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# GLASS RECYCLING SUPPLY CHAIN ASSESSMENT



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## 1 Abstract

According to the findings of this study, the glass recycling supply chain from the surveyed cities of Kosovo may or may not be economically feasible. The cities included in this study were Decan, Drenas, Ferizaj, Fushë Kosovë, Gjakovë, Gjilan, Istog, Kacanik, Klinë, Lipjan, Mitrovicë, Pejë, Podujevë, Prishtinë, Prizren, Viti, and Vushtrri. Based on the quantitative analysis, the total amount of flat glass that can be collected within a year in Kosovo is 1,909 tons. The businesses that dealt with glass claimed that they mainly processed transparent glass. As a result, if assumed that 85% of the flat glass is transparent, then 1,623 tons of this type of glass can be collected annually. In order to utilize the production capacity, the recycling company could collect 120 tons of transparent glass monthly at an initial cost of € 28,628, or about €0.238 per kg. These costs include the expenditures the company would face to purchase the containers. Since the containers are to be purchased once and used continuously, the costs in the following months would drop to €828, assuming the recycling company would not modify the supply route. It must also be emphasized that the total amount of glass bottles currently being distributed in the market by the surveyed businesses is around 122 tons monthly.

Table 1. Summary of Findings

Carbon dioxide emissions reduced if 6 tons of recycled glass are used in the manufacturing process instead of raw materials	1 ton
Monthly flat glass supply from surveyed area, assuming 85% of glass is transparent	124.85 tons
Tons of glass bottles distributed in the market monthly from the surveyed businesses	121.98 tons

## 2 Introduction

This study provides the assessment of the supply chain for glass recycling in Kosovo. Orient Mosaic Kosovo, is a new factory in Mitrovica that produces glass tiles and is looking to locally source the main input of recycled flat glass. The objective of the study is to evaluate and analyze the establishment of a recycling supply chain in the Kosovo market. Although the analysis focuses mainly on clear flat glass, information was also obtained on the potential supply of glass bottles from businesses operating in the beverage industry. The cities included in the study area were Decan, Drenas, Ferizaj, Fushë Kosovë, Gjakovë, Gjilan, Istog, Kacanik, Klinë, Lipjan, Mitrovicë, Pejë, Podujevë, Prishtinë, Prizren, Viti, and Vushtrri. In these municipalities, businesses that utilize glass for various reasons were identified and interviewed in person. The businesses that were visited include glass cutters, manufacturers of doors and windows, glass traders, and businesses in the beverage industry. The information obtained from these businesses was analyzed and modeled to construct a cost-effective supply.

Glass is considered to be one of a few valuable materials that retains all of its natural qualities despite the number of times it gets recycled and reprocessed<sup>1</sup>. Due to this quality of glass, recycling helps in saving energy, creating employment, and protecting the environment. In regards to energy savings, glass is made up of a mixture of plentiful and cheap raw materials, like sand, limestone, and soda ash. The process of melting these raw materials in furnaces requires huge amounts of energy. Hence, by recycling glass, the energy required to access and deliver these raw materials – meaning, to make the glass from “scratch” – is saved. As a result, carbon dioxide emissions are reduced. In a country like Kosovo, where carbon dioxide represents 80% of all greenhouse gas emissions, attempts to reduce such emissions through recycling would be crucial<sup>2</sup>. In terms of employment, both glass collection schemes and recycling companies producing their product from recycled glass create jobs locally. For every ton of waste glass melted in a furnace, there are 1.2 tons of raw materials saved. Glass recycling, in this case, contributes to the protection of the environment, preservation of natural

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<sup>1</sup> recyclenow.com, “Glass Bottles and Jars.”

<sup>2</sup> European Environment Agency, “Kosovo.”

resources, and the reduction of loads on landfills – indirectly assisting communities in avoiding expensive waste disposal costs<sup>3</sup>.

Looking at recycling from the business perspective, the process of recycling glass also cuts on the overall production costs due to the minimum amount of raw materials consumed, lower energy demands, and the increased life of furnaces and equipment. Lastly, the process of glass recycling is based on a “closed loop” system, in which no waste or by-products are produced<sup>4</sup>.

### **3 Relevant Literature**

Examples from other countries will be used to model Kosovo’s nascent recycling sector. In the United States, from 1986, California enacted the California Beverage Container Recycling and Litter Reduction Act, making it the first state in the United States to add a place of deposit for glass in addition to those of paper, metals, twine, and rubber already in place in other states at the time<sup>5</sup>. Meanwhile, in the same year, Rhode Island became the very first state to pass obligatory recycling legislation for glass and plastic bottles, aluminum and steel cans, and newspapers<sup>6</sup>. Hence, for 30 years now, glass has been representing a consistent part of recycling programs, with recycled glass typically finding a market at the container manufacturing industry, abrasive grit blasting, road-surfacing, water filtration,<sup>7</sup> and home insulation in the form of glass wool<sup>8</sup>. These end markets impact the amount, quality and demand for the recycled product, as these sectors are impacted by other factors the demand for glass will fluctuate.

