ASSESSMENT OF CONTAINER GLASS RECYCLING OPPORTUNITIES IN ETHIOPIA

Selection number: 1267064

FINAL GAP ASSESSMENT REPORT

Prepared for: World Bank Group – IFC

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Contents

0. Executive summary

We studied the glass container market and its related glass waste flows in Ethiopia. The research was performed through desk studies of publicly available data and documents along with questionnaire-based interactions with more than 25 stakeholders. Face to face meetings with the stakeholders could not be carried out due to travel restrictions caused by the Covid-19 pandemic. Although the research was hampered by the pandemic and by a certain reluctancy among fillers to provide their input on the questionnaires, we were able to reach a number of meaningful conclusions.

Ethiopia displays and interesting case when it comes to container glass and glass recycling. The Ethiopian market reveals a throughput of approximately 1.5 million tons of container glass per year. Shortage of container glass production on the one hand, and international currencies on the other, have forced businesses towards an unprecedented reuse-economy. Only 5% of all used bottles and jars is wasted on a yearly basis. The other 95% is returned into the economy. Most of it through the loop of deposit/return systems for beer, soft-drinks, wine and spirits and a smaller portion through the loop of small-scale users of 2nd hand bottles.

Maybe also remarkable; all of this is achieved without incentives coming from environmental legal frameworks and solid waste management policies. The legal framework has decentralized most of its waste management responsibilities to the municipality level and the municipalities mostly focus on collection and disposal; not on reuse and recycling.

At present, recycling of broken bottles as cullet in the glass industry has only a minor contribution. Increasing this recycling will be difficult as this growth will only be possible at the expense of direct bottle reuse. However, this situation can be typified as an unstable equilibrium and it is most probably going to change. Beverage consumption is growing at double digit speed, there's a pipeline of upcoming investments in the glass industry and the economic development may well lead to less currency restrictions. This will decisively change the scene and reduce the favorable reuse/recycling situation Ethiopia is in.
The simplest option for the glass industry is to increase the procurement of rejected bottles in the beverage fillers industry. It may well deliver some 210,000 tons of cullet to the glass industry by 2030. This option may collaterally lead to phasing out the reuse of 2nd hand bottles.

In case in the upcoming years, the packaging market is moving towards the use of non-returnable bottles, the glass industry will be challenged to involve itself more seriously and investments will be needed. There will be a need for introducing separate collection and recycling plants. Because of the volumes, passive collection of glass through a network of stationary bottle banks (street containers) will be most fitting.

The glass-industry itself could prepare for the expected phasing out of the use of 2nd hand bottles by introducing cheap, standardized bottles to serve the users of 2nd hand bottles. In this case, active collection can be used to recycle those bottles, employing a workforce of 400 in Addis Ababa alone, that go to collect the glass at the households.

Our advice to the glass container industry is, in the first place, to start negotiations with the beverage industry in order to maximize the return of broken and rejected bottles to their glass furnaces. In the second place we advise to consider the development of standard cheap bottles that should find their way to the market of small fillers. Parallel to this, the industry should consider to initiate separate collection and recycling facilities.

All of the options above can be enhanced by a good program on awareness, PR and CSR. The combined glass- and beverage-industry could consider to take initiatives on EPR, and in doing so preparing for the future growth of their volumes.

1. Introduction

On April 1st, 2020, BreAd B.V. was assigned the contract "Assessment of container glass recycling opportunities in Ethiopia" (no. 7195538). The assignment must generate three deliverables. The first one, the Inception Report, was delivered on April 19th. The second one, the Market Mapping Report, was delivered on May 31st. This report concretizes the third deliverable: The Final Gap Assessment Report.

This final report aggregates all the work done on this assignment. The assignment aims at enhancing glass recycling and, in doing so, reducing the environmental footprint of the glass-container production industry in Ethiopia.

The method for this assignment can be characterized as data-gathering followed by expert analyses enhanced by international experiences. The data-gathering is described in Chapter 2. The report then continues with providing overviews of the value-chain in Chapter 3, glass- and waste-flows in Chapter 4 and the legal framework in Chapter 5.

Chapter 6 reviews a number of options for increasing glass recycling. Most of these options do not have a stand-alone character and they can only be assessed on feasibility and viability when placed in a situation that will change over time. An option can lack viability at this moment in Ethiopia's economic context but can become viable within a few years when circumstances change. It's for this reason that this study needs scenarios. This factor of time is introduced in Chapter 7. It defines and rolls out a number of scenarios and describes the roles the options could play in them.

Then Chapter 8 evaluates the performance of these options in these scenarios, paving the way for the conclusions of Chapter 9.

2. Methods on data gathering

The main characteristic of this research is data-gathering and -analysis in order to enable advising IFC on the way ahead for enhancing glass recycling. At the moment the research was initiated, the Covid-19 pandemic started spreading around the world. When submitting proposals, it was still thought to be possible to have international experts visiting the country for data gathering. But already at the moment of contracting it was clear that traveling would not be possible. This is why the choice was made to perform data-collection without vis-à-vis visits and meetings.

Eventually the data-collection was done through a combination of methods:

- Gathering and reviewing IFC and publicly available general data and documents on the (glass) waste market (Annex 1)
- Internet search for data on the container-glass production industry and on the filler industry using container-glass (Annex 2)
- Internet search for academic literature on the waste situation in Ethiopia and Addis Ababa (Annex 3)
- Questionnaire based interviews by using emails, telephone calls, online meetings.

The team reached out to a total of 39 stakeholders as summarized in Annex 4. This outreach was mainly done through emails and questionnaires, followed by frequent email and telephone reminders when needed, along with some in-person visits (when possible due to the Covid-19 outbreak).

As indicated in Annex 4, 26 responses were received. This looks like a good score, especially bearing in mind the impeded communication channels. Nevertheless, it should be concluded that Addis Glass, being one of the two major container producers, and most of the important fillers have been reluctant to provide their input. The following two main reasons for this hesitance are expected to have played a role:

- The Covid-19 induced crisis situation many of these companies are in at the moment. Both glass factories and fillers are reporting production reductions of 50% or more, accompanied with lay-offs and salary-cuts.
- The cautiousness for sharing strategic corporate data with competitors as this is a Juniper/World Bank research.

After consulting with IFC it was concluded that further efforts to gather these missing primary data would not pay-off and it was agreed that the team would fill in remaining gaps by using secondary data, reasoned extrapolations and expert-team estimates.

Extrapolations and estimates were enhanced by performing cross checks on secondary data and by doing mass-balance checks to avoid incongruencies.

3. Value chain

a. Key actors

The key actors identified in the glass and glass recycling value chain are summarized in Annex 3. Their locations are marked on the map of Ethiopia below. It shows the dominant position of the combined area of Addis Ababa and Debre Birhan when it comes to the container glass and fillers industry in Ethiopia.

Figure 1. Sites of key actors

The actors in the formal part of the value chain can be grouped in 3 categories as described below:

- Glass container producers
- Glass container users
- Waste collection and recycling actors

b. Glass container producers

Currently there are 2 glass plants producing glass containers in Ethiopia.

- Juniper Glass

Juniper Glass belongs to the Consol Glass of South Africa and is located in Debre Birhan. It has started production in August 2019 and has one 220 tons/day furnace with two production

lines and an annual production capacity of 70,000 tons. Currently the plant has stopped production due to the pandemic. Before the interruption Juniper was producing 50 cl and 33 cl returnable amber colored bottles for the brewery industry. Flint glass production was being planned to produce soft drink and water bottles.

- Addis Ababa Bottle and Glass

The company has not responded to our questionnaire despite several reminders. The following information was obtained through desk research.
Addis Glass, a joint venture between Bazeto Industry and Trading PLC and Topview Asian Pacific Ltd is located in Addis Ababa and has 2 furnaces. The old furnace is a 35 tons/day furnace. In July 2016, a 50 tons/day furnace was commissioned. The company has announced an investment program to install 2 more 80 tons/day furnaces, but the current situation of this expansion project is not known. Before the pandemic, the company was producing amber and flint colored bottles for beer, wine, soft drink, water, and liquor industries.
In addition to these 2 companies there are 2 projects going on to build plants for glass container production:

- Goda Glass and Bottling

Located in the Tigray province near the city of Adigrat, Goda is building a 90 tons/day furnace with two production lines using equipment supplied by Glass Service of Italy. Initially only 1 production line will be started. With an annual capacity of 28,000 tons, production of bottles for beer, wine and water industries is foreseen. Production was planned to start in 2020, but the installation of the equipment is delayed because the international supervisors cannot travel due to the pandemic. Our estimate is that the plant will be operational by mid-2021.

- Dede Bottle Factory

A tender was opened in November 2016 for the turnkey construction of a 60 tons/day furnace in Debre Birhan. It is now reported that the capacity of the furnace is revised to 120 tons/day (38.000 tons of production annually) and the construction is 70% complete. No further information could be obtained. Again, our estimate is that the plant will be operational by mid-2021.

Apart from the glass container producers, Hansom Glass located in Addis Ababa is producing sheet glass. The company has not responded to our questionnaire and no information could be obtained. Another company, Daylight Applied Technologies was producing glass containers and houseware with a 20 tons/day furnace, which was stopped completely, and the company has no plans to restart. Daylight produces crown cork closures for glass bottles. They have not responded to our request for information about their closure production.

c. Glass container users

The main users of glass containers are industries for beer, soft drinks, water, wine, liquor and prepared food.

Breweries

The beer market in Ethiopia is growing fast. Sources (see annex 2) are mentioning 16% y-o-y growth rates. The main players in the beer industry are identified as, BGI, Heineken, Habesha, Dashen and Diageo Meta Abo. Only one of these has replied to our questionnaires despite several reminders. The below information was therefore mainly obtained through desk research:

- BGI

BGI has 5 plants in Ethiopia with a total production capacity of 4,500,000 hectoliter (HL) per year.
The plants are:
St George Brewery in Addis Ababa
Kombolcha Brewery in Kombolcha City
Hawassa Brewery in Hawassa
Zebidar Brewery in Welkite Town
Raya Brewery in Maychew Town
The company's products are packaged in 330 ml amber bottles and 20- and 30-liter kegs. BGI exports to 53 countries, but no information on the share of exports is available.

- Heineken

Heineken has 3 plants in Ethiopia with a total capacity of 4,050,000 HL per year.
The plants are:
Kilinto Brewery in Addis Ababa
Bedele Brewery in Bedele Town
Harar Brewey in Harar City

- Habesha

Habesha has, up until now, partly responded to the questionnaire. The company has one plant in Debre Birhan and a capacity of 750,000 HL per year.

- Dashen

Dashen has two plants in Debre Birhan and Gondar. The Debre Birhan brewery has a capacity of 2,000,000 HL per year with the possibility to increase to 3,000,000 HL per year.

- Diageo Meta Abo

Diageo Meta Abo has one plant in Sebeta with an annual capacity of 1,700,000 HL.

Soft Drinks

Two main actors in this sector are Moha Soft Drinks Industry (Pepsi Cola Bottler) and East Africa Bottling (Coca Cola)

- Moha Soft Drink Industry

Moha has 8 plants, 3 of which are in Addis Ababa. The others are in Awassa, Bure, Gondar, Dessie and Mekelle. Their total production capacity is calculated to be 3,800,000 HL using secondary sources. Moha's market share of the non-alcoholic beverage market is reported to be 52%.
They use 30 cl returnable glass bottles for soft drinks and 50 cl returnable glass bottles for carbonized water. Before 2019 all their bottles were being imported. Now in addition to imports bottles are supplied from Addis Ababa Glass. For 2020, 70% local supply was foreseen. But volumes are reduced significantly due to the pandemic.

- East Africa Bottling

The company has not replied to our questionnaire. The following information is obtained through desk research.
Currently East Africa Bottling has 3 plants in Ethiopia: Addis Ababa, Dire Dawa, Bahir Dar with an annual production capacity of 2,500,000 HL. In 2019 a new investment was started to build a fourth plant in Sebeta with a capacity of 70,000 cases a day. A fifth plant in Hawassa is also being planned.

Water

There are 2 main actors in this field:

- Ambo Mineral Water

The company has not replied to our questionnaire. Their production capacity is reported to be 500,000 HL. The company is located in Ambo and majority owned by SABMiller. A merger of the parent company with SABCO (Coca Cola South African Bottling Company) was challenged in courts in Ethiopia because it meant an effective merger of Ambo and East Africa Bottling company.

- Babile Mineral Water

Babile has one plant in Harar and producing mineral water in 450 ml returnable glass bottles and has plans to expand their products. They have not responded to our question on production.

Wine

The total wine market is estimated to be 13,500,000 liters per year. There are 2 players in this sector and imported wines have a market share of about 7%. The two local producers are:

- Awash Wine

Awash Wine has two plants in Lideta and Mekanisa. They have an 83% market share with 2018 sales of 11.2 million liters. They use 75 cl Bordeaux and Burgundy bottles (80% of sales) and 33 cl beer type bottles (20%) to pack their wine. Even though they do not charge a deposit on their bottles, the empty bottles are bought by the traders and exchanged for filled bottles. Thus, in effect a return and reuse system of bottles exists.
Since, per capita wine consumption is very low in Ethiopia, they expect a significant growth in the wine market, and they have finished a 270,000,000 ETB investment in 2019. However, due to the pandemic no YoY growth is expected as of May 2020.

- BGI Castel Wine

BGI Castel has 10% market share, with sales concentrated in mid-range and premium wines. There are no deposits at the retail level for Castel wines.

Liquor

2 main local players in this sector are:

- Balezaf Ethiopia Liquor

Balezaf is the biggest liquor producer in the country. It has one plant in Sabeta town and a production capacity of about 70,000,000 liters annually. They use 890 ml and 200 ml returnable bottles. They expect significant growth in the market for glass bottles as consumption increases and they plan to introduce new bottles. However, currently sales are reduced drastically because the outlets are closed due to the pandemic.

- Desta Alcohol and Liquor

Desta has one plant in Mekelle city and a production capacity of about 25,000,000 liters. They use 890-, 500- and 200-ml returnable bottles.

No figures for import of liquors into the country could be obtained.

Food

Currently there is no production of food jars in Ethiopia. All glass jars are being imported. Two companies were identified that use glass jars:

- Day Jam

Day Jam has one plant producing fruit jams with an annual capacity of 350,000 liters. They use 390 ml non-returnable jars that are imported.

- Laviva Fresh

Laviva is a manufacturer of sauces and condiments such as mayonnaise, ketchup, jams, sauces, tahini, hummus etc. using glass and PET packaging. The company has not responded to our questionnaire.

Table 4 gives a summary of the glass containers used by the actors in each sector and the amount of glass waste generated at each sector (More elaborated calculations for these figures are given in Annex 7). It should be noted here that the 105.000 tons/year that is identified as cullet available for glass producers indicates the potential that exists for the glass factories. As per today, Juniper reported a cullet supply of 15,000 tons/year from fillers and secondary sources. Translating the same ratio to Addis Ababa Glass would mean that their cullet supply is 5,000 tons. So, 85,000 tons of glass waste, in the form of unbroken but rejected returned bottles are sold by the fillers to traders for 2nd hand glass bottle users (see also paragraph 3f.).

Sector	Glass container usage (tons/year)	Cullet going to landfill (tons/year)	Cullet available for glass producers (tons/year)
Soft drinks	693,500	11,096	58,254
Beer	672,406	4,483	40,344
Wine	9,824	579	622
Liquor	53,994	3,150	5,849
Food*	239	239	
Total	**1,429,963**	**19,547**	**105,069**

*: Includes only the information available from the Day Jam

Table 1. Glass usage and waste generation of user sectors

d. Waste management actors

There are many actors in the field of waste collection, reuse, recycling and disposal. Diagram 1 below gives a schematic representation of the situation in Addis Ababa. On the left-hand side of the diagram are the waste generators (households, shops/offices/restaurants, industry). They are serviced by formal actors, collecting residual waste, and informal collectors, collecting recyclable components like plastics, paper, glass and metals. These recyclables are then sold to traders and recycling companies for paper, plastics and metals. The interviews and internet sources show that there are at least 16 major actors in this market, working from more than 30 sites across the country. There are no formal glass recycling companies in Ethiopia. Whole glass bottles are bought and sold for direct reuse.

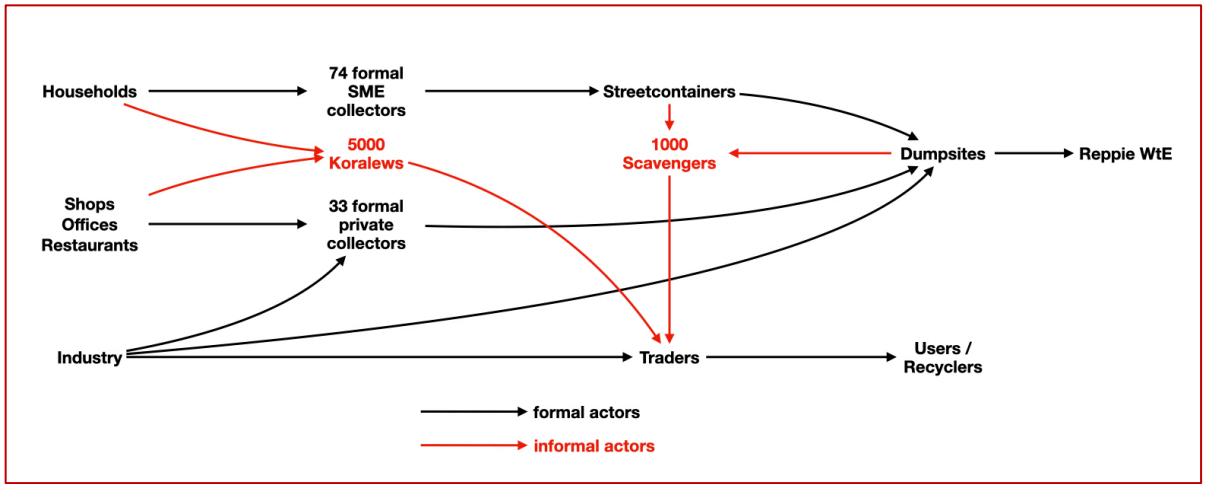


Diagram 1. Actors on waste collection, reuse, recycling and disposal in Addis Ababa

Below, a description is given of the most important actors in this network.

- Household waste collectors

This is a door-to-door collection of waste done by Medium and Small-scale enterprises

(MSEs). These are membership based cooperative associations organized and subsidized by the city government to undertake waste collection, transport across villages and sort it at designated sites (temporary transfer stations) across all the 10 sub-cities and *Woredas*. About 74 shareholding associations are established in Addis Ababa city, with more than 6,000 members for the waste collection purposes. Waste collection fees payable to the MSEs are assessed on the basis of the weight of disposable waste they deliver at the gate of the city dumpsite known as Reppie (or *Koshie*). Government avails transport services to deliver the waste from temporary transfer stations to this dumpsite.

- Institutional waste collectors

Collection from institutions (hospitals, bars and restaurants, schools etc.) is carried out by private companies with an appropriate business license and registered by the SWM Agency to render such services. There are 33 such companies across Addis Ababa. The collection fee is 90 ETB per meter cube payable by the respective institutions. However, these collection schemes are not specific to any waste fraction and cover all sorts of waste from organic matter to glass and metal scraps.

- Street sweepers

The city's main streets are swept daily with an army of 5,000 municipal employees and 20 sweeping machines. Their monthly salaries and benefits are paid from the municipality's annual budget.

- Informal collectors

There is a network of informal actors in Ethiopia. These are the independent collectors called Koralews that buy several kinds of waste material from households. This is an age-long custom in the major cities in Ethiopia. With regard to waste-glass it has reinforced the attitude of households to consider bottles as household possessions and made them reluctant to dispose of it along through regular mixed waste collection.

Various sources report that there are about 5.000 Koralews working on a given day in Addis Ababa collecting 42 kgs/day of mixed waste each and 16% of that amount is glass (about 35 tons/day). That glass is sold to the traders at the market (Merkato), who in turn sell them to secondary users, probably small filling operations, thus creating an additional loop of glass flow. Assuming the amount collected in Ethiopia as a whole is double the amount collected in Addis Ababa, we can conclude that annually 25,000 tons of glass waste is collected through this channel. The scavengers at the open landfills are reported to be collecting mainly plastic waste and glass waste recovery from that source is very low.

- Transport, sorting and disposal

Waste collected through the door-to-door collection system, that essentially includes glass fractions, is transported by the shareholding cooperatives and temporarily stored at the designated sites across the 10 sub-cities. Sorting is carried out by members of these cooperative associations at the transfer stations. This waste segregation solely focuses on PET bottles. As broken glass does not yet have any market value, it is not recovered from the waste stream, nor do households retain it before mixing it. Thus, almost all the glass component of the collected waste is transported to the *Reppie* dumpsite through the transport facility provided by the SWM Agency of Addis Ababa. Currently there is a shift in thinking to change this transport modality. The SWM Agency has approved Directives by the city cabinet to enable the use of dedicated waste-compaction-vehicles by the cooperative associations with investments based on a loan scheme.

