. Nitrogen oxide can be reduced by the use of Oxy-fuel firing .The process which save energy and improve productivity and also reduce nitrogen oxides emissions by about 70 percent and particulate emissions by 60 percent.
2. Lightweighting has become one of the single most important innovations in the industry. Improved technology has led to lighter weight glass containers that are remarkably strong and safe. Lightweighting has multiple environmental benefits, as lightweighting continues within the industry, the CO_2 savings will increase. Light weighting has these advantages. By reducing the weight, companies are able to save on raw materials and melting costs.
3. Recycling: Recycled glass is always part of the recipe for glass, Recycled glass containers are always needed because glass manufacturers require high-quality recycled container glass to meet market demands for new glass containers. And the more that is used, the greater the decrease in energy used in the furnace. This makes using recycled glass profitable in the long run, Sunglass Company Uses about 30% of recycled glass in their production, In order for the environmental impacts to be minimized effort has to be

put in to increase the percentage of recycled glass as it reduces emissions and consumption of raw materials, extends the life of plant equipment, such as furnaces, and saves energy. Energy costs drop about 2-3% for every 10% cullet used in the manufacturing process. One ton of carbon dioxide is reduced for every six tons of recycled container glass used in the manufacturing process.

6.4 General Recommendations

1) Use of Electric Furnace: With the current stability of electricity in the country it is possible to use electric glass furnaces of special design which produce far lower emissions and do not require expensive environmental protection equipment. The energy requirement per kg of glass can also be reduced by introducing such melting methods.

2) Compliant to Global Carbon Reduction Targets: Glass container manufactures should take measures to improve energy efficiency and reduce energy use to ultimately decrease environmental impact and reduce costs. Reducing overall emissions to minimize operational costs and environmental impact in support of global carbon reduction targets.Reinforcing workplace safety as an integral company value and ensure that each employee's safety is a top priority.

3) Container Deposit Legislation: Research has showed that country with container deposit legislation have an average glass container recycling rate of just over 63%, while non-deposit country only reach about 24%, For us achieve this, our governing bodies have to enact this law for us to achieve a greater percentage.

6.5 Contribution to Knowledge

On the assessment of 7up bottle raw materials, sodium carbonate is the most expensive material used by Sunglass Nigeria Limited, it is usually obtained from chaina.In Nigeria, this compound can be produced cheaply from readily available resources through a process known as Solvay process (also known as the ammonia-soda process)

The Solvay process is a continuous process using limestone ($CaCO_3$) to produce carbon dioxide (CO_2) which reacts with ammonia (NH_3) dissolved in brine (concentrated NaCl) to produce sodium carbonate.

For Glass making industries, if the process can be inculcated into the system, the cost impact of the compound will be greatly reduced.

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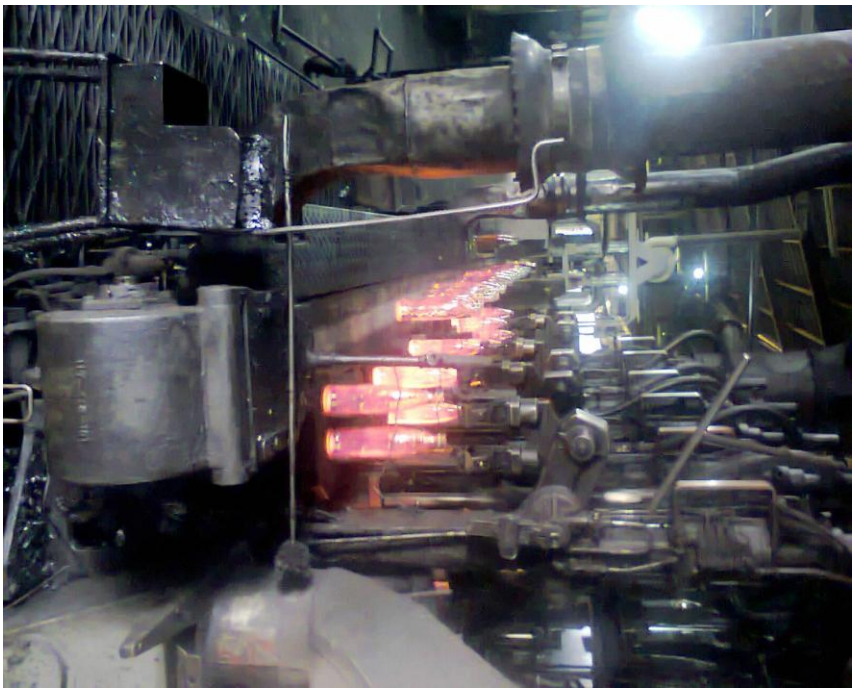
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APPENDIX I



SideView of IS machine.

APPENDIX II



Produced Bottle being conveyed for Labeling.

APPENDIX III



Bottles at the point of Labeling.

APPENDIX IV



Stored Sodium Carbonate

APPENDIX V



Granulated Dolomite

APPENDIX VI



A side View of the Storage Compartment

APPENDIX VII



Packed Bottles ready for dispatch

APPENDIX VIII



Loaded Truck, to be supplied to Kakuri Bottling Company