#### *3.1 Cost of Glass Recycling*

Having always been a lower-valued commodity, recycling managers today are facing new pressures with glass, in part to the commodity prices dropping in their end markets<sup>9</sup>. According

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<sup>3</sup> Glass Recycling UK, “Reasons For Recycling.”

<sup>4</sup> Ibid.

<sup>5</sup> Motor City Free Geek, “A Brief History Of Recycling.”

<sup>6</sup> State of California, “What Are States Doing: School Diversion Resource Guide.”

<sup>7</sup> Let’s Recycle, “Glass - Letsrecycle.com.”

<sup>8</sup> recyclenow.com, “Glass Bottles and Jars.”

<sup>9</sup> Will Flower, “Focusing on the Economics of Glass Recycling.”

to Steve Shannon, an ecologist and municipal services manager at Balcones Resources, the rarity of the components that make up the material to be recycled is what makes recyclables valuable<sup>10</sup>. Hence, the reason behind glass's lower price in the market in comparison to other recyclable materials is that glass is made of sand, and sand is more pervasive than the components of the majority of other recyclable materials. To process a ton of glass it costs from \$70 to \$90 (€63 to €81), which is then sold for approximately \$10 (€9) a ton<sup>11</sup>. In the United Kingdom, as of February 2016, a ton of brown bottles is sold to glass processors from £7 to £14 (€9 to €18); a ton of clear bottles from £10 to £25 (€12.9 to €32.3); a ton of green bottles from £0 to £14 (€0 to €18); a ton of mixed bottles from £0 to £13 (€0 to €16.8); whereas glass processors are paid from £10 to £31 (€12.9 to €40) to receive MRF (mixed) glass<sup>12</sup>, as shown in Table 2.

Table 3. Market Prices of Glass in the United Kingdom

2016: € per ton	January	February
Brown Bottles	9 - 18	9 - 18
Clear Bottles	12.9 - 32.3	12.9 - 32.3
Green Bottles	0 - 18	0 - 18
Mixed Bottles	0 - 16.8	0 - 16.8
MRF Glass	-12.9 - -38.7	-12.9 - -40

Source: "Glass," letsrecycle.com, 2016

### 3.2 *Economic and Environmental Impact*

The practice of recycling glass saves energy, reduces emissions and the redundant consumption of natural resources, and extends the life of furnaces and other plant equipment. Recycled glass can be safely substituted for 95% of raw materials in the process of glass production, reducing the need for raw materials as well as the water that is used to extract them. In practice, utilizing 1 ton of cullet (broken glass), eliminates the need for 1.2 tons of raw materials. Also, cullet requires approximately 25-30% less energy to melt, in comparison to virgin materials. In terms of the carbon footprint, for every 6 tons of recycled glass utilized in the manufacturing process

<sup>10</sup> Brandon Janes, "Is Recycling Glass Worth the Cost?"

<sup>11</sup> Ibid.

<sup>12</sup> letsrecycle, "Glass."

instead of raw materials, 1 ton of carbon dioxide is reduced. Hence, such a practice reduces the operating costs for manufacturers, while simultaneously benefiting the environment<sup>13</sup>.

Global brands, like Coca Cola, are recognizing the value of the “closed loop” recycling process by reducing the bottle weight of their product through a process known as “lightweighting.” Ongoing investments in design technology have enabled their container manufacturing operation to bring the weight of the 330 ml bottle down to 190 grams for the first time<sup>14</sup>. Apart from being considered an innovative sustainability project, this new practice is reducing the energy needed to manufacture the product and the carbon dioxide emissions. For instance, Coca Cola has estimated that it will decrease their carbon emissions by 2,400 tons annually by bottling their products in these new lightweight glass containers<sup>15</sup>.

### 3.3 *Challenges of Glass Recycling*

A considerable challenge for glass recycling is the expensive collection process, because glass is heavy and breaks in transit, and it is probative to ship across longer distances<sup>16</sup>. In single-stream recycling programs, the broken glass gets mixed up with other recyclables and creates issues and costs with sorting. Through dual-stream programs and drop-off centers where waste is collected separately, glass is also proving problematic with the wear on equipment<sup>17</sup>. Citizens in many states of the United States are now being required to pay premium charges to throw away glass, doubling the taxpayers’ cost of recycling glass<sup>18</sup>. Glass may impact the purity of the comingled recycling products with cardboard and paper mills become increasingly stringent on quality, as well as, used fiber buyers paying less for materials that contain crushed glass. The economics of glass recycling, with changes in the marketplace, high contamination rates, limited outlets and markets for recovered glass are reconsidering or eliminating glass in their recycling programs<sup>19</sup>.

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<sup>13</sup> Strategic Materials, “Containers.”

<sup>14</sup> Canadian Packaging, “Glass Bottle Goes Lightweight below the Magic 200g Mark.”

<sup>15</sup> Kiernan, “Coke to Cut 2,400 Tonnes of CO2 with Lightweight Glass Bottle | Packaging News.”

<sup>16</sup> Serena Ng, “High Costs Put Cracks in Glass-Recycling Programs.”

<sup>17</sup> Will Flower, “Focusing on the Economics of Glass Recycling.”

<sup>18</sup> Keeler, “Mauldin’s Glass Recycling Is Set to End on March 21.”

<sup>19</sup> Will Flower, “Focusing on the Economics of Glass Recycling.”