- Reppie Waste to Energy Plant

Reppie plant has the capacity to incinerate 400,000 tons of MSW per year to produce electricity. It has been reported that amount of glass going into their incinerators is very low and they have no plans to install a presorting facility for the MSW. It was reported that all collected waste in

Addis Ababa passes their weighing bridge and amounts to an average of 2250 tons/day (0.49 kg/person daily).

- Recycling company: Penda

Penda works on paper collection. They work with 50 self-employed collectors, who were given bicycles and deliver the paper they collect to Penda. They had plans to increase that number to 250 but are facing a crisis due to lowering of paper prices. Together with Dangote Cement they have proposed an MRF facility to the government producing RDF for Dangote. They expressed an interest in going into glass collection using their network of collectors.

- Recycling company: Roha Pack

Roha is active in PET and HDPE recycling producing flakes with a daily capacity of 60 tons. Their products are mainly exported to China. They have plans to invest in a bottle to bottle recycling plant in the next 3 years. They do not seem to have an interest in going into glass recycling.

- Recycling company: Coba Impact Manufacturing

Coba manufactures PET flakes and HDPE as a byproduct from post-consumer plastic bottles. They produce 2.800 tons of PET flakes and 140 tons of HDPE annually. They have no interest in going into glass recycling.

e. Market prices

As stated above, the flow of wasted, but unbroken bottles from the fillers to the 2nd hand traders and from consumers to the traders via the Koralews is about 110,000 (85,000 + 25,000) tons annually. An interview with a Koralew in Addis Ababa indicated that, they pay 3 to 8 birrs per bottle depending on the type of bottle. In a phone interview with Habesha, they stated that they sell their rejected but unbroken bottles to 2nd hand traders for 2 birrs a bottle. The deposit charged per bottle is around 8 birrs, so it is possible that some bottles leak from the deposit return system to Koralews, especially by consumers who do not want to carry empty bottles to the retailer shops. The purchase price for a locally produced 380-gram soft drink bottle is reported to be 8.5 birr/bottle (660 USD/ton).

To give an overview of the current market conditions, a sketch was made of the value chain using Juniper and Habesha, as an example (with rounded off prices).

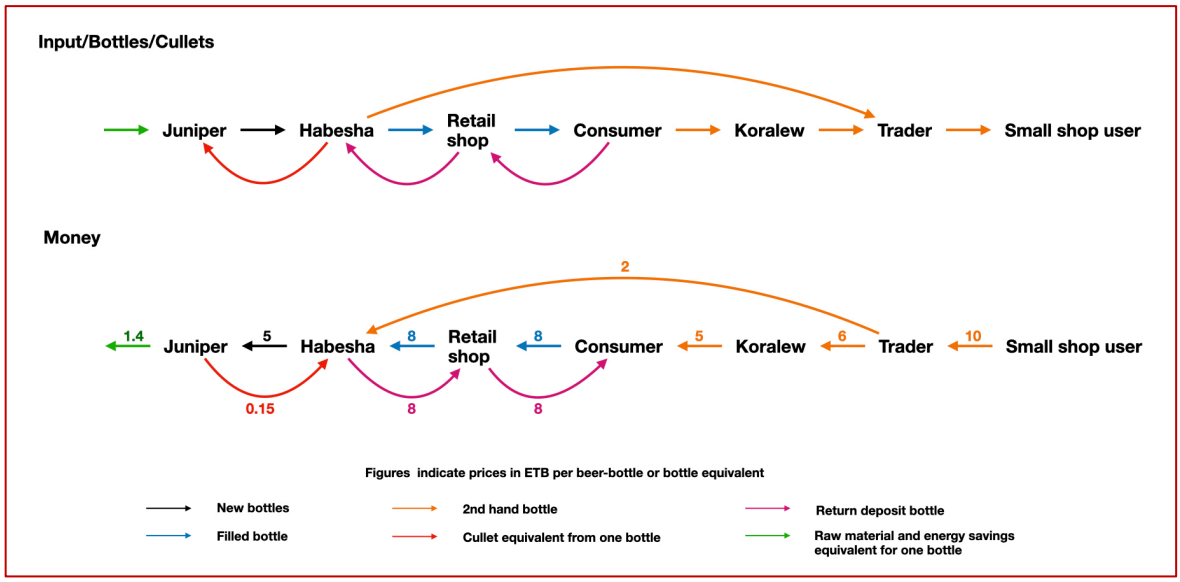


Diagram 2. Value chain and market prices

The upper chain pictures the physical stream of bottles; the lower one the reversed stream of money with some actual, calculated and assumed prices. These prices are in Birr per beer-bottle or bottle equivalent. The data about import of empty bottles to Ethiopia is not very reliable but the data obtained from the Ministry of Revenues indicate CIF prices to be around 630 USD/ton. It should be noted that this price has continually declined between 2013 to 2017 (from 775 to 591 USD/ton).

f. Assessment

From the above prices and the analyses carried out, the following conclusions can be drawn:

- Given the fact that a market exists for waste (unbroken) bottles, a passive collection scheme using bottle banks like in the EU and Turkey would not work in Ethiopia under current market structure. Consumers would never throw their bottle in such street containers as these bottles represent cash (5-8 Birr). And if they do, others will pick these bottles from the containers to sell them in the market.
- Experiences from Europe, Turkey and Georgia advise against pursuing initiatives on MRFs aiming at recycling glass. An MRF for mixed municipal waste would lead to cullet with high contaminations of organics, ceramics, stones, and metals. An MRF for mixtures of paper/plastics/metals/glass would need the introduction of separate collection and would lead to glass splinters in the resulting paper and plastics making these products unfit for recycling.
- The glass producers could increase the volume of cullet coming back from fillers, if they try to include the rejected bottles that are now sold by the fillers to bottle traders. Of course, the price difference is large (0.15 vs 2 Birr) but maybe an all-in mixed price can be calculated that could be below the 1.4 Birr being Juniper's savings in raw materials and energy for a one bottle equivalent of cullet (300 grams) (See Annex 6). In such an agreement the filler should agree to deliver all its rejected bottles to the glass producer. A possible positive side effect could be that fewer 2nd hand bottles go back into the market which would increase the demand for new glass bottles, as stated above. Obviously, this will affect the macro-balance of GHG emissions
- Glass producers could try to collect whole and broken bottles through agreements with Koralews or formal collectors like those of Penda. Based on first calculations, this scenario doesn't seem to pay off. The collectors would be able to pay the households no more than 0,5-1 Birr per bottle which doesn't compete with current prices that households are getting for selling the bottles being 5 Birr.
- Glass producers could consider introducing a range cheap, standard, low-quality bottle to be distributed through wholesalers to small shop users as was done in Turkey in the 80s/90s. These bottles could replace the current reuse of 2nd hand bottles. The price for these shops to buy them should be around 10 Birr in this example. If worth considering, then more exactly this price has to be established.
- The introduction of Extended Producer Responsibility (EPR) schemes would increase cashflows in the glass waste cycle, making collection and recycling schemes easier to pay off. It may even lead to the elimination of the use of 2nd hand bottles, thus leading to higher volumes in the glass industry. But mostly, the fillers are not enthusiastic about EPR because it needs a sector approach, it may raise their costs and it leads to extra administration. So, in general, EPR would be good for the glass industry but not for their clients. Maybe a dedicated format of EPR that would not affect current deposit/return schemes and fillers could be constructed.

In Chapter 6, these alternatives are analyzed in more detail and evaluated in Chapter 7 within a set of scenarios developed with appropriate recommendations for each scenario.

4. Glass and waste flows

This chapter will provide in paragraph 4.a aggregated overviews on flows of waste and glass-in-waste in Ethiopia. The next paragraph zooms in on the specific situation with regard to container glass and related waste flows. Paragraph 4c provides extrapolations for the next 10 years.

a. Waste and waste glass flows in Ethiopia

In order to enhance general understanding of container-glass flows it may be helpful to also gain some understanding on waste flows in Ethiopia in general. Annex 5 gives an overview of the parameters that were used to enable drawing up these flows. These parameters lead to flows of municipal solid waste in 2020 as presented in Diagram 3 below.

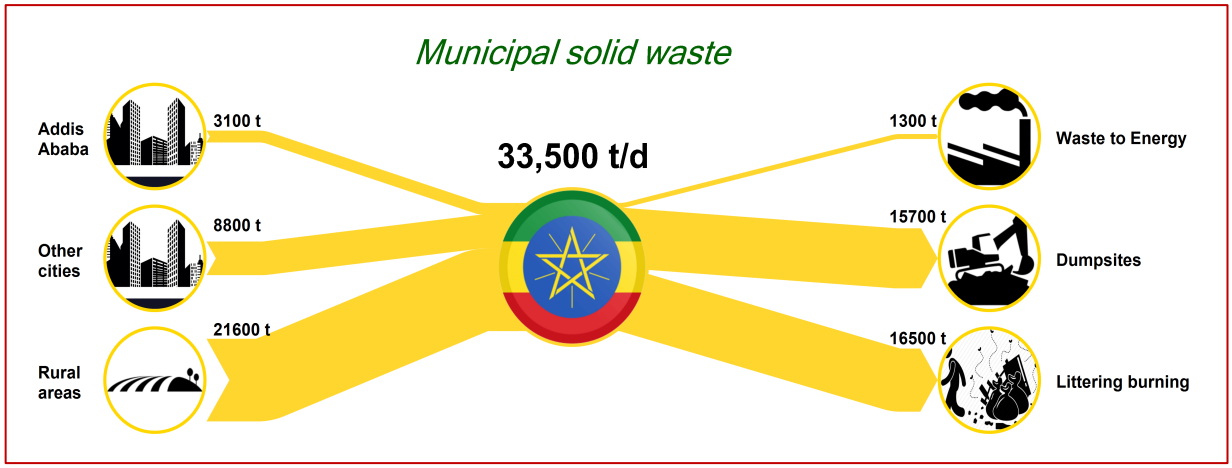


Diagram 3. Municipal solid waste flows in Ethiopia

Ethiopia produces approximately 33,500 tons of waste per day. The larger part (65%) of this waste is generated in Ethiopia's rural areas. Roughly 50% of all waste is collected and brought to a dumpsite or to the Waste-to-Energy plant in Addis Ababa. The other half is unmanaged and ends up as littered, burned, buried or dumped waste, mostly in the rural areas.

Diagram 4 below zooms in on the glass in Ethiopia's municipal solid waste, that is to say in the waste that is dumped or burned or handed over by the households to the collectors. The diagram does not include whole glass bottles that are separately collected at the household by the Koralews and it also does not include whole glass bottles that are collected at restaurants, shops, offices and industries by commercial waste collectors and traders.
On a daily basis roughly 670 tons of glass is in municipal solid waste. The glass that ends up in this waste is mostly present as broken pieces unfit for collection and recycling. The only way to recover the value of this glass is by preventing it to become part of the waste.
According to the calculations of paragraph 3c. this 670 tons of glass per day contains no more than 10% coming from broken deposit bottles. The rest is most probably mostly from bottles in the 2nd hand bottle market (see paragraph 4c. below), and also from glass table ware and other glass products in the households, from broken window panes and other glass sources (f.e. car window panes).

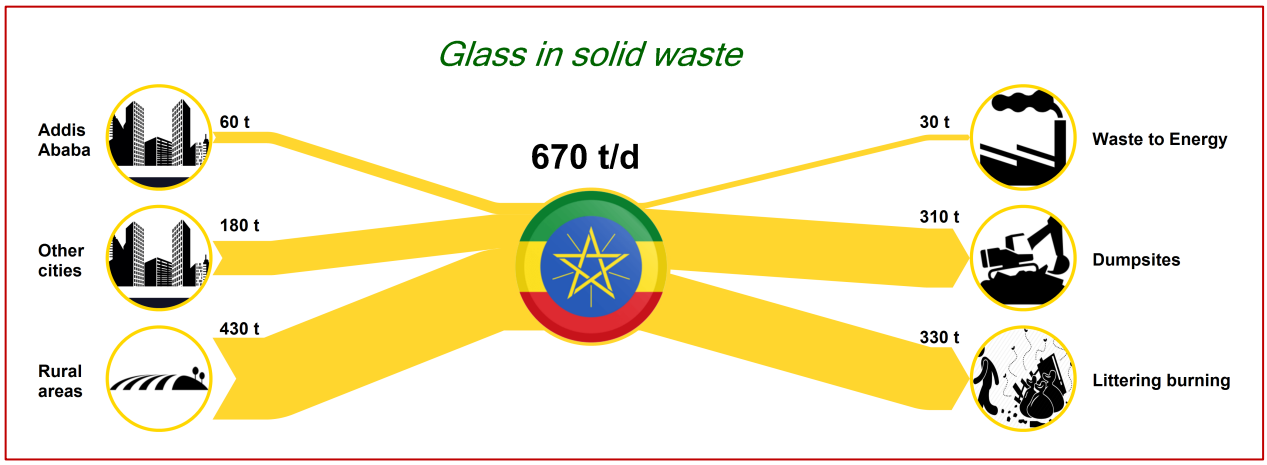


Diagram 4. Glass in municipal solid waste flows in Ethiopia

The input parameters of Annex 5 enable to extrapolate the above tonnages until 2030 as is done in diagram 5.

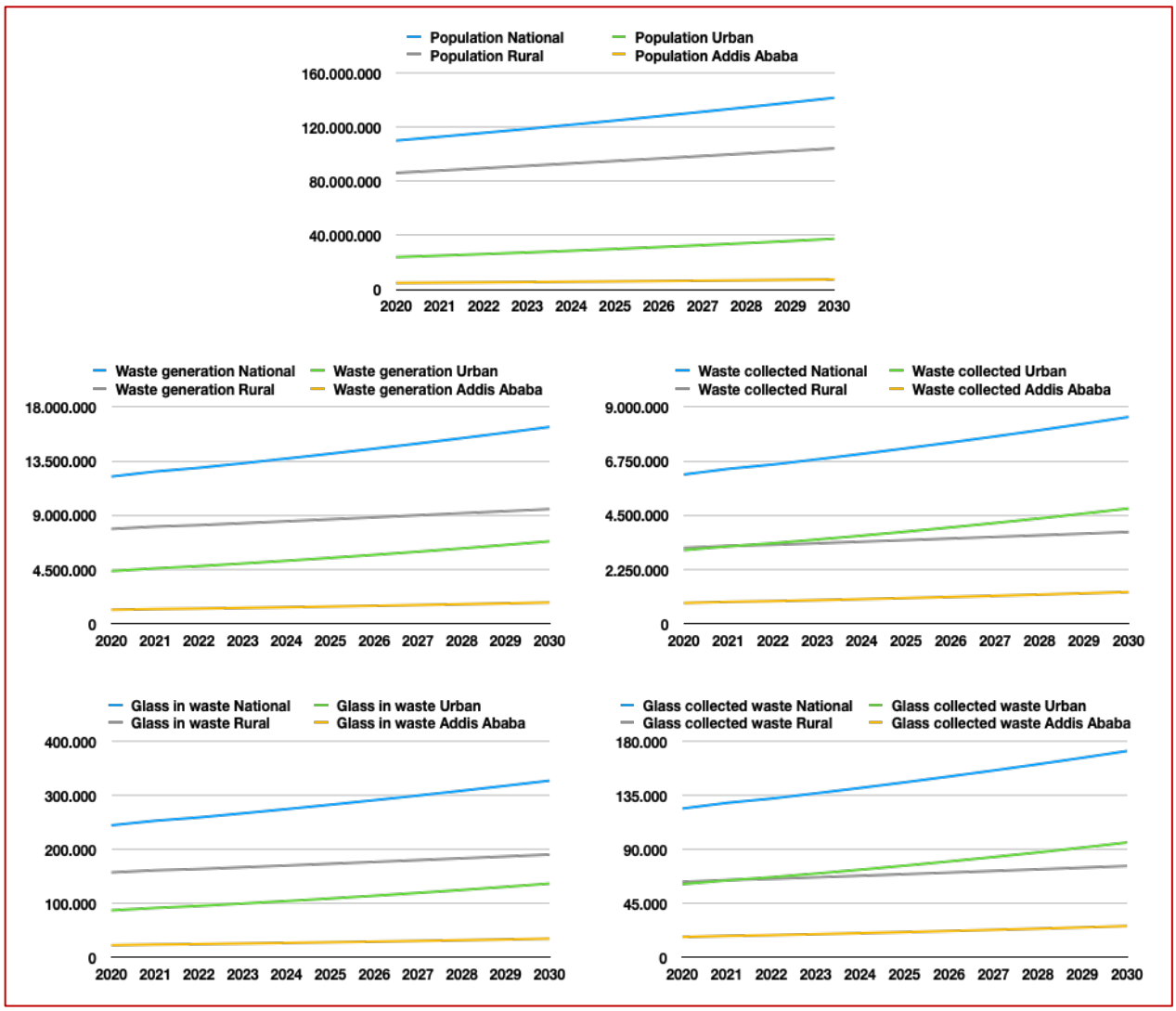


Diagram 5. Waste and waste-glass extrapolations (tons/year)

The five graphs show the Business-as-Usual evolutions for:

- Population
- Waste generation
- Glass in generated waste
- Waste collected
- Glass in collected waste

The plots illustrate that waste volumes in Ethiopia may go up from 12 million tons this year towards 16 million tons in 2030, while glass in this waste increases from 300,000 to 400,000 tons. In the same period Addis Ababa will grow towards 7.3 million inhabitants disposing of some 40,000 tons of glass per year.

b. Container glass flows in Ethiopia

As said, Diagram 4 does not include whole glass bottles that are collected at the households, shops, restaurants, companies etc. before having a chance to become part of the mixed municipal waste. Based on the analyses in Chapters 3 and Paragraph 4a. it is possible to draw the flows related to new, recycled and waste glass containers as given in the Sankey-diagram below. The Sankey character of this diagram has allowed for calibrating, cross-checking and verifying all used input-data.

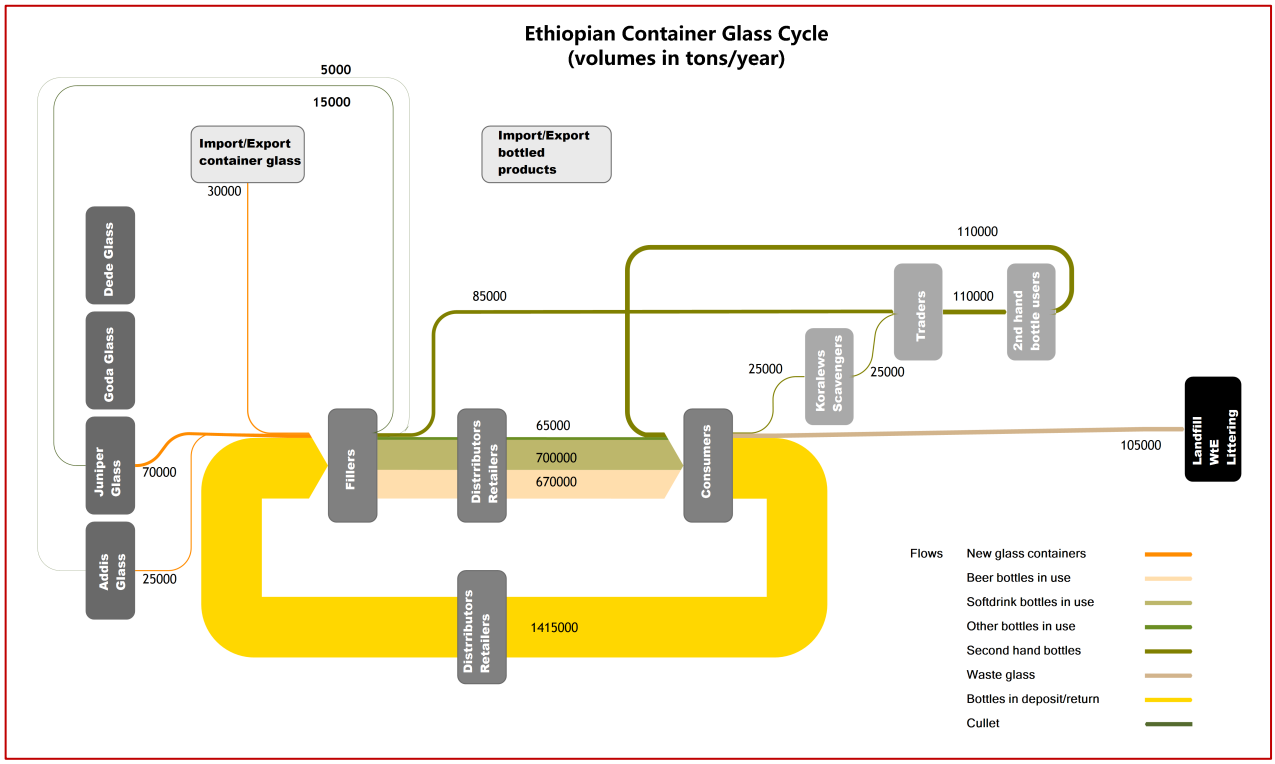


Diagram 6. Container glass cycles in Ethiopia

The diagram presents data for an improvised year 2020. “Improvised” because it does not take into account the effects of the current Covid-19 situation on production and consumption. The alternative would have been to map the 2019 situation but then the usefulness would have

been hampered by the fact that Juniper Glass only started up their operations in mid-august of that year.

This diagram shows three important loops:

- The primary loop is the one that covers the deposit/return system. This large loop involves a yearly cycle of a little over 1.4 million tons of glass in filled bottles going from the fillers to the distributors and then on to retail and households. After being consumed they are returned in reversed order, back to the fillers to be used again.
- The secondary loop comprises more than 0.1 million tons of empty unbroken bottles, collected at the fillers (off-spec rejected bottles) and at the households (mostly bottles without a deposit). These bottles are reused by small scale fillers and then brought on the market again.
- The tertiary loop covers the cullet from broken bottles at the fillers that are returned to the container glass industry. These 20,000 tons per year are used to replace virgin minerals in the glass furnaces and to reduce energy consumption.

All in all, it can be stated that Ethiopia is already recycling/reusing a vast volume of more than 1.5 million tons of glass per year or 4,200 tons per day. It represents 6 times the average tonnage of glass that ends up in the waste shown in Diagrams 1 and 2.
The flows also clearly show that the new bottles produced by the container glass production industry provide just a small percentage of the fillers' total need for bottles. Most of this need is fulfilled through the deposit-returns of bottles. This system can be regarded as an asset for Ethiopia in many regards. Because of its positive effect on reuse but also because it strongly reduces the need for imports within a currency restricted context. If this system would fail it would lead to a high glass demand on the input side and to a very strong need for new imports or substantial investments in new glass production facilities.
It has also worked the other way around; both, the primary and the secondary loop seem to be instigated by the current low bottle production capacity and by the restrictions on import. An increasing production capacity will probably ease the market, decrease 2nd hand volumes, increase glass in waste, increase volumes of returned cullet and pave the way for non-returnable bottles. Diagram 4 shows on the left-hand side that there are going to be two new players on the market being Goda Glass and DeDe Glass. Their start up in 2021, together with foreseen capacity increases at Addis Glass, will drastically change the picture. It will not only increase the input of new glass bottles; all three loops will show substantial reshufflings. The pipeline of investments in increased bottle production, as described in Chapter 3 will lead to a doubling of container glass production. Part of that will be absorbed by increased consumption but it may also lead to export of bottles, benefiting Ethiopia's trade balance. Some scenarios about the future development of the Ethiopian glass market and its impact on glass recycling is discussed in Chapter 7.
On the righthand side the diagram shows a flow of 105,000 tons per year of glass packaging being rejected from the system and going to waste. This equals to 290 tons/day and when this is compared to the 690 tons/day of Diagram 2, the conclusion could be that on a daily basis some 400 tons of waste glass should come from other sources like broken window panes, drinking glasses, glass objects etc. This number is counterintuitive as one would expect broken packaging glass to be the main source. The reasons for this can be twofold. The first is that the assumptions needed for filling the data-gap may show some flaws that may be acceptable when applied to large volumes, as in the deposit/return system, but may result in a substantial bias in smaller volumes like that of wasted glass. But it could also be that the figure is correct and that the exceptional Ethiopian situation, with extremely high reuse rates

for bottles, reduces the amount of glass waste from the households to a very low minimum. If so, this of course makes the other sources of waste glass seemingly more important in the waste that ends up as litter or on the dumpsites.

c. Assessment

The diagrams of this chapter enable some preliminary conclusions:

- Under current circumstances there are not many possibilities to increase glass reuse and recycling in Ethiopia. In theory one could think of trying to drain broken glass parts from the waste that is brought to the dumpsites and Waste-to-Energy plant but this path is difficult, expensive and will not result in good quality cullet.
- This situation assessment aligns with the fact that currently there is no enthusiasm amongst market players, such as recycling companies, to initiate operations in glass collection and recycling.
- It looks like cullet returns to the glass industry are competing with the 2nd hand bottle loop. There's a potential of 100,000 tons of cullet per year if the glass industry is able to win this competition. This potential volume is important as it equals the current production capacity.
- Towards the future new production capacities will get into play. This may lead to a decrease in the volumes of the primary and secondary loop meaning that more unbroken glass will enter the waste stream. In that case, separate collection and recycling may gain in importance.

5. Review of legal framework and governance

This chapter comprises an overview of the regulatory infrastructure on glass waste management in Ethiopia. The sections begin by scanning the frameworks at the federal level followed by a dissection of Addis Ababa city level regulations. At the end an assessment of the legal framework, with a focus on glass waste, can be found.

a. Federal Level

- National Policy

The foundational principles of waste management in Ethiopia are anchored in the FDRE constitution (1995) and the Ethiopian Environmental Policy. The Constitution confers the right to clean and healthy environment as a departure point for environmental action in Ethiopia (Article 43). It also asserts that any project, particularly those funded and undertaken by the government, has to undergo a compulsory environmental impact assessment before implementation. Following this, the Environment Policy of 1997 underscores the need to give priority to waste collection services and to its safe disposal. While doing so, it urges the practice of solid waste management in urban areas to turn solid wastes from homesteads and establishments for the production of energy, fertilizer and for other uses. The policy is already more than two decades old, and is currently undergoing revisions. Again, while providing the basic precepts for waste management in urban setups, it does not incorporate recent concepts that ascribe producer/ manufacturer responsibility on end of life products.

- Pollution Control Law

As a federal state, Ethiopia's regulatory system on waste management is two-pronged such that the federal government sets the tone while regional states draw on it and put in place more stringent regulations (Article 6.4 of the Pollution Control Proclamation No 300/2002). The law enforces what is known as the "polluter pays principle" to make polluters accountable to their acts. It further looks to the institutionalization of an integrated waste management system at urban set-ups, assuming to itself the role of evaluating the effectiveness of such a system.

- Solid Waste Management Proclamation

The federal pollution control law has been revamped by a later amendment (Solid Waste Management Proclamation No. 513/ 2007) that specifically focuses on waste management in urban setups. The waste management proclamation underlines the need for community participation in waste management practices and prescribes measures to be taken for the establishment of a plan-based management infrastructure across administrative levels. The law's primary objective is to lessen the adverse impacts of solid waste while creating economic and social assets out of the waste stream across city administrations in Ethiopia. It enlists glass waste as part of the broad composition of urban waste. Under Article 7 of the law, it imposes an obligation on manufacturers or importers of containers to collect and recycle used glass containers. A corresponding duty is placed on authorities to designate pre-collection sites to collect used glass containers for recycling purposes. The law also emphasizes the need to pursue a hierarchy of waste management where disposal is the last option while minimization, reuse and recycling are the preferred options. The rest of planning and setting up the required organizational structure of waste management is left to urban administrations where they are additionally required to create enabling conditions to promote investment on the provision of solid waste management services (Article 4.1). The law introduces a permit system to be administered by cities for undertaking any waste management service (Article 4.2) but leaves details to be drawn by respective municipalities.

b. Addis Ababa Level

Regulatory Framework on waste management

City administrations, including the city of Addis Ababa, are increasingly adopting their own institutional set ups and regulatory systems as per the federal law on waste management. Accordingly, Addis Ababa city administration established a Solid Waste Management (SWM) Agency to coordinate waste management functions at the city level. Besides, the City Council adopted the Executive Organs Establishment Regulation # 64/ 2018 that charted out the mandates of the SWM Agency, modalities of operation, and roles of various actors. More detailed examination of city level organizational structure, the rule pertinent to waste management under this Regulation and the general regulatory set up is presented in the subsequent sections. The directive places an EPR like obligation on manufacturers when it states that electronic equipment producers and importers shall make sure that end of life equipment are disposed in an environmentally sound manner. However, the directive does not have specifics as to how such a law is to be implemented and the consequences of failure to do so. The directive is silent on glass manufacturers.

Institutional arrangements on waste management

There are a number of government offices such as the city's Environmental Protection Authority, and the Solid Waste Reuse and Disposal Project Office currently under the SWM Agency with core and tangential mandates over solid waste management in Addis Ababa city. However, the major function rests in the city's Solid Waste Management Agency.

- SWM Agency

Its core mandates emanate both from Regulation # 64/ 2018 and a Directive issued in 2018 to implement it. This directive amended the previous law, Directive # 13/ 2010 and, as outlined in its preamble, is pivoted on the Polluter Pays Principle. As per these laws, the Agency is one of the 5 core offices that are directly accountable to the Mayor Office and tasked with the functions of solid waste collection, transport, reuse, recycling, disposal and public awareness related to urban waste. While the Agency is directly accountable to the city management, it has nodes at each of the 10 sub-cities and the various *Woredas* with the aim of reaching out to the city dwellers.

- Waste collection system

The Agency is empowered under Article 7 of the Directive to enable cooperative associations and street sweepers undertake citywide collection of waste. Pursuant to this, the Agency has devised three levels of collection across the city where each level has its own operational modality, fee structure, and actors involved (see paragraph 3d.). At the moment, glass waste is not treated separately through the waste collection system established by the Agency.

- Fee structures

The city has adopted a law where payment of household SWM fees is done through monthly water bills. 20% of the monthly water consumption fee goes to offset the cost of solid waste management. Institutions will pay a larger percentage being 42 percent of the monthly water consumption. At the lower end, households with lower incomes are expected to contribute to this pool by paying 5% of their water usage. This will be aggregated through the Addis Ababa Water and Sewerage Authority and goes to the city's coffers as per Regulation # 25/ 2002. According to the Agency, the revenue collected from waste generators (household to institutional levels) was as high as 42,668,024.9 Birr in 2016/17. Of this, the budget allocated by municipality per annum for the year 2017/18 was much higher compared to the revenues. For instance, the funds allocated for the Agency's recurrent budget was Birr 275,026,550, while a recurrent capital budget to the tune of Birr 61,570,511 and capital expenses

amounting Birr 155,700,000 was allotted to the City's Solid Waste Reuse and Disposal Project Office. This is an indicator of the huge budget deficit in the solid waste operations in terms of its capacity to generate sufficient revenues.

c. EPR

Extended Producer Responsibility (EPR) has gained worldwide interest in the past 20 years. Countries consider this as an option to reduce the cost of their waste management operations and to increase the performance on recycling. EPR schemes are legally embedded in laws and regulations. They extend the responsibility of producers of consumer-goods to go beyond the point where the product is discarded. The producers are obliged to take care of collection and recycling in this stage and they have to do so according to targets set by the government. The legal arrangements further provide regulations on organization, geographical coverage, governance, timeframes, financial provisions, reporting and monitoring. EPR schemes are known for an array of products such as end-of-life vehicles, batteries, electronic goods and packaging waste. Container glass is usually part of EPR schemes for this last category.
One of the basic preconditions for an effective EPR system is the need to forge partnership between local authorities involved in the enforcement of EPR legislation, and an industry led EPR organization. In the Ethiopian context, the later does not exist. However, there is an operational association serving the packaging industry or those that require packaging in their industrial processes. This association - named the Ethiopian Packaging Association - is not exclusive for the container glass sector but also encompasses the general interest of all range of actors dealing with any kind of packaging. As the sole responsibility of retracting its waste lies in the fillers, it is expected that a fund will be set aside where each of the fillers or packers contribute. The fund, administered by the EPA, is then used for financing the collection and recycling. The EPA will assume the functions of fund-management, contracting, administration, and reporting related to the operationalization of such an EPR mechanism.
Of late there is an interest on the part of the government to encourage local glass container manufacturers with a view to enhancing import substitution and halt the drainage of national foreign currency as a result of glass container import. Because of this ambition, the Food and Beverage Institute under the Ministry of Industry supports the Ethiopian Packaging Association so that the association will stand on its feet to represent the interests of the industry. This window can be exploited to spur the enforcement of EPR by engaging the mandated public organizations and this industry affiliated association. As EPR is itself a policy principle rather than a readily implementable legal tool, a range of administrative, economic and informative tools have to be packaged for its proper implementation. The following are logical steps towards this end:

- Mandate setting

Mandates have to be clarified among the many actors with overlapping responsibilities in the waste sector to avoid confusion in the implementation of the EPR system in Ethiopia. Accordingly, the following actors are identified to initiate and execute an EPR system in the glass sector:
Environment, Forest and Climate Change Commission – the commission is mandated to set the minimum standards for EPR. The Monitoring and Compliance Directorate of the Commission is well positioned as it is tasked to ascertain proper implementation of Article 7 of the waste proclamation dealing with EPR. It can also play a coordination role and oversight as municipalities execute the implementation of the law.
Addis Ababa City SWM Agency – this is the entity mandated to execute overall waste management functions including the execution of an EPR system in the City of Addis Ababa.

It can implement already existing EPR related provisions within both the federal and city level regulations.
Food and Beverage Institute of the Ministry of Industry – it can initially support the Ethiopian Packaging Association until the system can stand on its feet to coordinate roles of producer/ glass container users.
Ethiopian Packaging Association – ensure glass container users are in compliance with the EPR system and liaise with the regulators to build the capacity of the industry.

- Plan development

Mandated actors should initiate a joint plan that is clear on division of roles among all actors including federal and city level authorities, the packagers association, consumers, producers, waste collectors, as well as civil society organizations interested in waste management functions. Such an implementation plan should clearly indicate the workflow among these actors. The plan should include definition of targets, enforcement mechanisms, monitoring and surveillance as well as performance audits.

- Awareness instruments

Information packages which aim to raise public awareness (through reporting requirements, product labeling or information campaigns) should be deployed to support the initiated EPR programs.

d. Assessment

Looking at the policy and regulatory infrastructure for waste management, it can be stated that:

- The relevant national legal framework dates back to 2007. Since then no legal maintenance has been performed.
- Though it lacks appropriate policy back up, there is an increased recognition to change how waste management is carried out in Addis Ababa city. To this end there is an ambition to increase the level of sorting at source and boosting the recyclable content of generated waste as well as initiating an EPR system at least for the glass sector.
- While the minimum requirement for an EPR has been provided under the 2007 waste proclamation in Ethiopia, the provision lacks the required enforcement procedures and the accompanying monitoring and reporting systems.
- There is no state-of- the-art National Waste Management Plan in Ethiopia.
- The municipality level has become the dominant governance level with a high degree of autonomy.
- Also at the city level, there is no planning cycle with a dedicated plan covering all aspects needed in managing waste.
- The municipality has actively sourced out all of its collection services to formally organized cooperatives and private companies. This is with the exception of street sweeping which is still performed by public employees. Also, it has passively allowed the existence of a network of informal collectors of recyclable parts of the waste.
- There are no public plans with regard to glass waste and its recycling. Also, there are no incentives, be it through finance, enforcement, investment or otherwise, that will increase recycling in the near future.
- The existence of a dominant deposit/return system of glass bottles does not find its offspring in the legal framework nor is it protected by this. In fact, it may be assumed that this system is the indirect effect of shortage of international currencies and lack of bottle-production capacity.

6. Review of options

This chapter will provide an overview of available options for enhancing recycling of glass in Ethiopia. The options relate to the viewpoint of the glass-container production industry. These industries have an interest in enhancing recycling of cullet as it will lower their costs and environmental footprint, as well as improve their overall position in the packaging market. The following serves as a short introduction of these aspects.

- Cost reduction
  As already indicated in Paragraph 3g. the glass-container industry has an interest in re-using glass cullet as it reduces the consumption of virgin materials and energy. For the case of Juniper Glass this reduction and its financial implications is elaborated in Annex 5. This calculation uses the internationally used rule of thumb that melting cullet requires 25% less energy than melting virgin raw materials. When attributing all savings on energy and raw materials to the use of cullet this would lead to a value at the furnace of a little more than 4,600 Birr or $135 per ton. At this moment Juniper pays $15 per ton for picking up furnace-ready cullet or pays around $60 per ton for such material landed at their facility in Debre Birhan. As currently there is no carbon pricing scheme in Ethiopia, no cost reduction potential due to carbon emission reduction from cullet usage exists.
- Environmental footprint
  The reuse of 1 ton of cullet leads to a 1.2-ton reduction of the use of raw material, to a 25% reduction of energy use, to a reduction of 0.67 tons (on a cradle to cradle life cycle basis - European average value) of CO_2 emissions and to a 1-ton reduction of landfill use. This image of a reduced footprint will improve the public perception of both the product and the industry.
- Market position
  This improved public perception as a result of the above measure may lead to a stronger market position of glass in Ethiopia's packaging mix. This is particularly important in the context of the Ethiopian government's current ambition to become a fair regional player and in its continued effort to accede into the WTO

Options a. to d. have a technical/operational character whereas options e. and f. are related to legislation and communications. While some of the options are mutually exclusive, there are some that may fit together with other options.

a. Increased cullet procurement/replacing 2nd hand bottle market

As can be read from Diagram 5 the glass-container industry now uses around 20,000 tons of cullet on a yearly basis. This cullet is bought from the beverage industry at a price of 500 Birr per ton. The fillers do not sell all of their waste-glass to Juniper Glass and Addis Glass. In fact, 85,000 tons of it comes as rejected off-spec bottles and they are sold as 2nd hand bottles to traders, who return them to small filler shops, as shown in Diagram 1 and in the secondary loop of Diagram 5 (see end of paragraph 3c). As an example, Habesha sells these rejected bottles at 2 Birr/unit whereas they would get only the equivalent of 0.15 Birr per unit when they would sell them to Juniper.
The glass industry could consider initiating negotiations with the fillers aiming at contracting all of their cullet and rejected bottles. This could be supported through the brokering services of the Food and Beverage Institute under the Ministry of Industry, which has an expressed

interest to enhance glass manufacture as a measure of import substitute. Such a measure has the potential to raise cullet recycling from 20,000 to 105,000 tons per year.
A positive side-effect of this approach could be in the fact that contracting this extra 85,000 tons would create an equivalent demand for new bottles at the small shops who are now using 2nd hand bottles. This effect could be weighed by the glass industry and considered in the above-mentioned price-negotiations with the fillers. In general, further growth of the Ethiopian economy and the glass packaging market will inevitably lead to fading out the reuse of 2nd hand bottles. The container glass industry could consider accelerating this process by introducing a range of standardized lower-quality bottles at a lower price. Experience from Turkey showed the success of such a strategy. In that situation these bottles could be produced at a 10% lower cost and were distributed through a network of wholesalers.

Introduction of Standard Bottles in Turkey for low-cost markets
To enter the vinegar market that was mainly using low quality plastic bottles, a standard glass bottle was developed by Sisecam using scrap molds to bring costs down. Through this project, Sisecam not only gained access to the vinegar market, but in time, induced high-end vinegar fillers to use high quality special bottles to differentiate their products.
Similarly, agreements were made with enterprises that were collecting used wine bottles to sell to very small low-quality wine manufacturers, to sell the collected bottles to Sisecam as cullet and offering the wine makers low-cost standard wine bottles through wholesalers.

Box 1. Examples of standardized bottles from Turkey

There is however a downside to this. From a macro-level it can be argued that replacing bottle-reuse by cullet-recycle does not improve the environmental performance of the system as a whole.

b. Passive and active glass collection

Many countries around the world use separate collection of container glass in order to raise cullet-returns to the industry. There are two options:

- Passive collection
  This option uses dedicated bottle banks and places them in a dense network throughout the urban areas. The public is encouraged to participate in the system by bringing their container glass and throw them in these banks. When full, the bottle banks are emptied by a truck with a crane. Examples are shown below. The truck then brings the glass to a recycling facility in order to clean and sort it into furnace ready cullet.

Pictures 1. Examples of passive collection

A typical set-up would use a truck capable of collecting 18,000 tons per year that is serving a network of 350 bottle-banks with each of them supplying an average 10 tons per year. With investments in the truck being $70,000 and in bottle-banks being $500 per unit, the costs of collecting one ton of glass waste in this option would be about $25.
The introduction of this option needs extensive campaigns to raise the public awareness on the importance of their participation, which are costly and take time. Nonetheless the system has shown to be a success in many countries. It should be noted that, the cost of such extensive awareness campaigns is not included in the above cost of collection.
In the current Ethiopian situation this system is neither feasible nor viable because it would need to compete with active collection by the Koralews. There will be no incentive on the side of the household to participate in the option because the Koralews pick up the glass at their homes and pay money for each whole bottle. Passive collection will therefore only be an option in a situation in which the secondary loop of 2nd hand bottles has faded out and/or NRB bottles has penetrated the market.

A typical system of passive collection could start with a truck, able to pick up and transport 18,000 tons per year and 350 bottle banks located in Addis Ababa. Table 2 gives the investment needed to collect the amounts detailed in section 7.c of this report. It also provides the resulting costs per ton of glass collected.
It should be noted that the 10 ton/year yield of a bottle bank is rather ambitious. The benchmark in Turkey after many years of awareness raising activities is 12 tons/year, and it would take some years in Ethiopia to reach the 10-ton level.