However, glass recycling businesses are adapting to the changes in the recycling marketplace which have occurred over the past decade. Addressing the glass quality issue, companies like Resource Management Company (RMC) and Rumpke Consolidated Company Inc. in the U.S. have designed and invested in processing systems to effectively recover glass from single-stream collection programs. Given how abrasive broken glass is, the material recovery facility (MRF) operators are investing on processing equipment to isolate the substance early in the process to address the issue of comingled collection. This equipment includes metal detection, optical sorters, additional screens, and increased manual quality control stations. Directors of these recycling companies claim this investment is warranted, wise, and good business<sup>20</sup>.

### 3.4 *Supply Chain Management Strategies*

It is important to analyze the market properly in order to establish an efficient collection strategy. There are various examples from other countries that can be taken into consideration when building a cost-effective and fast supply chain.

One of the most effective glass collection programs can be found in Malta. In this country, in 2013, a door-to-door campaign was initiated to collect glass<sup>21</sup>. The collection service in Gozo, Malta, goes to every house, every month, to collect their waste glass. Such a program was initiated because of the growing concerns about the environmental externalities caused by such waste<sup>22</sup>. This collection method was proven to be effective since a record collection of more than 514 tons of glass waste were reported in 2014, helping Malta's attempt to attain its EU recycling target<sup>23</sup>. This amount of glass waste presented an increase of 114%, as compared to 2013.

In Hampshire, England, the local government implemented a collection plan for households. A very detailed handbook was created, including a calendar and instructions on the type of glass that are acceptable for the intention of recycling and reprocessing. Within the

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<sup>20</sup> Stoklosa, "New Life for Glass."

<sup>21</sup> "Door-to-Door Glass Collection Service Launched by Green Pak - Timesofmalta.com."

<sup>22</sup> Ibid.

<sup>23</sup> "Record Increase in Glass Collection - Timesofmalta.com."



calendar, the local government schedules the collection for each house for an entire year. The collection is done once every four weeks in the so called black boxes – a box which is filled with glass and placed at the edge of the property in order to be collected<sup>24</sup>. Additionally, there are private enterprises such as Grundon in the UK, offering glass collection services to businesses<sup>25</sup>. This company provides environmental friendly alternatives to get rid of the glass waste. The businesses are given a container which is emptied frequently, and the acquired glass waste are then recycled into components that are used for construction or road building<sup>26</sup>.

### 3.5 *Waste Management in Kosovo*

According to the Strategy of the Republic of Kosovo on Waste Management 2012-2021, “the pollution of the environment caused by improper waste management is one of the greatest challenges when it comes to the environmental protection in Kosovo”<sup>27</sup>. The State of Waste and Chemicals report published by the Kosovo Environmental Protection Agency (KEPA), indicates that in 2012, around 606 thousand tons of waste was collected from households<sup>28</sup>. From the total amount of waste that was collected throughout Kosovo, 6% were categorized as glass. Similarly, the 2011 regional workshop on recycling held in Tirana reported that 100,000 tons of glass waste is generated in Kosovo each year<sup>29</sup>.

The glass that ends in Kosovo landfills causes severe damages to the environment and fills landfills quicker. Improper waste management on top of illegal dumping sites are other significant problems. A total of 686 illegal landfills have been reported, in the Gjakova municipality<sup>30</sup> and 175 in the Pristina municipality<sup>31</sup>, though for the rest of Kosovo, the number of illegal dump sites are unknown. Based on these statistics, the rate at which the environment is being harmed by glass waste is concerning. Establishing a system to collect the glass waste properly is very important, but the economics require an end-user.

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<sup>24</sup> “Glass Collection.”

<sup>25</sup> “Glass Waste Recycling | Glass Waste Collection Services.”

<sup>26</sup> Ibid.

<sup>27</sup> Embassy of Finland, Pristina, “The Embassy Supports Kosovo in Waste Management.”

<sup>28</sup> Kosovo Environmental Protection Agency, “The State of Waste and Chemicals Report.”

<sup>29</sup> Berisha and Veselaj, “Regional Workshop on Recycling.”

<sup>30</sup> “Exposing Illegal Dumping Areas in Kosovo | European Public Sector Information Platform.”

<sup>31</sup> “Pristina Municipality Clears up 100 Illegal Landfills - Nacional - KosovaPress.”

Kosovo is lacking on an organized system of waste management. Waste is merely being transported to landfills and dumping sites without undergoing the process of sorting, treatment, or processing<sup>32</sup>. Although, thirty-six companies that deal with waste management and waste export have been identified, it is not known how many companies or facilities exist and are operating in the sector<sup>33</sup>. As such, the last reliable data from 2011 indicated that 50% of the total Kosovo population is not being provided with any organized waste management service<sup>34</sup>. In the urban areas, 90% of the population has waste collection services, whereas in the rural areas, 10% of the population has access to such formal services<sup>35</sup>. In rural areas, disposal systems are often non-existent and there are no reliable data on the amount of waste generated monthly<sup>36</sup>.