Cost model for collection of 120,000 tons of glass per year			
Truck investment/unit	$70,000	Bottle bank investment	$500/unit
Truck capacity	18,000 t/year	Bottle bank yield	10 tons/year
Investments	$7,500,000	Cost/ton	$25

Table 2. Cost model for passive collection

- Active collection

The option of active collection more or less resembles the current activity of the Koralews. It comprises a system in which organized individual collectors are going from door to door to collect all the glass from the households (except for the bottles with a deposit) and bring the glass to a collection point where it is thrown in a container. The container is then picked up by a truck and emptied at a recycling facility. In Addis Ababa a similar system is run for paper and cardboard by the recycling company Penda Paper. They use a team of 50 collectors covering a large part of the city with their tricycles.

Penda has considered to enhance the system with a network of small semi-stationary collection points.

Pictures 2. Examples of active collection equipment

In order to be able to collect sufficient glass containers the collectors will need to pay a price for them to the households. As said, in doing so they will be in direct competition with the Koralews.
A typical system of active collection could start with a truck, able to pick up and transport 18,000 tons per year, serving a network of twelve 5 m^3 containers and, at full use, 500 collectors, equipped with tricycles and each collecting 100 kilograms of glass per day and grow as needed. Table 3 gives the investments and number of workers needed under different collector efficiencies to collect the amounts detailed in section 7.e of this report. It also provides the resulting costs per ton of glass collected when paying 0.25-1 Birr per bottle to the households.

Cost model for collection of 60,000 tons of glass per year				
Monthly wage collector	$60	Container investment	$1,500/unit	
Truck investment/unit	$60,000	Truck capacity	18,000 t/year	
Tricycle investment/unit	$300	Container capacity	1,500 t/year	
Collector efficiency	Price paid per bottle	Investments	Workers	Cost/ton
100 kilo/day	1 Birr	$400,000	600	$135
100 kilo/day	0.5 Birr	$400,000	600	$90
100 kilo/day	0.25 Birr	$400,000	600	$65
200 kilo/day	1 Birr	$300,000	300	$120
200 kilo/day	0.5 Birr	$300,000	300	$70
200 kilo/day	0.25 Birr	$300,000	300	$50

Table 3. Typical costs for active collection for different collector capacities and paid bottle prices

When combining these costs with those of a recycling facility (see below under d.) it turns out that the maximum price for a bottle a collector could pay to the households would be 0.25 Birr.
The upside of this option is that it resembles current Koralew services. As people are used to having their glass picked up at their homes, there will be less need for extensive campaigning.
The systems viability is highly dependent on the network's efficiency, the productivity of the collectors and the price they have to pay to the households. It could be worthwhile to consider a pilot with the system bearing in mind that there will be social resistance coming from the Koralews. When the 2nd hand bottle market fades out also the Koralews

appetite to collect glass will disappear as well and then this option of active collection may be a winning model.

The success of Ljubljana, Slovenia

A 2015 assessment of the situation in Europe's capitals revealed the remarkable success of Ljubljana. The city of 350,000 inhabitants is one of Europe's frontrunners on increasing separate collection of waste components. In 2014 it showed an ability to collect 75% of separately collecting the paper, glass, plastics and organics contents of its waste. As for glass the capture was 87.5% which was done by a combination of active door-to-door collection and passive bring-points (850 per 100,000 inhabitants). The success in Ljubljana was underpinned by a very strong program on education, awareness and enforcement.

Box 2. An example from Slovenia[1]

c. MRF installation

In general, there are two types of MRF's.

- Mixed waste MRF
  This option aims at processing mixed municipal waste and tries to separate it into different fractions such as (i) an organic fraction that needs further composting or digestion, (ii) Refuse Derived Fuel (RDF) to be used, for example, by the cement industry, (iii) individual components like plastics, paper, metals and glass and (iv) a residue that goes to the landfill. This type of MRF needs considerable investments and a gate-fee, to be paid by the collectors/producers of the waste, in order to achieve viable cashflows.
  The system has some serious drawbacks. One of the most important is the poor quality of the products. The organic fraction, being more than 50% of the output, will not meet the quality standards that make it fit for compost production. Also, the paper and plastics are highly contaminated with organics and inerts (stones, sand, glass). This holds even more for the glass fraction as it will contain organics and inerts in quantities that make any type of recycling impossible. This option should therefore be discarded when considering alternatives to improve glass recycling.
- Clean MRF
  A Clean MRF aims at processing mixtures of separately collected recyclables and tries to separate the mixtures into clean recyclable components. In theory this option can be considered for mixtures of plastics, paper, cardboard, metals and glass. The technology is simple as it uses basic sieving along with extensive manual sorting as shown below.

[1] "Assessment of separate collection schemes in the 28 capitals of the EU" – European Commission 2015

Pictures 3. Examples of Clean MRF

The feasibility of a Clean MRF is very much dependent on the specific mixture of recyclables and on the quality of these components. A cashflow model was elaborated according to the layout presented in Annex 8. It shows the following results for a typical composition of incoming waste and for assumptions on the prices for the products.

	Flow %	Price		Flow %	Price	
Input	100%	$0/ton	Metals	5%	$70/ton	
Plastics	15%	$80/ton	Glass	10%	$20/ton	
Paper/CB	25%	$50/ton	Residue	45%	-$10/ton	
Capacity	Gross margin per year	Capex	Opex per year	IRR	NPV*	Employees
50 tons/day	$380,000	$2,500,000	$140,000	19%	$1,300,00	50
200 tons/day	$1,530,000	$5,300,000	$300,000	35%	$8,050,000	170

* NPV calculated at Weighted Average of Capital Cost of 9.6%

Table 4. Typical cashflow analyses of a Clean MRF

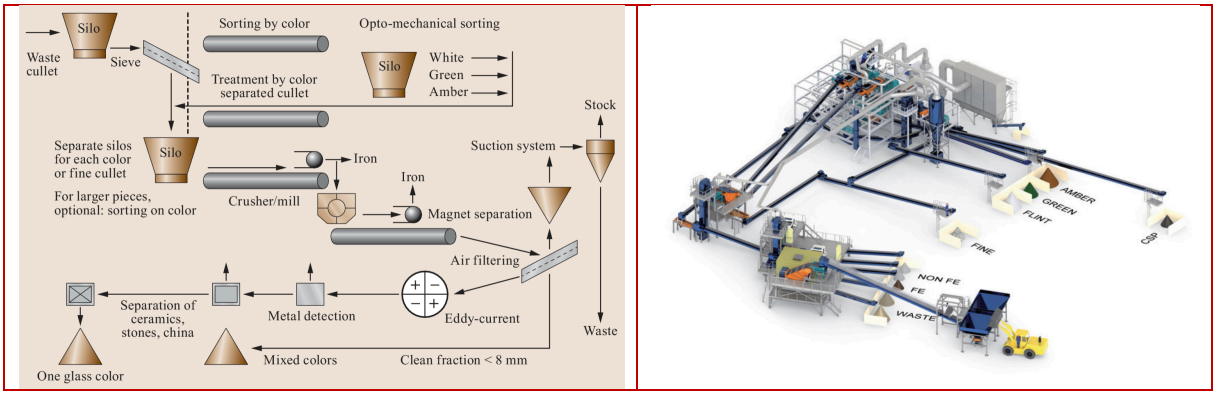
Although the financial results of such an analysis look promising there are some serious drawbacks, especially when it comes to glass.
The first one is that this option needs the operation of a system of separate collection of the mixture of recyclables to provide for the feed of the MRF. This makes the combined introduction of separate collection together with a clean MRF a difficult option. Nevertheless, it can be done and it has shown to be successful in many countries.
The second downside however is in the glass itself. There are no successful examples of using a Clean-MRF for mixtures that hold glass in it. During the collection and processing of these mixtures the glass brakes and the fine glass particles mix with the plastics and paper. This makes the manual separation difficult. But what's more important is that the plastics and paper are no longer fit for recycling because of the glass contamination. For that reason, this option should be disregarded.

Experiences with MRFs
The Waste &Resources Action Programme (WRAP) in England provides overviews and case studies of MRF installations inside and outside the UK including their design and financials. The reports show that a minority of these facilities accept glass, co-collected with other recyclables. In 2006, England was home to 61 MRFs for comingled recyclables. Most of them operated at capacities of less than 50,000 tons per year.
www.wrap.og.uk/content/sorting-materials-recovery-facilities-mrfs

Box 3. Examples from England

d. Glass recycling

Actively or passively collected glass needs cleaning and selection in order to meet the specification of furnace ready cullet. A glass recycling facility processes glass waste by breaking it in combination with color sorting and removal of impurities. Especially the removal ceramics, stones and porcelain (CSP) is important. In the past, color selection and cleaning were done manually. Nowadays this part of the process is mostly done by optical sorting machinery. This development has made it possible to lower the CSP content enabling a higher use of the cullet in the furnaces as CSP do not melt in the glass furnace and end up in the new product, rendering it unusable.



Pictures 4. Examples of Glass recycling

The feasibility of a glass recycling facility is very much dependent on the quality of the mixture and on pricing of the input and output flows. A cashflow model was elaborated with a layout as presented in Annex 9. The analysis, based on an active collection system with 100 kg/day collector efficiency and 0.25 birr buying price, could typically show the following results.

	Flow %	Price		Flow %	Price	
Input	100%	-$65/ton	Colored	75%	$120/ton	
Flint	10%	$135/ton	Residue	15%	-$10/ton	
Capacity	Gross margin per year	Capex	Opex per year	IRR	NPV*	Employees
50 tons/day	$555,000	$4,900,000	$55,000	12%	$410,000	12
200 tons/day	$2,220,000	$6,600,000	$85,000	36%	$10,000,000	15

* NPV calculated at Weighted Average of Capital Cost of 9.6%

Table 5. Typical cashflow analyses of a glass recycling facility

Also here, an interesting business-case emerges. The downside for this option lies in the availability of collected glass. Under current Ethiopian circumstances there is no need for this recycling as there is no collection scheme that could feed this option. This situation is underlined by the attempt Juniper Glass made in 2019 in which they invited market players to come up with proposals for initiating glass recycling. Juniper did not get any response for it. Nevertheless, this recycling facility will be needed somewhere in the next years when glass production increases and the 2nd hand bottle loop fades out.

Netherlands based recycling company Maltha

Maltha recycling company is the leading recycler of glass waste in Europe. The company operates 8 plants in 5 countries across Europe with a total capacity of around 1.5 million tons per year. One of the largest is the plant in Dintelmond, the Netherlands, treating almost 0.3 million tons per year.
Incoming CSP (ceramics, stones, porcelain) in the feed-glass ranges between 0.5 and 6 kilogram per tons.
Outgoing cullet product specifications show a maximum of 30 grams of CSP per ton.

Box 4. The market leader on glass recycling in Europe

e. EPR schemes

In a typical EPR scheme for packaging waste the responsibility lies on the fillers/packers. A filler has to pay a contribution per packaging-item to a fund. The fund is then used for financing the collection and recycling. Usually, the industry sector as a whole picks up the responsibility in close cooperation and attributes tasks on fund-management, contracting, administration and reporting to a separate organization. As suggested in the previous section, the Ethiopian Packaging Association can play this role through initial support from the Food and Beverage Institute. In Europe EPR-systems for glass containers are generally used and fund-contributions are around 0.5 eurocents per unit.
In general, the fillers are not enthusiastic about EPR schemes as it raises the price of their product, it increases their administrative burden and it forces them into involuntary relations with their competitors, with the municipalities and with the recycling sector. The position of the glass-container producers may be different as EPR schemes may increase cullet returns, lower their operational expenses and improve their environmental footprint whereas they are not burdened by the effects experienced by the fillers.
Although there is this divergence in interests, it is advisable that producers and fillers try to work together on EPR and align their actions at an early stage.

f. PR, Awareness and CSR

There are a number of options that reside in the sphere of Public Relations, Awareness and Corporate Social Responsibility. Possibilities are:

- Distributing flyers with safety guidelines on handling glass.
- Distribution of safety gear with logos to Koralews.
- Awareness campaigns at schools on the positive aspects of glass and on the importance of its recycling.
- Concerted communications of the glass and beverage sector on Deposit/Return systems, recycling and EPR.
- Placing pilot bottle banks at supermarkets.

All of these actions are relatively easy and cheap whereas they add to a positive perception of the container glass industry as being responsible, responsive and involved in the greater societal concerns. The actions could go hand in hand with most of the other options mentioned above.

European glass federation supports CSR of glass producers

FEVE is the European federation of glass producers. The cooperation supports its members by aligning their National programs on awareness and CSR. One of their projects is "Close the glass loop". It shows how the industry is aiming at raising the current collection rate of 76% to 90% while increasing the quality of the incoming cullet. Another project works on reducing the CO_2 emission of the glass furnaces by 50%.

Box 5. FEVE supports its members on CSR campaigns.

g. Assessment of options

The following preliminary conclusions can be drawn from this options review:

- The actions on PR, Awareness and CSR can be considered as "no-regret" options. They are cheap and easy and do align with all other options in this chapter.
- The glass industry could initiate negotiations with the fillers in order to establish an umbrella-contract, aiming at capturing all the glass waste (including rejected bottles) from their production lines.
- At the same time the glass industry could consider to introduce a cheap standard bottle in order to accelerate fading out the 2nd hand bottle market.
- At this moment there is no sense in initiating a passive or active collection system. Such a system would only be viable after fading out the 2nd hand bottle market.
- If this would happen the industry could consider to initiate an active collection system as this system likens the current Koralew service and it would not need extensive campaigning.
- When initiating collection systems, the need will be felt to also start up a recycling facility.
- MRF's of any kind will not be a viable option for the glass industry, if at all.

The next chapter will design a number of scenarios that may be useful when further investigating the use of the options under different circumstances.

7. Scenarios

Most of the options of Chapter 6 do not have a stand-alone character. For example, initiatives on glass-collection also need investments in glass recycling and such a plan must be underpinned by awareness campaigns.

The options can also only be assessed when placed in a situation that will change over time. An option can lack viability at this moment in Ethiopia's economic context but can become viable within a few years when circumstances change.

It's for this reason that this study needs scenarios; realistic developments in the glass market over a longer period of time. Scenarios enable to assess the viability, or even necessity, of combinations of options under different circumstances.

Three scenarios were developed about the future of the glass containers market in Ethiopia. The first scenario assumes the market will continue with its present structure in a Business as Usual Scenario (BaU). In the second scenario a gradual penetration of non-returnable bottles (NRB) is foreseen with different penetration rates in different beverage sectors. In the third scenario, the replacement of the 2nd hand usage of bottles is foreseen as a result of increased purchasing by the glass industry of the rejected bottles at the fillers and of the introduction of a low-cost standard bottle (option a. in Chapter 6).
Each scenario will have two sub-scenarios; one on high market growth and one on moderate market growth. These sub-scenarios are defined as follows:

- 2020 for both sub-scenarios: 10% contraction in the food and beverage market due to the pandemic.
- 2021 and onwards for the high market growth sub-scenario assumes
    - a yearly increase of beer consumption of 16%
    - a yearly increase of all other food and beverage consumption of 10%
- 2021 and onwards for the moderate market growth sub-scenario assumes
    - a yearly increase of beer consumption of 8%
    - a yearly increase of all other food and beverage consumption of 5%

So, with three basic scenarios and for each two sub-scenarios there will be a total of six scenarios.

a. Business as Usual – High Market Growth and High Production Capacity Growth

In this scenario, it is assumed that the glass and waste value chains as described in the previous chapter will continue to exist in the next decade, with high growth rates as described above. Under this scenario, it is foreseen that Juniper Glass will introduce a new furnace around 2025 to increase its capacity to 150,000 tons/year, Addis Ababa Glass will finish its already announced investment program and together with Goda Glass will introduce new furnaces towards the end of the decade bringing the total glass containers production in Ethiopia to 400.000 tons/year by 2030.

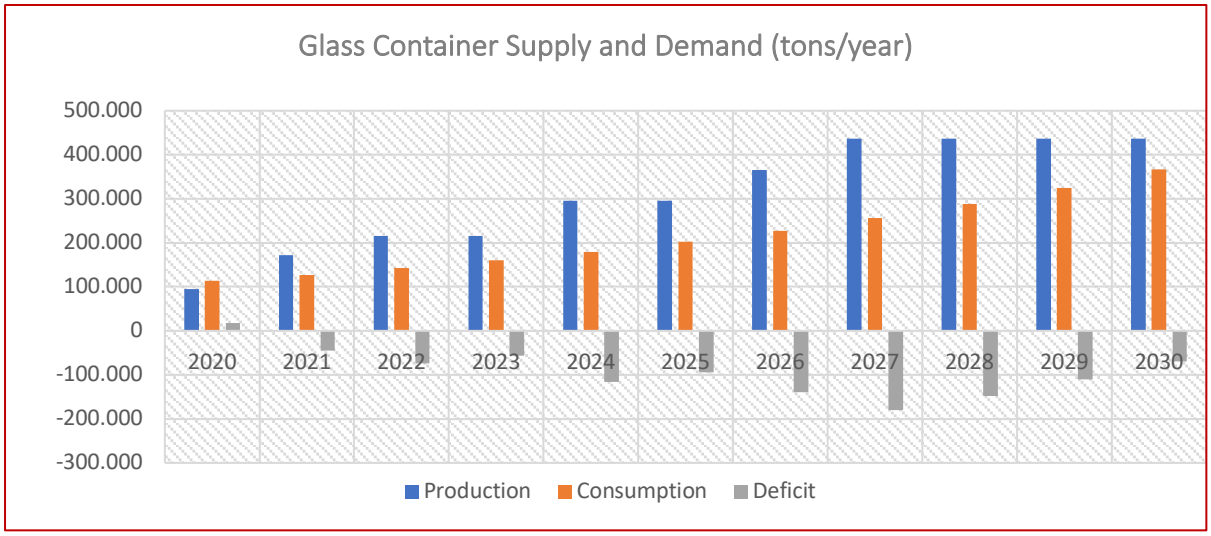


Diagram 7. Glass container supply and demand (BaU - high growth scenario)

The demand and supply of glass containers projections are shown in Diagram 7. As can be seen in the Diagram, there will be an oversupply of glass containers as from 2021, requiring the glass producers to develop export markets.

Under this scenario, the only source of cullet for the glass producers will continue to be the broken bottles at the fillers. Neither an active nor passive collection system as described in Section 6 of this report is deemed to be viable. The analysis about the maximum price glass producers would pay for cullet shows that external cullet usage would not be feasible for glass producers above the price of 4.600 ETB/ton delivered to their plant (See Annex 5). Combining this price with the cashflow analysis of a recycling plant and the cost structure of active collection reveals that, in order to meet that price the collectors in an active collection scheme can only pay 0.25 ETB/bottle to "buy" a used bottle from the final consumer, whereas the koralews are paying about 5 ETB per bottle. Hence, an active collection scheme cannot compete with 2nd hand bottle traders. For the same reason, a passive collection system would not work either, as nobody would throw a bottle into a bottle bank for free, even if they do, it would be stolen from there.

As a result, the external cullet-use will gradually grow as represented in Table 6. The percentage in glass production will go down in the first years and then gradually grow towards 26%.

Used cullet at glass producers	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Tons/year	18,062	22,047	26,779	32,388	39,027	46,875	56,138	67,060	79,923	95,057	112,848
% of melt	19%	13%	12%	15%	13%	16%	15%	15%	18%	22%	26%

Table 6. Cullet use at glass producers (BaU - high growth scenario)

In this scenario the best course of action for the glass producers is to carry out the awareness raising, CSR activities and try to capture the rejected but unbroken bottles currently going from the fillers to the 2nd hand bottle traders (options a. and f. of Chapter 6). If such a strategy would work and if 50% of the bottles going to the traders can be captured, the maximum external cullet percentage could go up to 50% as shown in Table 7 below. An important side-effect will be that the traders in 2nd hand bottles will now have to buy new bottles to fill up the demand-

gap, thus phasing out a considerable part of the 2nd hand bottle market and opening up a new market for the glass producers.

Used cullet at glass producers	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Tons/year	56,312	64,122	73,061	83,299	95,029	108,477	123,900	141,598	161,915	185,249	212,059
% of melt	59%	37%	34%	39%	32%	37%	34%	32%	37%	42%	49%

Table 7. Cullet use at glass producers under increased procurement (BaU - high growth scenario)

However, the maximum price glass producers could pay for a bottle is 1 ETB according to the delivered cost model for cullet analysis supplied by Juniper Glass, without exceeding the 4600 ETB limit. This price is still well below what the traders are paying the fillers, reported to be around 2 ETB.

b. Business as Usual – Moderate Growth

Due to lower growth in the beverage markets the demand for glass containers is lower in this scenario.
Hence it is foreseen that the new capacity introductions in the middle and end of the decade will not take place and the total glass container production will remain at 216.000 tons/year after the already started and announced investments are completed. Despite the lower capacity, as seen in Diagram 8, the overcapacity and the need for exports will continue.

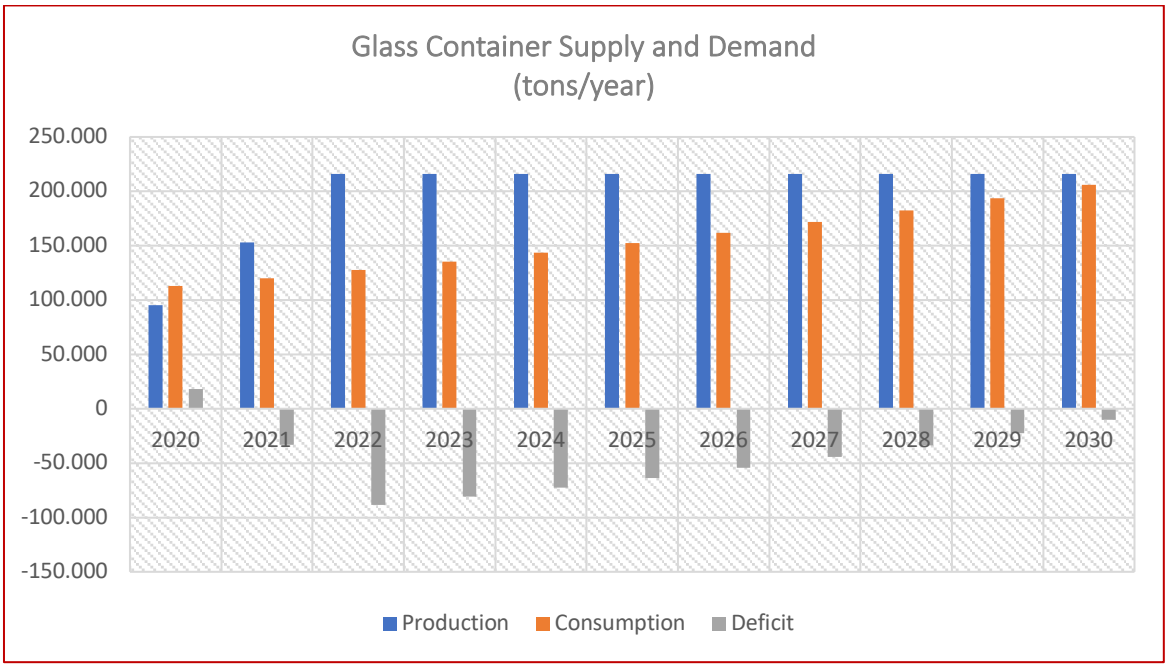


Diagram 8. Glass container supply and demand (BaU - moderate growth scenario)

As in the high growth case, the only source of cullet for the glass producers will be the broken bottles at the fillers. For the same reasons outlined above, neither an active nor passive collection system can be viable in this case as well.

If no share of the rejected bottles going from the fillers to the 2nd hand market is captured, the external cullet usage of the glass industry will not exceed 23% (Table 8). And in case of a 50% capture, this could go up to 50% as before (Table 9).

Used cullet at glass producers	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Tons/year	18,062	20,054	22,234	24,616	27,219	30,062	33,165	36,552	40,247	44,275	48,666
% of melt	19%	13%	12%	11%	13%	14%	15%	17%	19%	20%	23%

Table 8. Cullet use at glass producers (BaU - moderate growth scenario)

Used cullet at glass producers	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Tons/year	56,312	60,217	64,404	68,895	73,712	78,880	84,424	90,374	96,759	103,614	110,972
% of melt	59%	39%	35%	32%	34%	37%	39%	42%	45%	48%	51%

Table 9. Cullet use at glass producers under increased procurement (BaU - moderate growth scenario)

c. Penetration of NRB – High Market Growth

As described in the previous sections, the current glass container market in Ethiopia is entirely based on returnable bottles. The deposit return system works very well, thus the glass content in the SWM is quite low (about 2%). This scenario looks at a situation where the deposit return system starts to break down and the beverage market moves toward NRB. There could be several reasons for such a move: It has been reported that the pandemic is already disrupting the return system of bottles. The system might not be fully replaced after the pandemic. The increase of super/hyper markets that do not want to be involved in the logistics of bottle collection and return could be another reason. Or, it could be a conscious effort by the glass producers to expand their market by introducing lightweight bottle production technology (NNPB). For both high and moderate growth sub-scenarios, it has been foreseen that the NRB penetration in different beverage sectors will be as given in Table 10.

% Penetration of NRB	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Beer	0%	0%	5%	10%	15%	20%	20%	20%	20%	20%	20%
Soft drinks and water	0%	0%	10%	15%	20%	20%	20%	20%	20%	20%	20%
Wine	0%	10%	20%	30%	40%	50%	50%	50%	50%	50%	50%
Liquor	0%	10%	20%	30%	40%	50%	50%	50%	50%	50%	50%
Food and condiments	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Table 10. NRB penetration percentages

Such a shift in the market, would increase the demand for glass containers immensely, prompting the glass producers to invest in new capacities and it is foreseen that the total glass production capacity will reach 436,000 tons/year. However, as seen in Diagram 9, this capacity would be far from meeting the demand and a deficit of 385.000 tons/year would occur by 2030. As it would not be realistic to meet that excess demand by imports alone, the glass container producers would be forced to invest in even more production capacity under these circumstances.

In this scenario, there is an opportunity and a requirement to develop a collection system to boost glass recycling. As the returnable bottles decrease, cullet available from fillers will decrease and as seen in Table 10 will go down to 18.000 tons by 2030. So, the main source of cullet for the glass industry will be the glass waste collected from the consumers of beverages. Using the design parameters for an active collection system in Addis Ababa (see Chapter 6 option b.) reveals that about 5000 collectors would be needed for a 30% collection rate. Such a big operation is deemed to be unpractical. So, in this case, it is recommendable to develop a passive collection system. A passive collection system in this scenario, would not run into the problem mentioned under the Business as Usual scenarios, (namely, nobody throwing their bottles in to the bottle banks when they can get cash for it) because the amount of NRB waste would vastly exceed the demand for 2nd hand bottles.

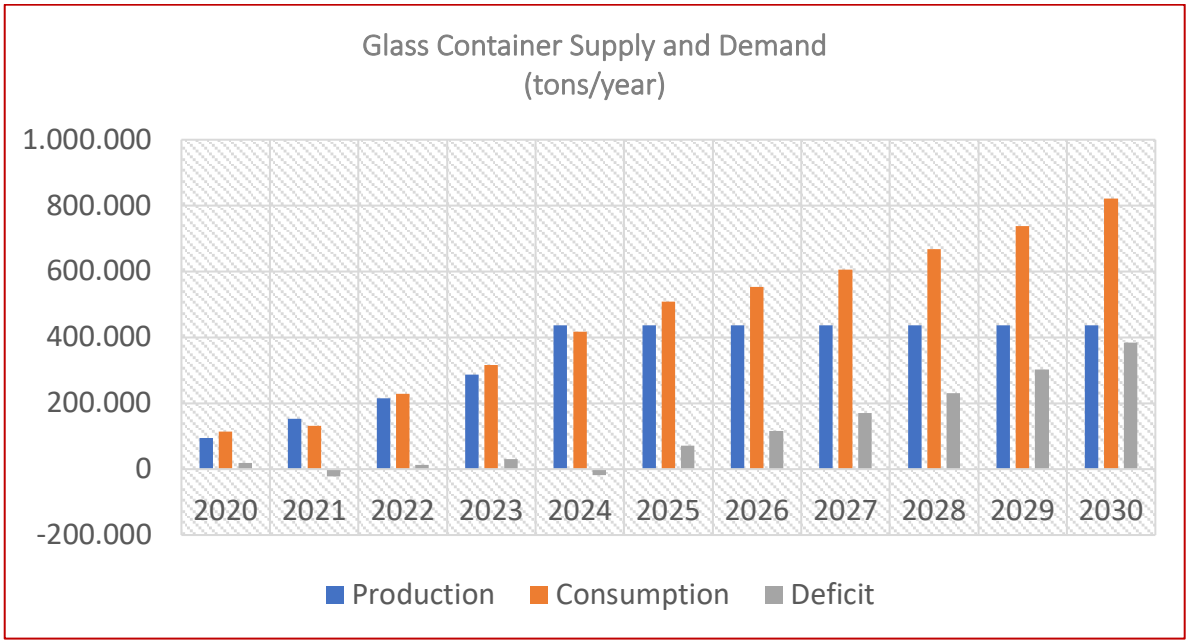


Diagram 9. Glass container supply and demand (NRB - high growth scenario)

Table 9 shows the amount of cullet going to the glass producers with a collection system set up in Addis Ababa only, that captures 30% of glass waste by 2030. To achieve that, glass producers would need to focus on partnering with a recycler/collector to invest in a recycling facility, bottle banks, collection trucks and awareness raising campaigns This last one would be now become very important in a country that has no culture of giving their glass bottles for "free". An EPR scheme could also be considered and discussed with relevant stakeholders to partially offset the costs. After such a system is established in Addis Ababa, rolling out the system to other parts of the country should be carried out as well.

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Cullet from fillers (t/yr)	**21,580**	**24,029**	**25,161**	**25,272**	**24,335**	**22,944**	**21,733**	**20,656**	**19,679**	**18,781**	**17,948**
Glass collected in AA (t/yr)	0	1,498	6,252	10,685	24,272	31,790	47,883	67,665	91,857	103,990	117,807
Cullet to Producers (t/yr)	21,580	25,527	31,412	35,956	48,607	54,733	69,617	88,320	111,536	122,771	135,755
Cullet to Producers (%)	23%	17%	15%	13%	11%	13%	16%	20%	26%	28%	31%

Table 11. Total cullet going to glass producers (NRB – high growth scenario)

In this scenario, the external cullet supply at the glass production industry would eventually rely mainly on collected glass. With 30% collection in Addis Ababa, the external cullet usage of glass plants could eventually go up to 30% by 2030.

d. Penetration of NRB – Moderate Market Growth

As shown in Diagram 10, the reduced growth of the beverage markets decreases the need for new investments in the glass industry as compared to the high growth scenario. The investments foreseen under that scenario, which brings the total supply to 436,000 tons by 2030, would more or less balance the supply and demand situation, minimizing the need for export or imports.

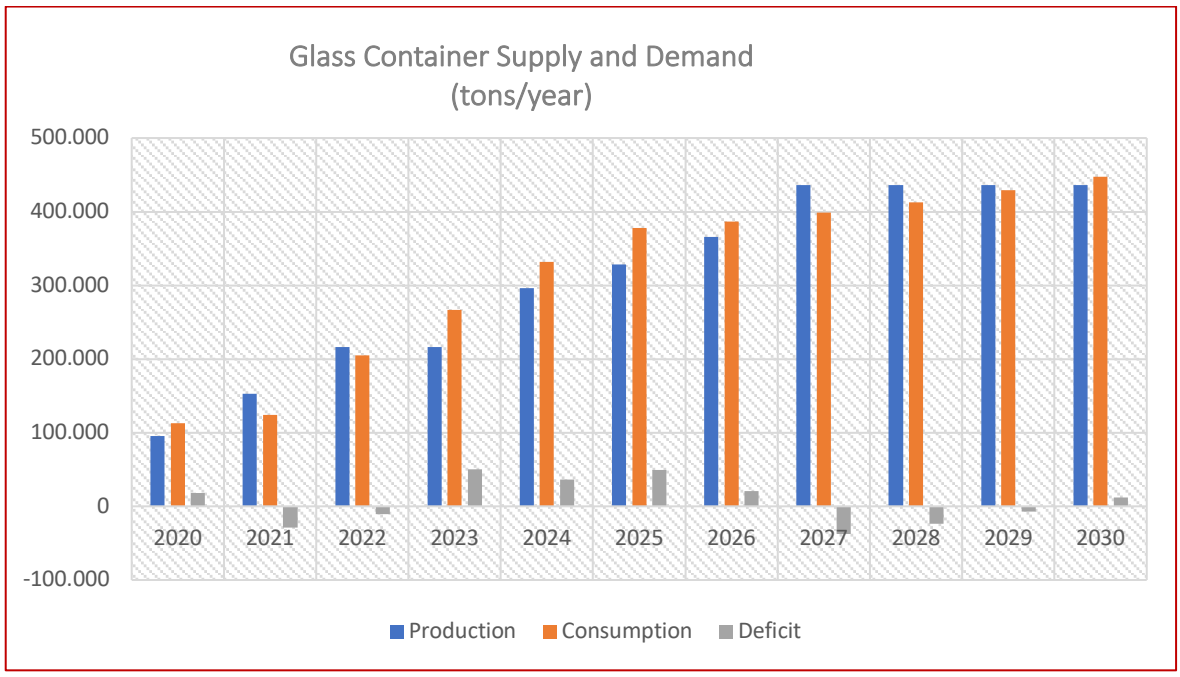


Diagram 10. Glass container supply and demand (NRB - moderate growth scenario)

Although in this scenario, the need for collectors in an active collection system in Addis Ababa is reduced to about 2500, a passive collection system would be more practical in this scenario as well.
Table 12 summarizes the resulting cullet availability with a passive collection system in Addis Ababa that achieves 30% collection. As domestic glass production satisfies the demand and need for imports is reduced, the external cullet usage ratio of the glass industry is also reduced, going as low as 12% and reach 17% by 2030. This would mean that the glass producers would need to increase their efforts mentioned above, to achieve higher collection rates and extend the system to outside of Addis Ababa.

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Cullet from fillers (t/yr)	**21,580**	**22,726**	**22,484**	**21,314**	**19,348**	**17,200**	**15,358**	**13,754**	**12,345**	**11,096**	**9,985**
Glass collected in AA (t/yr)	0	1,430	5,622	9,049	19,349	23,731	33,664	44,778	57,190	60,881	64,824
Cullet to Producers (t/yr)	21,580	24,156	28,106	30,362	38,698	40,931	49,021	58,532	69,535	71,978	74,809
Cullet to Producers (%)	23%	16%	13%	14%	13%	12%	13%	13%	16%	17%	17%

Table 12. Total cullet going to glass producers (NRB – moderate growth scenario)

e. Replacement of 2nd hand bottles – High growth

Another option for the glass industry to increase their cullet supply and their market within the current deposit return system, could be introducing a low cost, standard bottle for the users that buy 2nd hand bottles. If such bottles gain share in the 2nd hand market, it would decrease the amount of rejected but unbroken bottles going from the fillers to the traders and increase the amount of cullet available for the glass producers. Additionally, as will be discussed below, such an introduction would create an opportunity to set up an active collection system to further increase cullet availability.

A detailed analysis of product development and production of such a low cost bottle is beyond the scope of this report, however based on the cost structure of Turkish glass container industry, it can be estimated that, through lowering the quality specifications and using end-of-life mold sets after some repair, the production cost can be lowered by about 10%, which could be passed on to the customers.
To analyze the effects of such a bottle on the glass container and glass waste market, it has been foreseen that its penetration into the 2nd hand bottle market will be as follows:

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
% Replacement of 2nd hand market	0%	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%

Table 13. 2nd hand bottle replacement scenario

The supply and demand of glass containers under this scenario is given in Diagram 11. The total demand for new containers reaches about 500,000 tons by 2030, and the glass producers all invest in new capacities beyond their current ones and ongoing projects to meet that demand. Some export markets would need to be developed as well, as the production capacity is likely to exceed demand until late in the period.

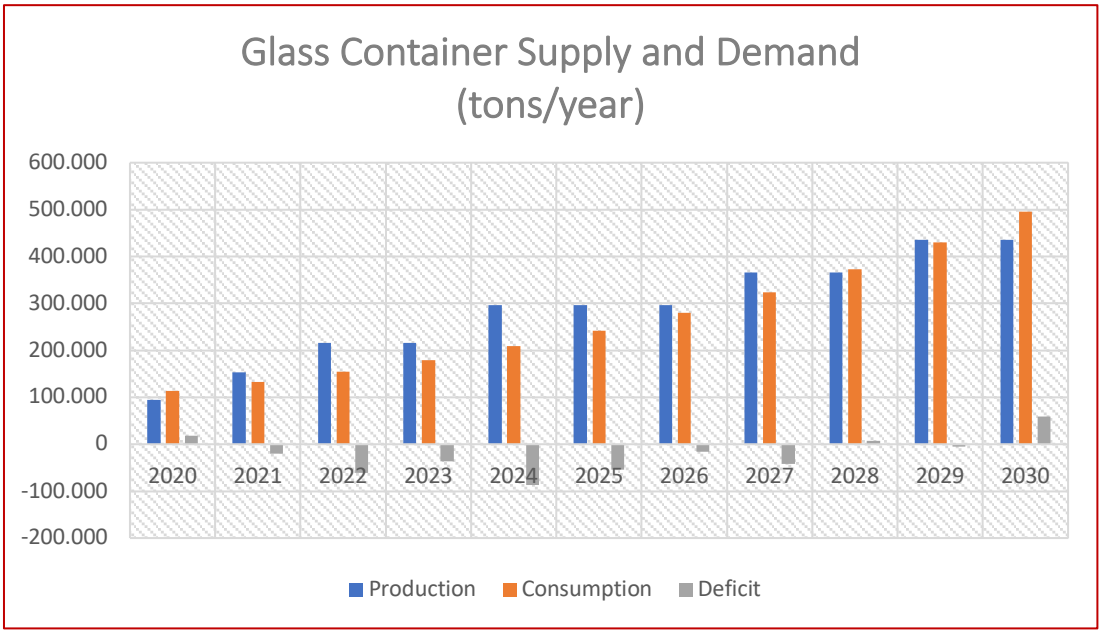


Diagram 11. Glass container supply and demand (2nd hand bottle-high growth scenario)

The replacement of bottles for the 2nd hand market will obviously increase the cullet coming from the fillers as the new bottle will decrease the demand for the rejects by the traders. But, as mentioned above there will also be an opportunity to set up an active collection system in Addis Ababa and the other cities.

An active collection system is a system to collect waste bottles from the final consumers much like what the Koralews are doing now. The self-employed collectors will buy waste bottles from the consumers for cash and carry them with a bicycle or tricycle with a special basket to designated containers to be placed in the city. A hook truck will take the full container, bring it to the recycling facility, leaving an empty container in its place. An analysis of such a system in Addis Ababa only shows that with about 600 collectors an estimated 15,000 tons of glass waste can be collected by 2030, which is 50% of the waste going through the Koralews in Addis Ababa. The analysis further shows that for the system to generate cullet at a viable price for the glass producers, the price to be paid by the collectors need to be 0.25 ETB/bottle. Although, this price is very low with current price structure, the introduction of the low-cost bottle would reduce the demand for such waste by the traders and reduce the price the Koralews pay, making the active collection system feasible.

An active collection system is more advisable than a passive collection because it would require significantly less investment in awareness raising as it is really not any different than the current system by Koralews. It would also generate employment for 600 people. Penda Paper company who has indicated an interest to go into glass collection could be a partner in such a system.

Table 14 shows the amount of cullet that can be collected in Addis Ababa and cullet that would be available through the fillers. By 2030, the external cullet percentage of the glass production would reach about 60% under this scenario.

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Cullet from fillers (t/yr)	18,062	27,492	38,758	52,153	68,017	86,735	108,753	134,583	164,809	200,104	241,238
Glass collected in AA (t/yr)	0	1,238	2,042	2,995	4,118	5,435	6,976	8,769	10,852	13,263	14,590
Cullet to Producers (t/yr)	18,062	28,729	40,800	55,148	72,134	92,170	115,729	143,352	175,661	213,367	255,828
Cullet to Producers (%)	19%	19%	19%	26%	24%	31%	39%	39%	48%	49%	59%

Table 14. Total cullet going to glass producers (2nd hand bottle – high growth scenario)

f. Replacement of 2nd Hand Bottles – Moderate Market Growth

In case of lower growth in the beverage market, the supply and demand for glass containers will be as shown in Diagram 12. It is foreseen that due to lower demand from the beverage industry, Goda and Dede will not invest in additional capacity after finishing their ongoing projects and there will be the need to export bottles throughout the period. It is foreseen that the total glass production capacity would be about 365,000 tons/year by 2030.

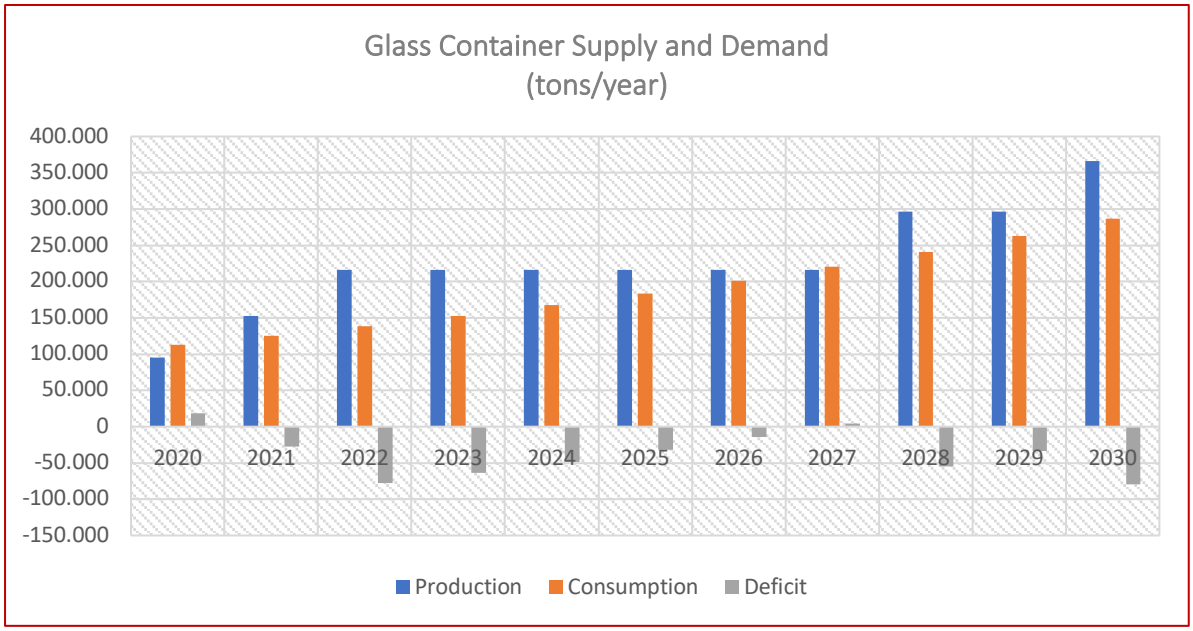


Diagram 13. Glass container supply and demand (2nd hand bottle-moderate growth scenario)

The active collection system analysis shows the system would still be viable at the purchase price of 0.25 ETB/bottle and about 400 collectors would be needed in Addis Ababa. Achieving a collection rate of 50% by 2030, the external cullet usage by the glass industry would be around 40% (Table 15), about 30% less than the high growth scenario, due to high proportion of glass production being exported.