### *3.5.1 Regulatory Responsibilities*

Reducing and collecting waste at the source, as well as sorting it, is considered a characteristic of good management<sup>37</sup>. As such, two of the main goals set by the Government of Kosovo are to reduce the amount of waste generated at source and to develop an infrastructure for an integrated approach in waste management. The Strategy of the Republic of Kosovo on Waste Management for the year 2020 is the decrease of the amount of waste that is disposed in landfills for 40% a year. This strategy also aims to reach a 20% collection rate of glass and glass bottles by 2021. Some of the methods that are planned to be used to reach such targets include the selection of waste by type at source, reusing of different wastes, building capacities for waste management, and harmonizing national legislation with the EU legislation. The plan includes increasing waste processing to 90% by 2020 in the Kosovo municipalities<sup>38</sup>.

Kosovo Law on Waste does not provide any guidelines on the steps that must be taken by businesses or households in regards to glass waste. However, in January 2016, the Kosovo

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<sup>32</sup> GIZ, "Developing Sustainable Municipal Waste Services."

<sup>33</sup> Ministry of Environment and Spatial Planning, "Strategy of the Republic of Kosovo on Waste Management."

<sup>34</sup> .A.S.A. International Environmental Services, "Pre-Feasibility Study for the Implementation of an Integrated Waste Management System Including Collection, Transport, Treatment and Landfilling in the Peja Region,"

<sup>35</sup> Ministry of Environment and Spatial Planning, "Strategy of the Republic of Kosovo on Waste Management."

<sup>36</sup> GIZ, "Developing Sustainable Municipal Waste Services."

<sup>37</sup> Luxottica, "Reducing Waste at the Source."

<sup>38</sup> Ministry of Environment and Spatial Planning, "Strategy of the Republic of Kosovo on Waste Management."

Ministry of Environment and Spatial Planning has issued an administrative instruction for penalties with mandatory fines for littering and waste dumping in public places, which already has entered into force. The penalties are categorized from €5 to €100, depending on the damage done to the environment, where higher fines will be imposed for the disposal of any kind of waste into waters streams, rivers, lakes, or other water surfaces<sup>39</sup>.

Nevertheless, considering that Kosovo wants to join the European Union, the conditions set forth by the EU for its members can be used as a reference point. The EU Directive 2008/98/EC obliges member states to promote the reuse of products and to prepare the infrastructure for such activities. Article 11, obliges EU countries to prepare for the re-use and recycling of waste materials, such as glass, plastic and paper from households. This article, suggests that by 2021, that the rate of the aforementioned activities should be increased to at least 50% of the total weight. Other conditions set forth by this directive include the disposal operation which must be safe so as to not risk human health or the environment<sup>40</sup>.

### *3.5.2 Glass Recycling in Practice*

In Kosovo, there is no organized national recycling system due to the lack of a functional waste management system and an insufficient existing infrastructure<sup>41</sup>. There are a few small recycling initiatives in schools and institutions, NGO activities, and local businesses, however, which offer waste collection services with the intention of recycling the waste<sup>42</sup>. Nonetheless, these collection and recycling endeavors do not cover glass. Generally, glass waste is thrown out into landfills or other dumping sites which contributes significantly in the degradation of the environment.

From the field analysis, some of the businesses cutting glass or manufacturing windows and doors, throw their glass waste themselves without requiring the assistance of regional waste management companies. The companies which were interviewed and are operating in the beverage industry, like Stone Castle and Frutomania, do not have their own collection

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<sup>39</sup> "Gjoba, 5 Deri Në 100 Euro, Për Hedhësit E Mbeturinave Në Vende Publike."

<sup>40</sup> EUR-Lex, "Waste Framework Directive 2008/98/EC."

<sup>41</sup> Ministry of Environment and Spatial Planning, "Strategy of the Republic of Kosovo on Waste Management."

<sup>42</sup> Berisha and Veselaj, "Regional Workshop on Recycling."

system. As a result, the glass bottles they distribute are thrown out by the end consumer. However, Peja Brewery receives a large portion of their glass bottles (50%) back from their business customers<sup>43</sup>. These bottles are cleaned and stripped of their labels to be reused. The broken glass and certain bottles that cannot be reused have been preserved on their premises, with a plan to recycle and reuse the glass after purchasing a grinding mill.

#### **4 Case Study Description**

Orient Mosaic is a Turkish glass company with one of their plants located in Mitrovica, Kosovo, as of early 2016. The company recycles flat glass to produce glass tiles for use on walls and floors in bathrooms and kitchens. The recycling work is done through the plant machinery and equipment, but the tile manufacturing process requires the handiwork of their 17 skilled employees. The number of employees is expected to increase to 40 in the next two months. The plant's production processing rate is 5 tons of glass per day, with a maximum processing capacity of 120 tons a month. Its storage capacity is roughly 1,500 m<sup>2</sup>.

#### **5 Supply Chain Methodology**

To study the market and the optimal supply chain for glass recycling, dynamic optimization methods were used. For this analysis, it was assumed the business will want to operate feasibly and to manage the stock and the processing of glass capacities. An important objective of the company is to expand within the country and to contribute in halting the environmental degradation caused by glass waste. To find the solutions of the above discussed problems, the key inputs are the production and transportation costs, including the timing as a prerequisite to organizing an effective supply route.