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Cullet from fillers (t/yr)	18,062	25,252	33,148	41,807	51,286	61,650	72,966	85,308	98,754	113,387	129,297
Glass collected in AA (t/yr)	0	1,181	1,860	2,605	3,419	4,307	5,277	6,332	7,480	8,726	9,163
Cullet to Producers (t/yr)	18,062	26,433	35,009	44,411	54,704	65,957	78,243	91,640	106,234	122,113	138,459
Cullet to Producers (%)	19%	17%	16%	21%	25%	31%	36%	42%	36%	41%	38%

Table 15. Total cullet going to glass producers (2nd hand bottle – high growth scenario)

g. Assessment

Diagrams 13 and 14 show a comparison of the three scenarios in terms of the quantity of cullet used by the glass producers and the corresponding cullet percentages in a high growth environment. It can be seen that the secondhand replacement scenario generates the highest amount of cullet for glass producers. The Business as Usual scenario, where 50% of rejected but unbroken bottles are procured from fillers, is a close second. This scenario has the advantage of not requiring an investment in an active collection system, but under the current demand from the secondhand bottle users and the pricing structure, achieving 50% procurement of such bottles by the glass producers, is rather questionable.
Diagrams 15 and 16 show the same data in a moderate growth environment. Although the numbers differ, the above conclusions remain to be valid.
Thus, it seems the optimum course of action for the glass industry would be to start developing a low-cost bottle for the secondhand market and simultaneously start negotiating an exclusivity deal with the fillers. Developing an active collection system should start when the low-cost bottle is introduced.

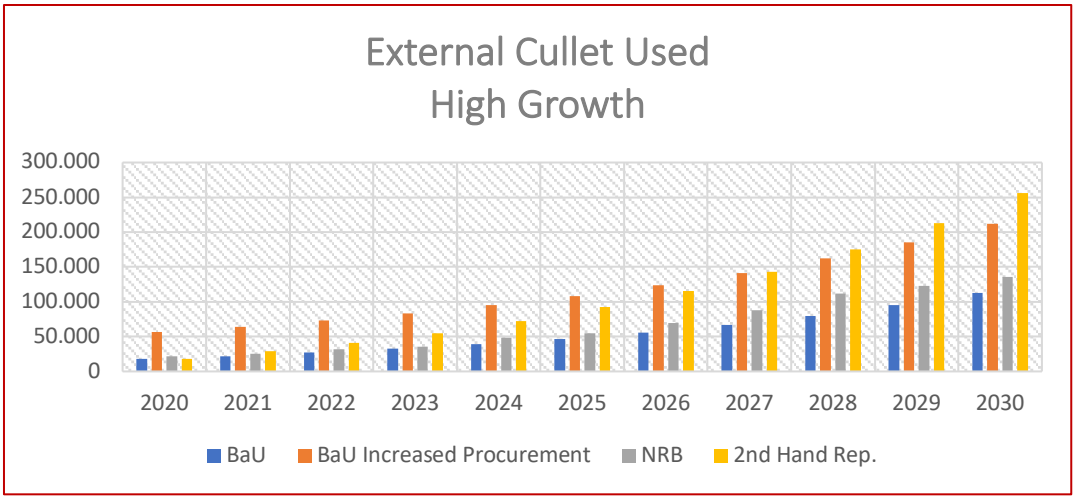


Diagram 13. Quantity of External Cullet Used (High growth environment)

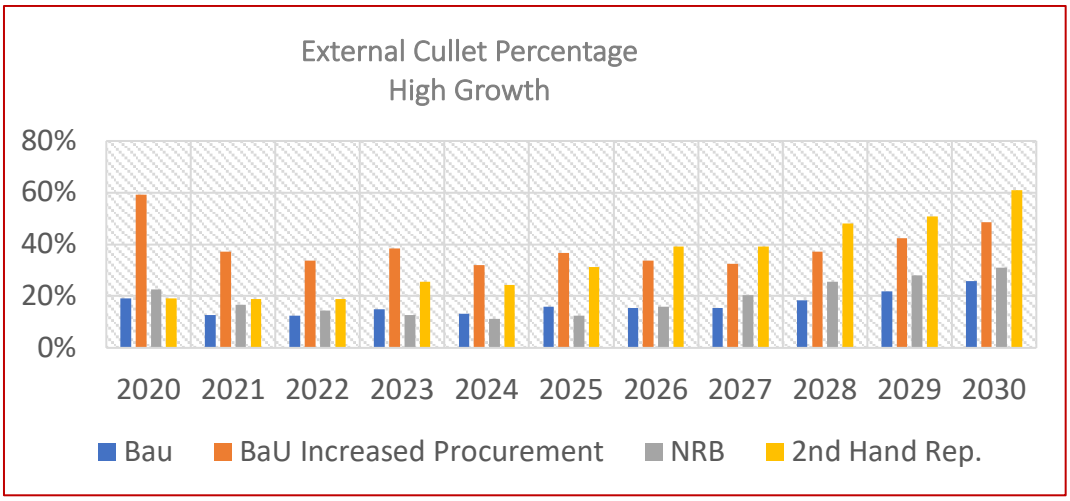


Diagram 14. Percentage of External Cullet Used (High growth environment)

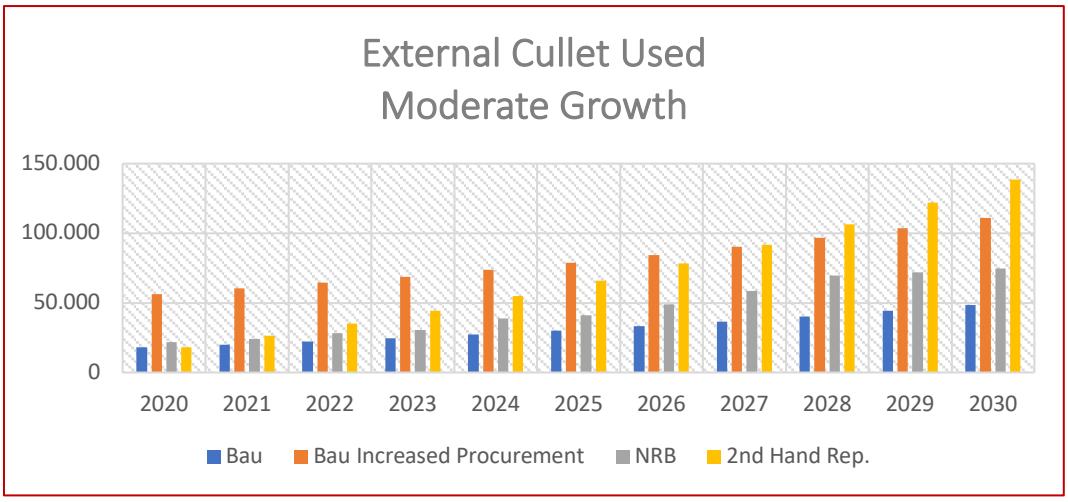


Diagram 15. Quantity of External Cullet Used (Moderate growth environment)

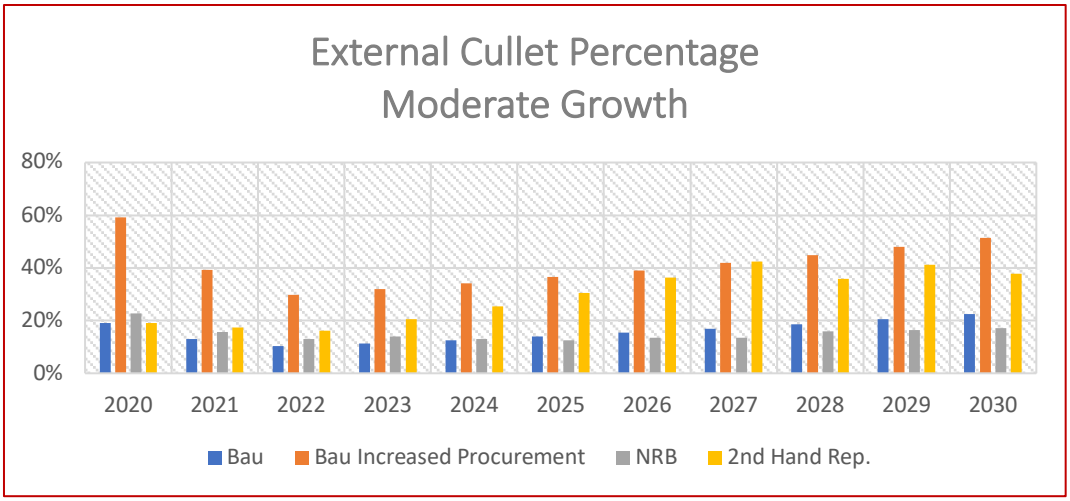


Diagram 16. Percentage of External Cullet Used (Moderate growth environment)

8. Integration and evaluation

Now that the options are combined in a logical way and placed in the scenarios in Chapter 7, it is possible to perform the final evaluation.
This evaluation is done with a focus on how the options may serve the interest of the glass container industry in the best way. This will be done in three steps. The first step is an appraisal of those options that have a general applicability being the PR, CSR and EPR approaches. The second step is a rough one as it assesses the fundamental usability of some of the options with regard to glass recycling. The third step is the detailed evaluation of the remaining options in the Ethiopian context and under different scenarios.

Step 1. General

Chapter 6 assesses the group of options like PR, awareness-campaigns and CSR-actions as "no-regret". They have a general value in any circumstance and can be attributive to almost all of the other options. It can even be regarded at as a "must-have" for Passive Collection as this option needs the full participation of the public.
The introduction of EPR-schemes may also have a more or less general value as it infuses money into the collection/recycling value-chain. In doing so it enhances the viability of the entire chain and increases resulting recycled volumes. One important reservation: In the current situation there is no sense in introducing EPR. Recycling and reuse are already running at their max. A money injection at the moment could at best not harm current recycles.

Step 2. Rough

When looking at the options of Chapter 6 it must be concluded that both types of MRF's are not technically feasible when it comes to glass. They have no potential to show sound operations nor acceptable glass products. Both options may well be feasible or even viable for other waste-types but not for glass. Therefore, these options must be abandoned.

Step 2. Detailed

It's not possible to evaluate the remaining options of Chapter 6 on an individual basis. The reasons for this are:

- Not all of the options are "stand-alone". Most of them only work when combined. So, for example, a glass recycling facility always needs some kind of collection of glass.
- In the current context, most options are neither technically feasible nor economically viable as they don't have the potential to contribute to recycling in a market that is already saturated with recycling and reuse.
- The context of Ethiopia's glass and waste market is extremely dynamic and processes in the three loops are highly connected. Abstracting an option from this context makes any evaluation speculative.

Even though these options may be unattractive at this moment, their potential contribution to recycling will emerge and increase in the near future when Ethiopia's economy will grow and planned investments in the glass industry materialize. Chapter 7 describes the most credible scenarios for Ethiopia's glass container market and the way they will incorporate the options of Chapter 6. It therefore seems most suitable to evaluate the options as they will unfold in these scenarios. This is done in Table 16 below. The table shows for each of the high-growth scenarios (i) the options that will be involved, (ii) the tonnage of cullet that will be recycled to

the industry, (iii) the investments needed for this recycle, (iv) the number of workers involved and the positive GHG effects. As the scenarios are time-series, this is done for two milestones being 2025 and 2030. For calculating GHG effects the benchmark of 0.67 tons of CO2 per ton of recycled cullet, calculated in the international FEVE LCA-study, was used.

		2025				2030			
High growth Scenarios	**Involved combinations of options**	**Cullet use (ton/yr)**	**Investments * ($)**	**Workers (#)**	**GHG effects (ton/yr)**	**Cullet use (ton/yr)**	**Investments* ($)**	**Workers (#)**	**GHG effects (ton/yr)**
Business as Usual	**Incr. cullet procurement**	**110,000**	**Low**	**0**	**70,000**	**210,000**	**Low**	**0**	**140,000**
NRB penetration	**Passive collection glass +PR/Awareness/CSR + Glass recycling facility**	**55,000**	**8,000,000**	**Low**	**35,000**	**135,000**	**13,500,000**	**Low**	**90,000**
Replacement 2nd hand bottles	**Incr. cullet procurement + Intro. standard bottle + Active collection glass + Glass recycling facility**	**90,000**	**3,800,000**	**220**	**60,000**	**255,000**	**4,000,000**	**600**	**170,000**

*: Total investment required for the collection system and recycling facility; costs of awareness excluded.

Table 16. Evaluation of scenarios and options

Table 16, shows that the business as usual option with increased cullet procurement and the option for replacement of 2nd hand bottles with complimentary investments in active collection and recycling facility maximizes the cullet to the glass industry. The former has the advantage of requiring virtually no investment in a cullet return system, whereas the latter requires an investment of $4,000,000 over the next 10 years. However, it should be kept in mind that, the first scenario is only possible, if the glass producers are able to convince the fillers to sell all their waste (broken and rejected un-broken bottles) to the glass producers. The replacement of the 2nd hand bottle scenario has the advantage of creating 600 jobs in Addis Ababa. So, as already stated in section 7 g. of this report, the glass producers are advised start developing a low-cost bottle for the secondhand market simultaneously.

The introduction of non-returnable bottles does not seem to be advisable from the cullet availability point of view. Even though the collection costs are lower with a passive collection system, it requires a much bigger investment in collection systems and a very substantial investment in awareness raising campaigns.

It should also be noted that, in all cases, the glass industry is advised to increase the cullet purchasing price, passing all cost savings that cullet usage brings to the cullet suppliers to develop the cullet supply chain, and in the case of 2nd hand market penetration scenario, actively take part in its development by partnering with relevant actors.

The effects of the scenarios are also illustrated in the three Sankey diagrams 16-18. It shows:

- That scenario 1 reduces the loop of 2nd hand bottles and increases the loop of returned cullet.
- Scenario 2 leaves the loops of returned cullet and of 2nd hand bottles untouched. It strongly raises imports and the amount of glass to landfill. This last one is partly compensated by introducing collection and recycling.

- Scenario 3 increases the cullet returns from the fillers and reduces the importance of the 2nd hand bottles market. It has the lowest glass-in-waste, partly due to some collection and recycling.

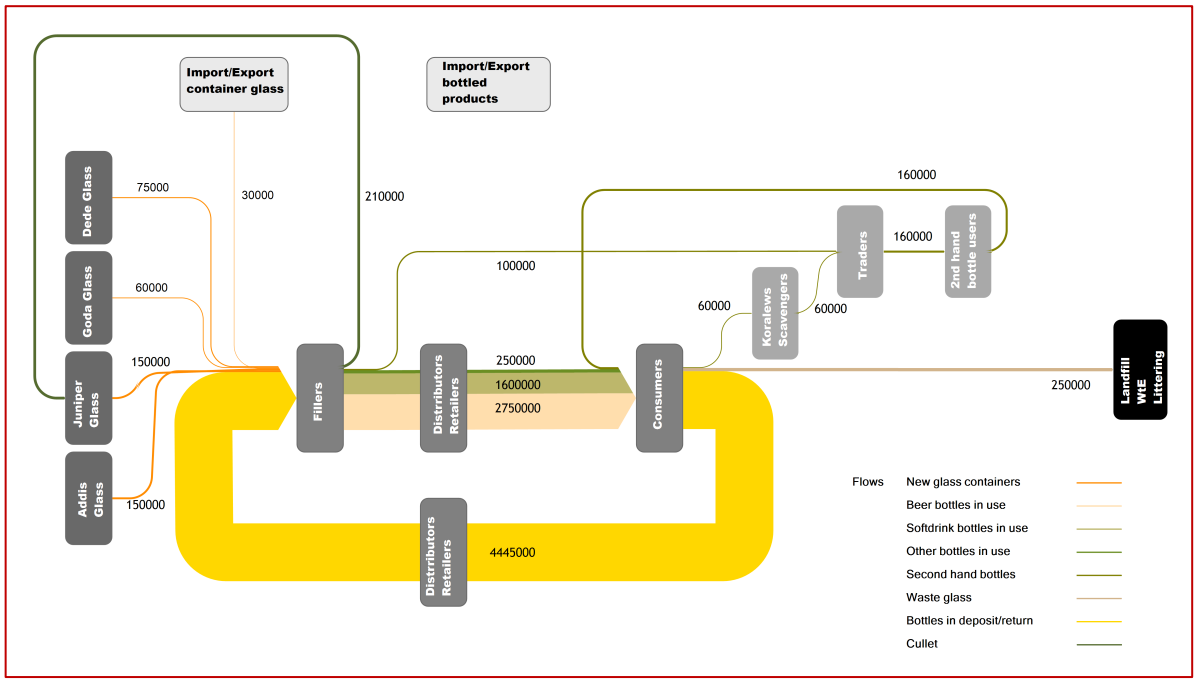


Diagram 16. 2030 effects on glass loops in BaU scenario with high growth and increased cullet procurement

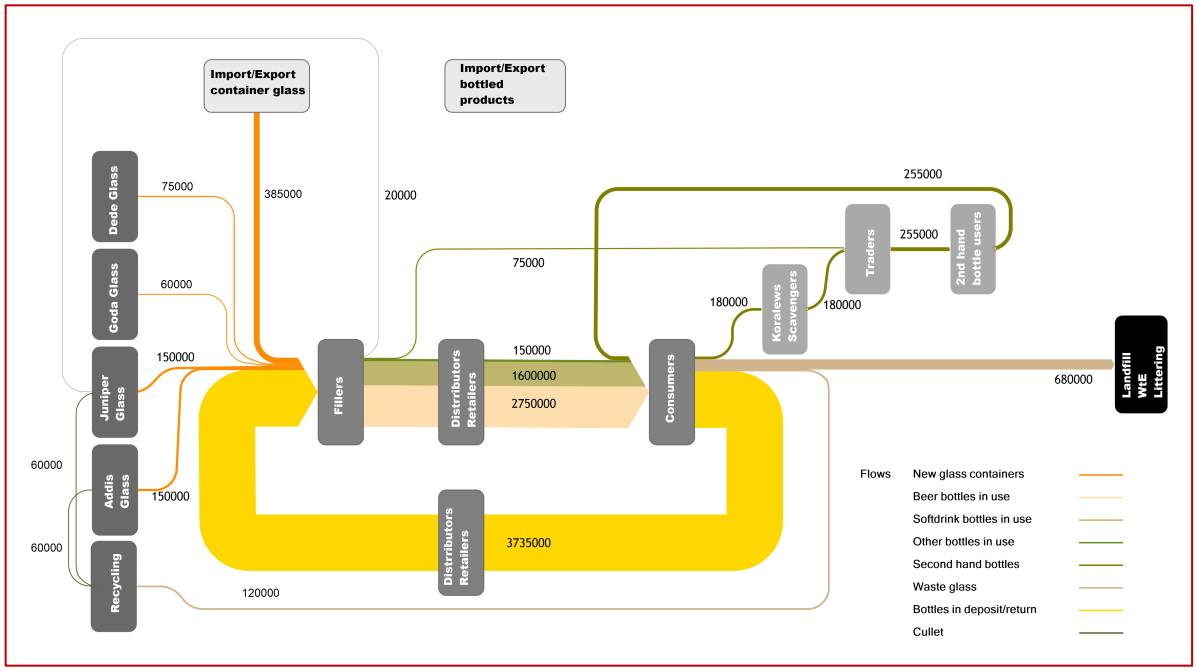


Diagram 17. 2030 effects on glass loops in NRB scenario with high growth and passive collection

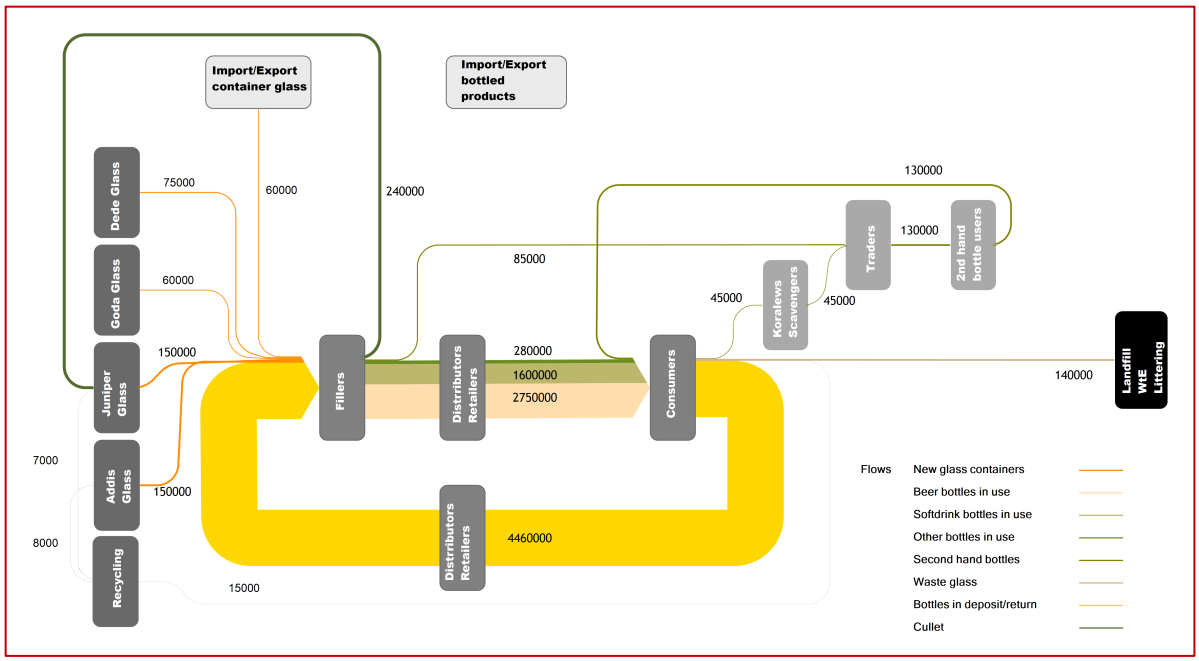


Diagram 18. 2030 effects on glass loops in 2nd hand bottle scenario with high growth and active collection (thin line at bottom)

9. Conclusions

Ethiopia displays and interesting case when it comes to container glass and glass recycling. Shortage of container glass production on the one hand, and international currencies on the other, have forced businesses towards an unprecedented reuse-economy. Only 5% of all used bottles and jars is wasted on a yearly basis. The other 95% is returned into the economy. Most of it through the loop of deposit/return systems for beer, soft-drinks, wine and spirits and a smaller portion through the loop of small-scale users of 2nd hand bottles. And maybe also remarkable; all of this is achieved in the absence of environmental legal frameworks and solid waste management policies.