To create an efficient supply chain it is important to minimize the collection costs. The equation built on such basis includes four constrains. Initially, components of this equation are the quantity of products( $x_m$ ) that are processed and the costs ( $c_x$ ) associated with such a process. Additionally, the costs of storage( $c_s$ ), for the storage of glass ( $x_l$ ), including the

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<sup>43</sup> Ibid.

collection costs ( $c_c$ ) are part of this calculation. It is important to emphasize that all these constraints are a function of time ( $t$ ).

$$\min C = c_x x_m(t) + c_s x_I(t) + c_c(t) \quad (1)$$

The first constraint that must be taken into consideration in analyzing the supply chain is the stock capacity ( $x_t$ ), that the company has. The amount of storage that they have was calculated as a function of the amount of glass stocked in the previous period ( $x_{t-1}$ ), the amount of glass that was collected ( $x_2$ ), and the quantity of glass that the factory processed and sold ( $x_m$ ).

$$x_t = x_{t-1} + x_2 - x_m \quad (2)$$

Over the period of time that was being optimized, the recycling company needs to collect enough to meet the stock requirements. For example, since Orient Mosaic wanted a minimum of 120 tons, the model was optimized to collect that amount over four weeks. Hence, the additional per-week amount of glass collected was added to the previous amount.

$$x'(t) = -\sum_{at} \{x_{at} * (p_a + D_a + v)\} \quad (3)$$

The third step involves the adjustment of timing in the glass collection process, so as to establish an optimal supply chain (Equation 3). This optimum involves the utilization of glass processing capacities of the company and the expenditure piece respective to the travel route to each supply point.

## 6 Data Collection

In analyzing the supply chain of glass recycling in Kosovo, information on potential glass suppliers was collected through surveys. Sixty-nine surveys were conducted in all the major municipalities in Kosovo. As depicted in Table 4, at least one business was identified and surveyed in Decan, Drenas, Ferizaj, Fushë Kosovë, Gjakovë, Gjilan, Istog, Kacanik, Klinë, Lipjan, Mitrovicë, Pejë, Podujevë, Prishtinë, Prizren, Viti, and Vushtrri.

The businesses surveyed included glass cutters, window and door manufacturers, glass traders, and beverage companies. The identification of these respondents was done randomly. These businesses capacities' to collect glass waste, and their willingness to do so as part of a collection-supply network, were assessed through the surveys. Most of the surveyed businesses were located in urban areas because of the demand for glass in those areas. The businesses were located in different parts of the city, mainly outside the city center. Both the English and the Albanian version of the survey with the questions that were used for this study can be found in Appendix.

Table 5. Surveys Conducted in Kosovo

Municipality	N	Municipality	N
Decan	1	Lipjan	1
Drenas	8	Mitrovicë	3
Ferizaj	4	Pejë	1
Fushë Kosovë	1	Podujevë	8
Gjakovë	1	Prishtinë	9
Gjilan	9	Prizren	5
Istog	2	Viti	3
Kacanik	3	Vushtrri	5
Klinë	5		

Businesses were informed at the beginning of the survey that their participation was voluntary and that they could refuse to answer any question the answer to which they did not know or were not comfortable answering. These responses were coded as “I do not know” (888), “Not applicable” (777), and “It varies” (4444) to make sure non-responses were not coded as zeroes.

The location of Orient Mosaic Kosovo is located in the city of Mitrovica. Utilizing the GPS coordinates for the factory (42.888014, 20.881823), the distance from every surveyed business from the factory was assessed. The list of businesses can be found in the Appendix with the appropriate distances calculated.

## 7 Descriptive Statistics

The objective of this study was to identify the quantity of flat glass available in the country that can be recycled. The majority of surveyed businesses (n=39) were manufacturers of doors and windows, as per the objective. Additionally, 25 had glass cutting services, 2 with glass trading, 3 with beverage production, and one was a restaurant. The businesses were categorized by the type of glass collected at each site, therefore, 65 businesses were identified to work with flat glass and 4 with bottles.

### 7.1 *Glass Waste Quantities*

One of the surveyed businesses shared their calculations on flat glass waste, when manufacturing doors and windows. According to their assessments, there are 15 kg worth of glass waste with the construction of a standard, double-glazed window (0.8m x 1.4m); and 20 kg when a triple-glazed window of the same dimensions is produced. In regards to doors, there is 25 kg of glass waste when a standard, double-glazed door (0.8m x 2.4m) is produced; and 38 kg when a triple-glazed door with the same dimensions is produced. This may be used as an approximate when calculating the impact of increasing the number of efficient windows that are bought or sold domestically.

To determine the specific amount of waste glass that could be collected, three different questions were asked. Businesses were asked about the approximate amount of waste glass they produce within a week and a month. Most businesses (n=36) produce between 0 to 1 ton of flat waste glass each month, as shown in Figure 1. Fourteen respondents collected 1 to 3 tons, and four produced more than 10 tons of flat waste glass per month. Assuming that at least 85% of the glass is transparent, the total monthly amount of flat glass which could be collected is 124.85 tons.