At present, recycling of broken bottles as cullet in the glass industry has only a minor contribution. Increasing this recycling, being the focus of this research, will be difficult as this growth will only be possible at the expense of direct bottle reuse.

However, this situation is most probably going to change. Beverage consumption is growing at double digit speed, there's a pipeline of upcoming investments in the glass industry and the economic development may well lead to less currency restrictions. When trying to extrapolate these developments we distinguish three scenarios: (i) Business as Usual, (ii) Introduction of Non-returnable bottles and (iii) replacement of the 2nd hand bottle market. All these scenarios more or less pave the way for initiatives of recycling of cullet in the glass industry.

The simplest option for the glass industry is to increase the procurement of rejected bottles in the beverage fillers industry by using the full extent of the value that is in recycling cullet, which is 4,600 Birr per ton. It may well deliver some 210,000 tons of cullet to the glass industry by 2030. This option has an interesting side-effect as it reduces the availability of used bottles for the 2nd hand bottle market and sets the scene for a shift to the use of new bottles at this market niche.

In case the packaging market is moving towards the use of non-returnable bottles the glass industry will be challenged to involve itself more seriously and investments will be needed. There will be a need for introducing separate collection and recycling plants that select and clean the collected glass. Because of the volumes, passive collection of glass through a network of stationary bottle banks (street containers) will be most fitting. Investments will range up to 13.5 million US$ in 2030 and 135,000 tons of cullet can be recycled per year.
In the third scenario, the glass-industry itself could take the initiative by trying to bring the current 2nd hand bottle market to the use of new bottles by introducing a collection of cheap, standardized bottles. The attraction of this scenario may lie in its high return of cullet (255,000 tons per year) and its lower investments (4 million US$). Lower investments are mainly due to the fact that, in this case, active collection can be used, employing a workforce of 400 in Addis Ababa alone, that go to collect the glass at the households.

Our advice to the glass container industry in general, and to Juniper in particular, is in the first place to start negotiations with the beverage industry in order to maximize the return of broken and rejected bottles to their glass furnaces. In the second place we advise to consider the development of standard cheap bottles that should find their way to the market of small fillers. Parallel to this, the industry should consider to initiate separate collection and recycling facilities.

All of the options above can be enhanced by a good program on awareness, PR and CSR. The combined glass- and beverage-industry could consider to take initiatives on EPR, preparing for the future growth of their volumes.

Annex 1 General data and document sources

- Municipal solid waste management services in Africa and Arab countries; Van Niekerk et al.; PSI 2018
    - According to this study waste generation in Ethiopia is between 0.61 and 1 kg/inh-day. In general, African waste holds around 5% of glass.
    - It reports that fees from households and enterprises only covers 50% of actual costs in Ethiopia.
- The World Factbook – CIA – Ethiopia
    - The CIA's estimate of Ethiopia's July 2020 population is 108,113,150 with growth being 2.56%. Urbanization is at 22% and growing at 4.63% per year.
    - AA's 2020 population is estimated at 4.794 mln.
    - GDP/PPP per capita was $2,200 in 2017 and growing at around 10%
- World Markets (www.worldmarkets.com) forecasts for Ethiopia
    - GDP growth was at 9% but will go towards 6.5% in 2021 (no pandemic effects incorporated.
    - Inflation is at 20%. Corporate tax rate at 30% and Income tax rate at 35%
- Use of alternative fuels in the cement sector in Ethiopia: opportunities, challenges and solutions; World Bank IFC report 2017
    - Coal price in Ethiopia $120-160 per ton in 2016
    - Report provides scenario's for cashflows on sourcing RDF through comprehensive MRF operations.
    - It assumes 0.30 kg/inh-day for Ethiopia, leading to 12 mln ton/day. For AA it assumes 1.5 mln tons for 2020 with 60-70% of this being collected. 76% of the waste is from households. This would mean a generation of 0.82 kg/inh-day.
    - The report gives 3% of glass in AA's waste.
    - Waste management is charged at 20% of the water bill for households and 40% for organizations. It covers 30% of all costs.
    - The Repi dumpsite charges $0.6 per ton of waste.
- Overview of Addis Ababa city solid waste management system; Tessema; 2010
    - Provides overview of city organization
    - 0.4 kg/inh-day with glass at 0.5%
    - No role for municipality in recycling
- Solid waste management project – strategic and technical studies and works supervision; Artelia final report 2013;
    - Expects for 2020 around 550,000 tons per year
    - Amount of glass is expected to decrease towards 2.5% in 2020
- IGNIS project; Joint Final Report 2014
    - The research gives 244,000 tons of waste produced per year in 2012
    - 2.1% of this being glass
- World Bank; What a Waste 2.0
    - 70% waste collection coverage in Addis Ababa in 2016
    - 43% of waste collected in Ethiopia
- PPT presentation Addis Ababa City SWM Agency October 2019
    - Current generation 3,200 tons/day
    - 0.45 kg of MSW per inhabitant per day
    - Collection rate is at 85%
    - Glass contents at 2.1%
    - 1,400 tons per day going to the Waste-to-Energy plant

- Worldpopulationreview.com
    - AA population in 2020 at 4.79 mln and growing at 4.37% per year
- Indexmundi.com
    - Urbanization rate 2020 (growth of urban population) 4.6% per year

Annex 2 Internet sources

- https://www.capitalethiopia.com/capital/juniper-glass-factory-opens/ reports in 2019 the opening of Juniper's new glass plant in Debre Birhan with a maximum capacity of 200 million bottles per year. Construction and equipment took some $100 mln. The number of employees is 140. Juniper uses gas and oil in its furnaces. The glass packaging market is expected to grow by 18% between 2015 and 2020. According to the ministry of trade and industry imports of glass will be at 49.6 thousand tons per year by 2021. Local production is losing its market share.
- https://www.glass-international.com/news/addis-glass-plans-to-triple-production-capacity reports in 2019 that Addis Glass is planning to increase its capacity from 80 tons per day in 2019 to 240 tons per day by 2022. Investments of $40 mln are expected. Addis Glass uses electric melting and through this is well positioned for low CO2 glass production
- https://www.ifc.org/wps/wcm/connect/news_ext_content/ifc_external_corporate_site/news+and+events/news/cm-stories/ethiopia-business-competition reports in 2018 that IFC is co-financing Habesha's $131 mln expansion eightfolding its beer production to 4.5 mln hectoliters within 5 years. This IFC source reports that nearby Juniper's capacity will be 300 mln bottles per year. The weak Ethiopian currency is a risk when procuring foreign equipment.
- https://www.thereporterethiopia.com/content/bottle-maker-expands-fully-supply-beverage-industry reports in 2016 a demand for bottles and glasses in Ethiopia of 65,000 tons per year. Addis Glass is supplying at that moment 25,000 tons per year equaling 81 million bottles. The company has set aside 1,5 billion Birr for expansion. This will increase Addis Glass' production to 250 mln bottles per year. The source also reports that BGI is in need of light weight bottles for export. Addis Glass wants to step into that market and is also planning to produces glass bottles for mineral water. Yearly imports of bottles and glasses is valued at $25 mln. The expansion with 170 mln bottles equals an export substituting value of $11 mln. Finally, it reports that Addis Glass is using 40% cullets as raw material (i.e. in 2016 10,000 tons) and has installed 4MW of power, increasing to 11MW when reaching the 250 mln bottles per year.
- http://www.addisglass.org/state.html reports that the Addis Glass site on the road from Addis to Ambo covers an area of 81,000 m2. The old plant produces 35 tons per day and the new plant comprises three lines of 50, 80 and 80 tons per day. In total this is 245 tons of glass per day or 76,012 per year (average 310 production days per year). The expansion took $45 mln. Preparation of raw materials is shifted towards a 24,000 m2 site in Sululta.
- https://mutesi.net/business/the-evolution-of-ethiopias-beer-industry/2019/04/ reports in 2018 that beer consumption has reached $620 mln per year while growing at 16% per year. This equals to 7 mln hectoliters. Numbers of breweries have almost doubled and acquisitions are rather regular. Raya is producing 0.6 mln hectoliters and is aiming at 0.75. BGI as a whole produces 3.6 mln hectoliters and Heineken 4 mln, while the latter is completing expansion towards 5 mln (totaling its investments in Ethiopia to €500 mln). Meanwhile Habesha is claiming 13% marketshare with a capacity of 0.75 hectoliters at its 7.5 hectare site in Debre Berhan, and it aims at doubling towards 1.5 at $43.3 mln investments. This source refers to Canadean, a researcher in the beer economy. In Ethiopia beer represents 90% of revenues for the alcoholic beverage industry. If BGI acquires Raya and Zebidar it will reach 4.6 mln hectoliters. Total production capacity is then 11 mln hectoliters.
- https://www.marketresearch.com/Timetric-v3917/Goda-Adigrat-Bottle-Glass-Manufacturing-11163121/ reports in 2017 that Goda Bottle and Glass Share Company is planning to build a $28 mln glass bottle factory on a 39ha site in Adigrat. The capacity will be 1 mln bottles per year

- http://static1.squarespace.com/static/5559978ee4b0f0ee9b7b9d5e/t/5719c0442eeb8157703b8630/1461305419939/Dashen+Brewery+TDM+Case+Study.pdf reports that Dashen is preparing the construction of its second brewery. The old one is in Gondar and the new one, with an estimated investment of $120 mln is located on a 12ha site in Debre Birhan. The facility will start at 2 mln hectoliters and will have a maximum capacity of 3 mln.
- http://directory.foodstuff-africa.com/business/bc05ca2170/AMBO-MINERAL-WATER-FACTORY reports that Ambo is planning to increase its mineral water production capacity towards 0.5 hectoliters. Packaging alternatives include 500ml returnable glass bottles, 330ml and 750ml NR glass bottles and 500ml and 1250ml PET bottles.
- https://waste-management-world.com/a/turning-trash-into-cash-in-ethiopia reports in 2011 a population in AA of 2.8 mln, reaching 6 mln in 2030. Waste generation is at 0.25 kg/inh-day with 72% of the waste being collected and 5% being recycled.
- https://bulletin.ids.ac.uk/index.php/idsbo/article/view/2859/ONLINE%20ARTICLE This 2017 article provides an overview of the formal and informal actors in AA's decentralized SWM system. In 2016 time almost 4 mln inhabitants were reported, living at 540 km2. Generation is reported at 0.36 kg/inh-day.-manufacturing-industries-in-ethiopia.pdf
- http://ethiopianchamber.com/Data/Sites/1/downloadables/lm-scale-beverage-manufacturing-industries-in-ethiopia.pdf The CoC provides an overview of the large and medium scale beverage industry.
- https://addisfortune.net/articles/legal-wrangling-over-ambo-coca-merger-backtracks/ EABC started construction of its third site in Bahir Dar. Others are in AA and Dire Dawa. These two sites produce 605 mln bottles. EABC is also constructing a plastic bottle plant
- https://addisfortune.net/articles/legal-wrangling-over-ambo-coca-merger-backtracks/ EABC is bottling 250 mln litres of beverage in 2017
- https://www.ethiosports.com/2013/09/09/coca-cola-unveils-pet-bottles-in-ethiopia/ EABC states that glass bottles will continue to be 75% beyond 2020

Annex 3 Academic sources

- Solid waste generation rate and management practices in the case of Chiro Town, West Hararghe Zone, Ethiopia; Umer et al; Am. J. of Env. Prot. 2019
    - It reports generation of waste at 0.304 kg/inh-day with glass contents at 12.1%. It refers to AA's waste generation to be 0.5 kg/inh-day
- Composition, generation and management method of municipal solid waste in Addis Ababa City, Central Ethiopia; a review; Tassie et al; Asian J. of Env. And Ec. 2019
    - It reports a population of 3.5 mln (in 2007?) projected to rise towards 12 mln in 2025. 4% growth rate is mentioned.
    - No. of enterprises in collection is 750 with 5815 operators.
    - Households pay 30 birr per m3. Payments are done through the water bill.
    - Generation is at 0.45 kg/inh-day. Total waste is increasing at 5% per year. 70% is from households, 10% from street cleaning, 12% by commercial entities and 6% by industries. Glass is reported to be only 0.5% of the waste.
    - 70% is collected and 40% of streets are cleaned.
- Generation rate and physical composition of solid waste in Wolaita Sodo Town, Southern Ethiopia; Goa et al; Ethiopian J. of Env. St. and Man. 2017
    - The towns show generation of waste at 0.47 kg/inh-day with only 0.2% glass.
- Solid waste management in Adama, Ethiopia; aspects and challenges; Hailemariam et al; Int. J. of Env. And Ec. Eng. 2014
    - It reports that household waste contains 1% glass and waste from organizations 16%.
- Domestic waste management and its environmental impacts in Addis Ababa City; Mohammed et al; Afr. J. of Env. And Waste Man. 2017
    - This research reports 0.45 kg/inh-day with a 65% collection coverage.
    - 76% of the waste is from households, 6% from street sweeping, 12% from the commercial sector and hospitals and 5% from the industry (2012 figures)
    - Glass contents is reported at 0.5% (based on AASBPDA 2003)
    - The only segregated collection in AA is through the informal collectors.
- Assessment of solid waste management practices in Bedele town, Oromia, Ethiopia;Abuye et al; Eth. J. of Env. St. and Man. 2019
    - 0.342 kg/household.day is reported but probably this figure is not related to generated but to collected waste. Tins, cans and glass together provide for 7% of its contents
- Waste management in the case of Bahir Dar City near Lake Tana shore in Northwestern Ethiopia: a review; Fenta; Afr. J. of Env. Sc. And T. 2017
    - Reports 0.45 kg/inh-day of which 0.25 is from households.
    - Glass contents is reported as 0.6%.
- The role of micro enterprises In urban solid waste management in selected areas of Addis Ababa, Ethiopia; Megersa; Thesis at Adama Science and Technology University 2017
    - Provides a good description of the work of these enterprises. They generate a monthly income of 2000-2500 ETB
- Challenges and opportunities in municipal solid waste management: the case of Addis Ababa City, Central Ethiopia; Regassa et al; J. Hum. Ecol. 2011
    - Provides an overview of SWM systems in AA.
- Sustainable solid waste collection in Addis Ababa: the users' perspective; Tilaye et al; Int. J. of Waste Resources 2014

    - Overview on social aspects of AA's SWM services
- Environmental policy review: key issues in Ethiopia 2011; Cheever et al; Colby College Environmental Policy Group
    - Provides an overview of related laws and policies
- Practice of waste payment collection from public and the improvement of its challenges; Abebe; J. of Waste Recycling 2018
    - Private associations are paid 80 ETB per m3. Cost coverage is only 25%
    - Provides overview of today's AA SWM finances and suggestions for improvement.
- Composition, generation and management method of municipal solid waste in Addis Ababa City, Central Ethiopia: A review; Kassahun T. et al; Asian J. of Env. And Ec.
    - 70% collection coverage and 15% waste separation.
    - There are 750 MSEs with 5815 workers who also sort out recyclables that they sell.
    - There are an uncounted number of street foragers
- Practices of informal resource recovery from a solid waste stream; case study: Addis Ababa, Ethiopia; Tarekegn M. M. et al; Int. J. of Sc. and Eng. Res. 2016
    - 4864 Koralews in Addis Ababa collect an average of 150 tons/day of which 16% is glass
    - 955 Scavengers collect an average of 22 tons/day but this is only metal and plastics

Annex 4 Stakeholder list

Name of entity	Type
Juniper Glass	Glass bottle producer
Addis Glass	Glass bottle producer
Goda Glass & Bottling	Future glass bottle producer
De De Glass	Future glass bottle producer
Hansom Glass	Flat glass producer
Daylight	Glass products and crown corks producer
Heineken	Breweries
BGI Ethiopia	Breweries and winery
Habesha	Breweries
Dashen Brewery	Breweries
Diageo Meta Abo Brewery	Breweries
East Africa Bottling	Coke soft drinks filler
Moha	Pepsi soft drinks filler
Awash Wine Factory	Wine producer/filler
Balezaf Ethiopia Liquor Factory	Liquor producer/filler
Desta liquor Factory	Liquor producer/filler
The Day Jam	Jam producer/filler
Laviva Fresh	Sauces/Condiments producer/filler
Ambo Mineral Water Factory	Water producer/filler
Babile Mineral Water Factory	Water producer/filler
Food and Beverage Institute	Sector institute
Ethiopian Packaging Association	Sector Association
Reppie WASTE-TO-ENERGY PLANT	Waste to energy
GIZ/IZES	NGO/development partner
Habesha Cement	Non-glass recovery
National Cement	Non-glass recovery
Coba Impact Manufacturing	Non-glass recovery
Penda Manufacturing PLC	Non-glass recovery
Rose PLC	Collector recycler
Roha Pack / Oryx PLC	Non-glass recovery
University of Addis Ababa	Academia
ENDA Ethiopia	NGO/development partner
GG consulting	IGNIS contributor
Ministry of Revenues	Government
Ministry of Industry	Government
Commission of Environment, Forest and Climate Change	Regulator
Addis Ababa city Environmental Protection and Green Development Commission	Regulator
Addis Ababa Solid Waste Recycling and Disposal Project Office	Regulator/Operator
Addis Ababa Solid Waste Management Agency	Regulator/Operator

	Response received
	No response received

Annex 5 Parameters for waste flows in Ethiopia

For the calculation of waste and glass-in-waste flows in Ethiopia, the following parameters were used.