Four of the businesses surveyed did not work with flat glass; instead, they worked with glass bottles. On a monthly basis, 121.98 tons of glass bottles are distributed in the market from these businesses. The largest contributor of glass bottles from the beverage industry, Peja Brewery, re-collects a portion of its empty bottles and reuses them. The portion of the bottles that cannot be reused are preserved on site. The latter portion of bottles, as well those that

were broken during the bottling and internal recycling processes, amount to 84 tons of mainly brown glass bottles the company could supply for recycling each month. The other bottle businesses have not yet established such a system, and therefore, the amount of glass that could be collected in their facilities is low.

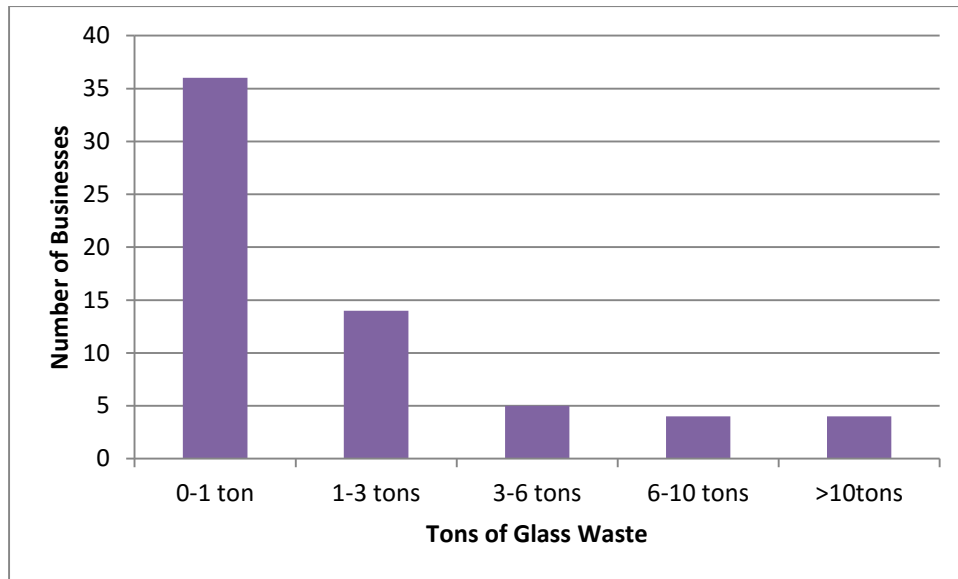


Figure 1. Tons of Flat Glass Waste per Month

Businesses were asked how many days they needed to fill a one-ton container. The largest portion of the companies (n=33), claimed that they would be able to fill such a container within 30 days. Whereas, 18 respondents said that they would need 70 days or more to generate 1 ton of waste glass (Figure 2).



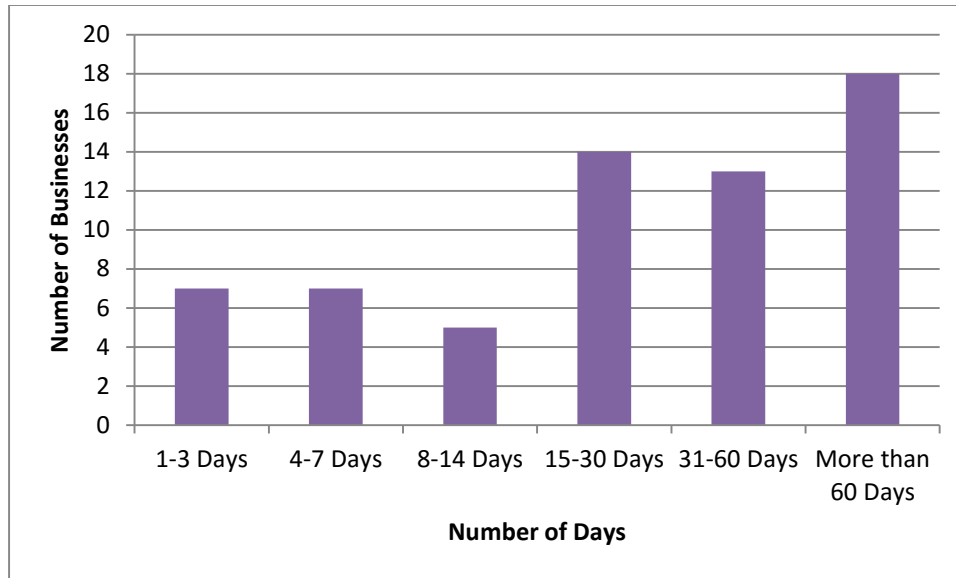


Figure 3 Number of Days needed to fill a 1 ton container

### 7.2 Willingness to Supply

When asked “What do you usually do with the glass waste?” - 63 companies, or 91.3% of the sample, throw it away. Six companies reported they give it away to unspecified individuals/companies, and only 1 sold it to an unknown trader at a price of €0.15 per kg (Figure 4). However, it is important to mention that 32 businesses that were throwing it away were paying a service to get rid of their glass waste. It is the general assumption that the remaining companies are likely not getting rid of the waste properly, given the current state of affairs in waste sorting and are contributing to the degradation of environment.

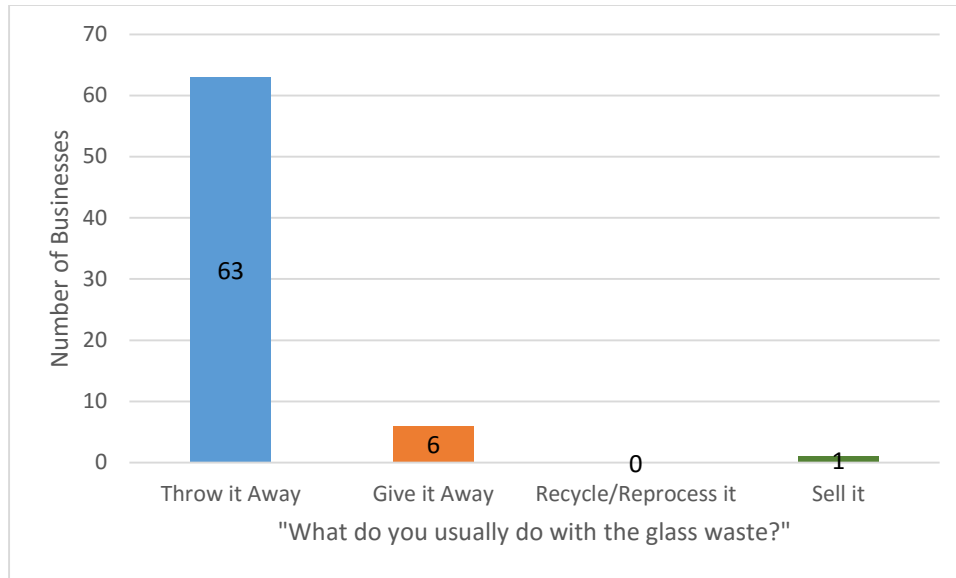


Figure 5. What is being done with the Glass Waste?

In order to assess the potential of the glass recycling supply chain, these companies were asked if they would be willing to supply their glass waste, only one business refused to cooperate. All other respondents (n=68) indicated they would be able to supply their glass waste in order for it to be recycled. Three of the companies were willing to be part of the supply chain asked for a financial remuneration, though the others were ready to give it away for free.

In terms of the color of the glass waste, 97.1% of the sample (n=67) indicated their glass waste is transparent. The recycling company prefers transparent flat glass, because of its cleanliness and the easiness to work with associated with it. Green (n=31) and brown (n=23) resulted to be popular colors for both flat glass and bottles, whereas blue (n=23), black (n=18), and white (n=8) were colors that only flat glass businesses worked with. Similarly, 18 businesses claimed to work with all the glass colors found in the market, as shown in Figure 6.

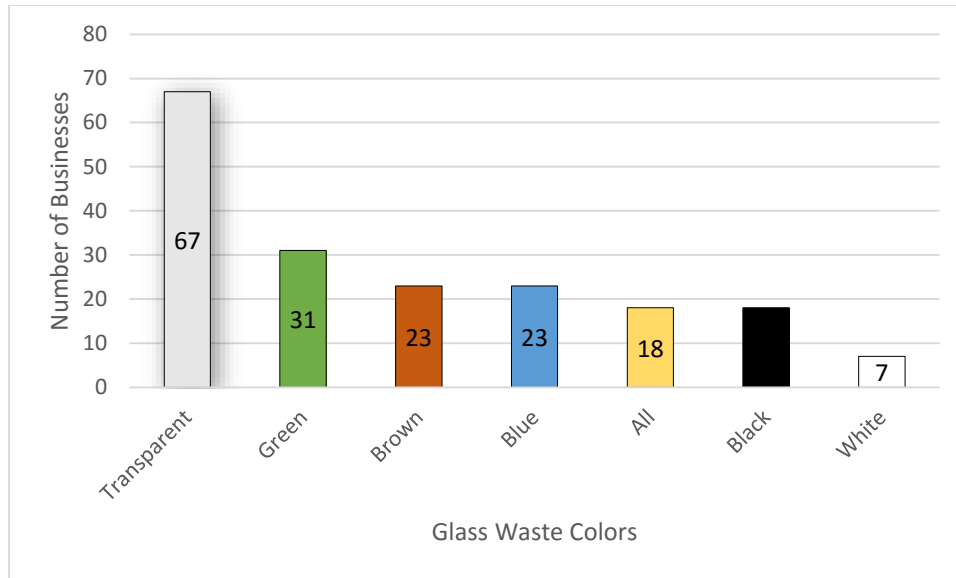


Figure 7. Glass Waste Colors

## 8 Analysis of Results

### 8.1 Collection Costs

To create a cost-efficient supply chain it is important to identify the costs that are associated with the collection process. The expenditures that the company faces in order to collect glass include the transportation and the labor costs, as well as supplying collection containers. The assumptions used in assessing these cost are the following.

The transportation costs as expenditures that must be taken into consideration are subject to the distance of the collection point (round-trip) and the price of gasoline. To estimate the costs per km it was assumed that the truck consumes 25 liters of diesel fuel per 100 km. Based on daily-updated prices on Fuel Prices Europe, the per liter diesel price is €0.88<sup>44</sup>. It was also assumed that the transportation costs would be spread over a fully loaded truck, containing 10 tons of glass. Based on these calculations, the truck would spend €2.2 worth of fuel every 100 km per 10 tons of glass, or €0.022 per km/ton on a per unit cost.