Item	Ethiopia	Addis Ababa
Population 2020	110 mln	4.79 mln
Population growth	2.56%	4.37%
Urbanization in 2020	21.7%	n.a.
Urbanization rate	4.6%	n.a.
Urban waste generation rate (kg/inh-day)	0.5	0.65
Rural waste generation rate (kg/inh-day)	0.25	n.a.
Total waste generation (kg/inh-day)	0.33	0.65
Total waste generation (tons/day))	33,500	3,100
Urban waste collection coverage (% of population)	70%	75%
Rural waste collection rate (% of population)	40%	n.a.
Total waste collection rate (% of population)	50%	75%
Glass contents in waste	2.0%	2.0%
Total glass in waste generation (tons/day)	670	60
Economic growth (own assumption)	5%	10%
Elasticity coefficient (waste growth per % of economic growth)	10%	10%
Number of Koralews, Foragers, Scavengers	15000	7000
Collected by Koralews, Foragers, Scavengers (tons/day)	400	200
Collected glass by Koralews, Foragers, Scavengers (tons/day)	70	35

Annex 6 Maximum cullet price

Cullet savings for situation Juniper Glass situation	
Fuel Savings	
Average Fuel Consumption (lt of LFO/ton melted)	132
Average LFO Price (Birr/lt)	16,77
Average Fuel Cost (Birr/ton melted)	2213
Average Cullet % (Internal+External)	30
Fuel Cost with no Cullet (Birr/ton melted)	2.393
Fuel Saving to be Achieved by 10% Cullet (Birr/ton melted)	59,83
Daily Pull (tons/day)	220
Fuel Saving to be Achieved by 10% Cullet (Birr/day)	13.162
Cullet Needed to Achieve that Saving (ton)	22
Price that Can be Paid for Cullet (Birr/ton cullet)	**598**
Batch Material Savings	
Batch Cost (Birr/ton melted)	4044
Price that Can be Paid for Cullet to Replace that Batch (Birr/ton cullet)	**4044**
Maximum Price That Can be Paid for Cullet (Birr/ton)	**4.642**
Price Currently Paid for Cullet (Birr/ton)	**1163 - 2979 depending on transport distance**

Annex 7 Calculations of cullet availability

Cullet Available from Soft Drink and Water Fillers					Source of the Figure
	Moha	**EABC**	**Ambo**	**Others**	
Capacity (HL)	3,800,000	2,500,000	500,000	500,000	Secondary Sources
Capacity Utilization	75%	75%	75%	75%	Assumed
Volume Packed in Glass (HL)	2,850,000	1,875,000	375,000	375,000	
Volume Packed in Glass (HL)	5,475,000				
Volume/Container (liters)	0.30	0.30	0.30	0.30	Replies to Questionnaire + Assumed
No of Fillings/year	950,000,000	625,000,000	125,000,000	125,000,000	
Weight/Bottle (grams)	380	380	380	380	
Weight of bottles filled/year (tons)	361,000	237,500	47,500	47,500	
Average Total Number of Trips of Each Bottle	10	10	10	10	Replies to Questionnaire + Assumed
Average No of Trips/Year	12	12	12	12	Assumed
Time for the Bottle to Reach End of its Life (Months)	10	10	10	10	
Total Number of Bottles Becoming Waste/Year	95,000,000	62,500,000	12,500,000	12,500,000	
Weight becoming Waste/Year (Tons)	36,100	23,750	4,750	4,750	
Total Weight Becoming Waste Each Year (tons)	69,350				
% Recovered through the Deposit System	84%				Replies to Questionnaire + Assumed
Waste Going to Landfills (Tons/Year)	**11,096**				
Total Waste from Filler/Year (Tons)	**58,254**				

Cullet Available from Breweries						Source of the Figure
	BGI	**Heineken**	**Habesha**	**Dashen**	**Diageo Meta Abo**	
Capacity (HL)	4,500,000	4,050,000	500,000	2,000,000	1,700,000	Secondary Sources
Capacity Utilization	75%	75%	75%	75%	75%	Assumed
Share of Glass Pacakaging	80%	80%	80%	80%	80%	
Volume Packed in Glass (HL)	2,700,000	2,430,000	300,000	1,200,000	1,020,000	
Volume Packed in Glass (HL)	7,650,000					
Volume/Container (liters)	0.33			0.50		Answers to Follow up Questions to Juniper + Assumed
% in Total Containers	90%			10%		Answers to Follow up Questions to Juniper + Assumed
Total No of Fillings/year	2,204,610,951					
No of Fillings/Container Type	1,984,149,856			220,461,095		
Weight/Bottle (grams)	300			350		Answers to Follow up Questions to Juniper + Assumed
Weight of bottles filled/year (tons)	595,245			77,161		
Average Total Number of Trips of Each Bottle	15			15		Answers to Follow up Questions to Juniper + Assumed
Average No of Trips/Year	8			8		Assumed
Time for the Bottle to Reach End of its Life (Months)	22.5			22.5		
Total Number of Bottles Becoming Waste/Year	132,276,657			14,697,406		
Weight becoming Waste/Year (Tons)	39,683			5,144		
Total Weight Becoming Waste Each Year (tons)	44,827					
% Recovered through the Deposit System	90%					Answers to Follow up Questions to Juniper + Assumed
Waste Going to Landfills (Tons/Year)	**4,483**					
Total Waste from Filler/Year (Tons)	**40,344**					

Cullet Available from Wineries					Source of the Figure
	Awash		Castel-BGI	Imports	
Total Size of the Market (HL)	135,000				Replies from Awash
Market Share	83%		10%	7%	Replies from Awash
Volume Packed in Glass (HL)	112,050		13,500	9,450	
Volume/Container (liters)	0.75	0.33	0.75	0.75	Replies from Awash + Assumed
% in Total Containers	80%	20%	100%	100%	Replies from Awash
Total No of Fillings/year	16,824,324		1,800,000	1,260,000	
No of Fillings/Container Type	13,459,459	3,364,865	1,800,000	1,260,000	
Weight/Bottle (grams)	535	325	535	450	
Weight of bottles filled/year (tons)	7,201	1,094	963	567	
Average Total Number of Trips of Each Bottle	10	10	1	1	Replies from Awash
Average No of Trips/Year	7	7	1	1	Replies from Awash
Time for the Bottle to Reach End of its Life (Months)	17.14	17.14			
Total Number of Bottles Becoming Waste/Year	1,345,946	336,486	1,800,000	1,260,000	
Weight becoming Waste/Year (Tons)	720	109	963	567	
Total Weight Becoming Waste Each Year (tons)	829		963	567	
% Recovered through the Deposit System	75%		0%	0%	Assumed
Waste Going to Landfills (Tons/Year)	**207**		**963**	**567**	
Total Waste from Filler/Year (Tons)	**622**		**0**	**0**	

Cullet Available from Liquor Producers						Source of the Figure
	Balezaf		**Desta**			
Capacity (HL)	700,000		250,000			Replies from Balezaf and Desta
Capacity Utilization	75%		75%			Assumed
Volume Packed in Glass (HL)	525,000		187,500			
Volume/Container (liters)	0.89	0.20	0.89	0.50	0.20	Replies from Balezaf and Desta
% in Total Containers	80%	20%	70%	10%	20%	Assumed
Total No of Fillings/year	69,813,830		26,297,335			
No of Fillings/Container Type	55,851,064	13,962,766	18,408,135	2,629,734	5,259,467	
Weight/Bottle (grams)	650	250	650	350	250	Assumed
Weight of bottles filled/year (tons)	36,303	3,491	11,965	920	1,315	
Average Total Number of Trips of Each Bottle	6	6	6	6	6	Replies from Balezaf and assumed
Average No of Trips/Year	3	3	3	3	3	Assumed
Time for the Bottle to Reach End of its Life (Months)	24.00	24.00	24.00	24.00	24.00	
Total Number of Bottles Becoming Waste/Year	9,308,511	2,327,128	3,068,022	438,289	876,578	
Weight becoming Waste/Year (Tons)	6,051	582	1,994	153	219	
Total Weight Becoming Waste Each Year (tons)	8,999					
% Recovered through the Deposit System	65%					Replies from Balezaf and assumed
Waste Going to Landfills (Tons/Year)	**3,150**					
Total Waste from Filler/Year (Tons)	**5,849**					

Cullet Available from Day Jam		Source of the Figure
Products	Jam	
Share in Total Volume	100%	Replies to Questionnaire
Volume Packed in Glass (liters)	351,000	
Volume/Container (liters)	0.39	Replies to Questionnaire
No of Fillings/year	900,000	Assuming 2 shifts per day, 6 days per week, 50 weeks per year operation
Weight of bottles used per year	239	
Weight/Bottle (grams)	265	Replies to Questionnaire
Weight becoming Waste/Year (Tons)	239	
% Recovered through the Deposit System	0%	Non-returnable containers
Waste Going to Landfills (Tons/Year)	**239**	
Total Waste from Filler/Year (Tons)	Very minimal	Replies to Questionnaire

Annex 8 Business case Clean-MRF

An excel cashflow-model was elaborated based on the layout presented below. The model allows for introducing multiple capacities, changes in waste- and product composition, prices, costs of labor and utilities, cost of land, investments and changing financing conditions.

- Definition of main variables

Variables		totals or inputs	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
	year #		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
received tonnage of recyclables	tons/yr	225.000	0	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000
tonnage of plastics produced	tons/yr	33.750	0	2.250	2.250	2.250	2.250	2.250	2.250	2.250	2.250	2.250	2.250	2.250	2.250	2.250	2.250	2.250
tonnage of paper produced	tons/yr	56.250	0	3.750	3.750	3.750	3.750	3.750	3.750	3.750	3.750	3.750	3.750	3.750	3.750	3.750	3.750	3.750
tonnage of metals produced	tons/yr	11.250	0	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750
tonnage of glass produced	tons/yr	22.500	0	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500
tonnage of residue produced	tons/yr	101.250	0	6.750	6.750	6.750	6.750	6.750	6.750	6.750	6.750	6.750	6.750	6.750	6.750	6.750	6.750	6.750
workers	#		40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
staff	#		2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
eletricity consumption	kWh/yr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
water consumption	m^3/yr	9.000	0	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600
fuel consumption	liter/yr	1.800.000	0	120.000	120.000	120.000	120.000	120.000	120.000	120.000	120.000	120.000	120.000	120.000	120.000	120.000	120.000	120.000
needed workspace	m^2		5.500	5.500	5.500	5.500	5.500	5.500	5.500	5.500	5.500	5.500	5.500	5.500	5.500	5.500	5.500	5.500

- Calculation of revenues

Revenues and direct costs		totals or inputs	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
	year #		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
gatefee revenues/costs	$/yr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
plastics revenues	$/yr		0	180.000	180.000	180.000	180.000	180.000	180.000	180.000	180.000	180.000	180.000	180.000	180.000	180.000	180.000	180.000
paper revenues	$/yr		0	187.500	187.500	187.500	187.500	187.500	187.500	187.500	187.500	187.500	187.500	187.500	187.500	187.500	187.500	187.500
metals revenues	$/yr		0	52.500	52.500	52.500	52.500	52.500	52.500	52.500	52.500	52.500	52.500	52.500	52.500	52.500	52.500	52.500
glass revenues	$/yr	450.000	0	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000
costs of residues	$/yr	-1.012.500	0	-67.500	-67.500	-67.500	-67.500	-67.500	-67.500	-67.500	-67.500	-67.500	-67.500	-67.500	-67.500	-67.500	-67.500	-67.500
Gross margin	$/yr	**-562.500**	**0**	**382.500**	**382.500**	**382.500**	**382.500**	**382.500**	**382.500**	**382.500**	**382.500**	**382.500**	**382.500**	**382.500**	**382.500**	**382.500**	**382.500**	**382.500**

- Calculation of Capex

Capex		totals or inputs	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
	year #		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Terrains	€	-275.000	-275.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Investments	€	-2.856.068	-2.196.975	0	0	0	-219.698	0	0	0	0	-219.698	0	0	0	0	-219.698	0
Total Capex	€	**-3.131.068**	**-2.471.975**	**0**	**0**	**0**	**-219.698**	**0**	**0**	**0**	**0**	**-219.698**	**0**	**0**	**0**	**0**	**-219.698**	**0**

- Calculation of Opex

Opex		totals or inputs	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
	year #		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
electricity costs	$/yr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
water costs	$/yr	900	0	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
fuel costs	$/yr	954.000	0	63.600	63.600	63.600	63.600	63.600	63.600	63.600	63.600	63.600	63.600	63.600	63.600	63.600	63.600	63.600
workers wages	$/yr	960.000	60.000	60.000	60.000	60.000	60.000	60.000	60.000	60.000	60.000	60.000	60.000	60.000	60.000	60.000	60.000	60.000
managers wages	$/yr	115.200	7.200	7.200	7.200	7.200	7.200	7.200	7.200	7.200	7.200	7.200	7.200	7.200	7.200	7.200	7.200	7.200
miscellaneous (10%)	$/yr	203.010	6.720	13.086	13.086	13.086	13.086	13.086	13.086	13.086	13.086	13.086	13.086	13.086	13.086	13.086	13.086	13.086
Total Opex	$/yr	**2.233.110**	**73.920**	**143.946**	**143.946**	**143.946**	**143.946**	**143.946**	**143.946**	**143.946**	**143.946**	**143.946**	**143.946**	**143.946**	**143.946**	**143.946**	**143.946**	**143.946**

- Resulting cashflows and financial performance

		totals or inputs	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
	year #		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Gross margin	$	**5.737.500**	**0**	**382.500**	**382.500**	**382.500**	**382.500**	**382.500**	**382.500**	**382.500**	**382.500**	**382.500**	**382.500**	**382.500**	**382.500**	**382.500**	**382.500**	**382.500**
Total Capex	$	-3.131.068	-2.471.975	0	0	0	-219.698	0	0	0	0	-219.698	0	0	0	0	-219.698	0
Total Opex	$	**2.233.110**	**73.920**	**143.946**	**143.946**	**143.946**	**143.946**	**143.946**	**143.946**	**143.946**	**143.946**	**143.946**	**143.946**	**143.946**	**143.946**	**143.946**	**143.946**	**143.946**
Correction accounts	$	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Operating/investments cashflow	$	4.839.543	-2.398.055	526.446	526.446	526.446	306.749	526.446	526.446	526.446	526.446	306.749	526.446	526.446	526.446	526.446	306.749	526.446
Operating/investments cashflow cumul.	$		-2.398.055	-1.871.609	-1.345.163	-818.717	-511.969	14.478	540.924	1.067.370	1.593.816	1.900.564	2.427.010	2.953.456	3.479.902	4.006.348	4.313.097	4.839.543
Needed working capital	$	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Equity for investments and working capital	$	-939.320	-741.593	0	0	0	-65.909	0	0	0	0	-65.909	0	0	0	0	-65.909	0
Debt for investments and working capital	$	-2.191.747	-1.730.383	0	0	0	-153.788	0	0	0	0	-153.788	0	0	0	0	-153.788	0
Debt interest plus principal payment ann.	$	-3.470.049	-216.878	-216.878	-216.878	-216.878	-216.878	-216.878	-216.878	-216.878	-216.878	-216.878	-216.878	-216.878	-216.878	-216.878	-216.878	-216.878
Net cashflow for equity	$	8.309.592	**-2.181.177**	**743.324**	**743.324**	**743.324**	**523.627**	**743.324**	**743.324**	**743.324**	**743.324**	**523.627**	**743.324**	**743.324**	**743.324**	**743.324**	**523.627**	**743.324**
			0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Pay out time		**2025**	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Project IRR		**18,9%**																
Project NPV	$	**1.274.353**																
Equity IRR		**32,2%**																
Equity NPV	$	**940.479**																

Annex 9 Business case Glass recycling facility

An excel cashflow-model was elaborated based on the layout presented below. The model allows for introducing multiple capacities, changes in waste- and product composition, prices, costs of labor and utilities, cost of land, investments and changing financing conditions.

- Definition of main variables

Variables		totals or inputs	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
	year #		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
received tonnage of glass	tons/yr	225.000	0	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000
tonnage of flint cullet produced	tons/yr	22.500	0	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500
tonnage of coloured cullet produced	tons/yr	168.750	0	11.250	11.250	11.250	11.250	11.250	11.250	11.250	11.250	11.250	11.250	11.250	11.250	11.250	11.250	11.250
tonnage of residue produced	tons/yr	33.750	0	2.250	2.250	2.250	2.250	2.250	2.250	2.250	2.250	2.250	2.250	2.250	2.250	2.250	2.250	2.250
workers	#		10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
staff	#		2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
eletricity consumption	kWh/yr	5.625.000	0	375.000	375.000	375.000	375.000	375.000	375.000	375.000	375.000	375.000	375.000	375.000	375.000	375.000	375.000	375.000
water consumption	m^3/yr	9.000	0	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600
fuel consumption	liter/yr	450.000	0	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000
needed workspace	m^2		4.750	4.750	4.750	4.750	4.750	4.750	4.750	4.750	4.750	4.750	4.750	4.750	4.750	4.750	4.750	4.750

- Calculation of revenues

Revenues and direct costs		totals or inputs	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
	year #		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
gatefee revenues	$/yr	-4.500.000	0	-300.000	-300.000	-300.000	-300.000	-300.000	-300.000	-300.000	-300.000	-300.000	-300.000	-300.000	-300.000	-300.000	-300.000	-300.000
flint cullet revenues	$/yr	2.587.500	0	172.500	172.500	172.500	172.500	172.500	172.500	172.500	172.500	172.500	172.500	172.500	172.500	172.500	172.500	172.500
coloured cullet revenues	$/yr	16.875.000	0	1.125.000	1.125.000	1.125.000	1.125.000	1.125.000	1.125.000	1.125.000	1.125.000	1.125.000	1.125.000	1.125.000	1.125.000	1.125.000	1.125.000	1.125.000
costs of residues	$/yr	-337.500	0	-22.500	-22.500	-22.500	-22.500	-22.500	-22.500	-22.500	-22.500	-22.500	-22.500	-22.500	-22.500	-22.500	-22.500	-22.500
Gross margin	$/yr	14.625.000	0	975.000	975.000	975.000	975.000	975.000	975.000	975.000	975.000	975.000	975.000	975.000	975.000	975.000	975.000	975.000

- Calculation of Capex

Capex		totals or inputs	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
	year #		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Terrains	€	-475.000	-475.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Investments	€	-4.656.080	-3.581.600	0	0	0	-358.160	0	0	0	0	-358.160	0	0	0	0	-358.160	0
Total Capex	€	-5.131.080	-4.056.600	0	0	0	-358.160	0	0	0	0	-358.160	0	0	0	0	-358.160	0

- Calculation of Opex

Opex		totals or inputs	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
	year #		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
electricity costs	$/yr	168.750	0	11.250	11.250	11.250	11.250	11.250	11.250	11.250	11.250	11.250	11.250	11.250	11.250	11.250	11.250	11.250
water costs	$/yr	900	0	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
fuel costs	$/yr	238.500	0	15.900	15.900	15.900	15.900	15.900	15.900	15.900	15.900	15.900	15.900	15.900	15.900	15.900	15.900	15.900
workers wages	$/yr	240.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000
managers wages	$/yr	115.200	7.200	7.200	7.200	7.200	7.200	7.200	7.200	7.200	7.200	7.200	7.200	7.200	7.200	7.200	7.200	7.200
miscellaneous (10%)	$/yr	76.335	2.220	4.941	4.941	4.941	4.941	4.941	4.941	4.941	4.941	4.941	4.941	4.941	4.941	4.941	4.941	4.941
Total Opex	$/yr	839.685	24.420	54.351	54.351	54.351	54.351	54.351	54.351	54.351	54.351	54.351	54.351	54.351	54.351	54.351	54.351	54.351

- Resulting cashflows and financial performance

		totals or inputs	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
	year #		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Gross margin	$	14.625.000	0	975.000	975.000	975.000	975.000	975.000	975.000	975.000	975.000	975.000	975.000	975.000	975.000	975.000	975.000	975.000
Total Capex	$	-5.131.080	-4.056.600	0	0	0	-358.160	0	0	0	0	-358.160	0	0	0	0	-358.160	0
Total Opex	$	839.685	24.420	54.351	54.351	54.351	54.351	54.351	54.351	54.351	54.351	54.351	54.351	54.351	54.351	54.351	54.351	54.351
Correction accounts	$	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Operating/investments cashflow	$	10.333.605	-4.032.180	1.029.351	1.029.351	1.029.351	671.191	1.029.351	1.029.351	1.029.351	1.029.351	671.191	1.029.351	1.029.351	1.029.351	1.029.351	671.191	1.029.351
Operating/investments cashflow cumul.	$		-4.032.180	-3.002.829	-1.973.478	-944.127	-272.936	756.415	1.785.766	2.815.117	3.844.468	4.515.659	5.545.010	6.574.361	7.603.712	8.633.063	9.304.254	10.333.605
Needed working capital	$	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Equity for investments and working capital	$	-1.539.324	-1.216.980	0	0	0	-107.448	0	0	0	0	-107.448	0	0	0	0	-107.448	0
Debt for investments and working capital	$	-3.591.756	-2.839.620	0	0	0	-250.712	0	0	0	0	-250.712	0	0	0	0	-250.712	0
Debt interest plus principal payment ann.	$	-5.686.591	-355.412	-355.412	-355.412	-355.412	-355.412	-355.412	-355.412	-355.412	-355.412	-355.412	-355.412	-355.412	-355.412	-355.412	-355.412	-355.412
Net cashflow for equity	$	16.020.196	-3.676.768	1.384.763	1.384.763	1.384.763	1.026.603	1.384.763	1.384.763	1.384.763	1.384.763	1.026.603	1.384.763	1.384.763	1.384.763	1.384.763	1.026.603	1.384.763
			0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Pay out time		2025	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Project IRR		23,1%																
Project NPV	$	3.183.039																
Equity IRR		36,0%																
Equity NPV	$	2.106.350																