<sup>44</sup> "Fuel-Prices-Europe.info - Current Fuel Prices in Europe."

Acknowledging that the company will likely not have to pay to obtain the glass, the other acquisition costs are likely to be the employee salaries. To calculate the costs per ton several assumptions were made. First, it was assumed that the company has one driver that deals with the collection process. Second, it was assumed that the driver is paid a fixed salary of €500 a month, which is €25 per day for 20 working days per month.

The other variable costs that the company will incur will be the container for collection. The cost of the container for analysis purposes was assumed to be €200, based on the amount the company will likely spend. It should be noted that the recycling company will incur such costs only in the beginning as the containers can be used continuously. Therefore depending on the number of businesses, amount of waste at each collection point and the frequency that the containers are collected will impact the number of containers needed.

### 8.1 *Quantity*

The main aim of the company is to collect enough glass so as to utilize their production capacities. Based on the information that was obtained from businesses the maximum amount of flat glass that can be collected within a year in Kosovo is 1,909 tons. Nonetheless, the businesses that dealt with glass said that the vast majority of glass that they process is transparent. As such, if assumed that 85% of the glass processed by these businesses is transparent glass than the collectable annual amount of this type of glass is 1,623 tons.

The glass recycling company can process 120 tons per month, therefore using the data available the costs were minimized so as to provide the company with such an amount of flat transparent waste glass. According to the conducted analysis the company would be able to collect 120 tons of transparent glass within a month at a cost of €28,628 or about €0.238 per kg. However, it must be emphasized that these costs take into account the expenditures that the company would face to purchase enough containers so as to be able to collect the aforementioned amount of glass waste. As such, in the following month the costs allocated for containers would be deducted and the total expenditures to get the glass waste would significantly drop to only €828, assuming that they do not add any additional businesses or supplies at any location don't increase.

## 9 Sensitivity Analysis

To determine the most feasible scenario, it is important to analyze other alternatives as well. A potential alternative the recycling company could find more attractive is to collect transparent waste glass from all the surveyed businesses. In such a scenario, the costs would not present any constrain and thus would not be minimized, instead the transparent flat waste glass collection amount would be maximized.

If the recycling company decides to include all the businesses, the total amount of transparent flat waste glass that would be collected annually is 1,623 tons. Whereas, in a monthly basis, the company would collect 125 tons of this type of glass. In this case, the costs would surge to €33,092 for the first month, or approximately €0.265 per kg. As previously discussed, such costs would decrease after the first month of operation because the company would not have to purchase containers again. As a result, the monthly expenditures the business would face to collect the glass would amount to €892 assuming the supply route would remain unchanged.

The difference between the cost minimization scenario to collect 120 tons and the collection maximization alternative in regards to the amount of glass is only around 5 tons. In order to collect this additional amount of glass the recycling company's expenditures in the first month would increase for €4,464, or for about €0.93 per kg. While, in the following months the business monthly operation costs would increase for €64. As a result, the annual expenses would rise for €768, while excluding initial costs.

Based on the CENR's Household Wood Consumption Study<sup>45</sup>, 520 out of 1,160 household respondents claimed their houses do not have double-glazed windows. If assumed that energy efficiency is going to increase by 30% in these households by 2018 due to increased awareness and availability of funds, then double-glazed windows are to be installed in 348 households in this area. Considering the average Kosovar household has 10 standard-sized windows (0.8m x

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<sup>45</sup> UNFAO and CENR, "Wood Fuel Consumption in Kosovo Households."

1.4m),<sup>46</sup> it follows that 3,480 windows are to be replaced by then. Assuming that 15 kg of glass are wasted for each standard-sized window produced, as one of the surveyed businesses disclosed, then 52.2 tons of waste glass are to be generated only in the surveyed rural area of Kosovo due to window replacement. Hence, this push for efficiency in these particular households would translate into an increased supply of waste glass for the recycling company.

## **10 Conclusion**

This market analysis showed that the supply of flat waste glass in Kosovo is large enough for the recycling company, Orient Mosaic Kosovo, to maximize its production capacity. The maximum amount of transparent waste glass that can be collected in a year in the surveyed regions of Kosovo is 1623.11 tons, whereas a total of 124.85 tons can be collected in a monthly basis. Taking into consideration that 91.3% of the surveyed businesses claimed they throw away their waste glass, there are large economic and environmental benefits that could be reaped from recycling glass.

Additionally, the company's recycling potential of glass bottles lies in the large amount of glass bottles distributed in the market by the four surveyed businesses operating in the beverage industry in Kosovo (121.98 tons), with one business alone being able to supply 37.5 tons worth of glass bottles monthly. Expanding their operations to include glass bottles into their recycling process could prove to be beneficial for the recycling company in the sense that there already is a considerable supply of glass bottles in the market. Apart from the environmental benefits, such a practice would be advantageous for the citizens of Kosovo as well, considering that a business expansion of this sort would create jobs in the sector.

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<sup>46</sup> English et al., "Energy Consumption and Potentials for Energy Efficiency Implementation: Analyzing Low Income, Low Service Areas of Kosovo."

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