6 Costs and impact Plastic Credits

In this chapter, approximate costs for one PC per ton in Lusaka are calculated. Furthermore, possible effects in the economic, social and economic area are described.

6.1 Plastic Credit Price

The transferable unit PC is intended to cover costs incurred within the scope of the collection and proper disposal of plastic waste. This includes the administrative and organizational costs of the PC provider, as well as the guarantee of basic environmental and social standards (cf. ValuCred 2022: 29–30). In order to achieve the full benefits, the costs for the expansion of the current waste infrastructure (e. g., sorting stations) must also be included in the calculation. In addition, benefits or margins must be taken into account for all actors involved. The waste flow in Lusaka has various branches, but for the determination of the PC price per ton, the focus is placed on the following flow. The waste flow depicted here shows a component of the existing waste flow in Lusaka (see chapter 4). Due to the likelihood of implementation and the fastest possible improvement of the situation using the current infrastructure, the following process is considered in detail and serves as basis for a cost-calculation (see Fig. 20:).

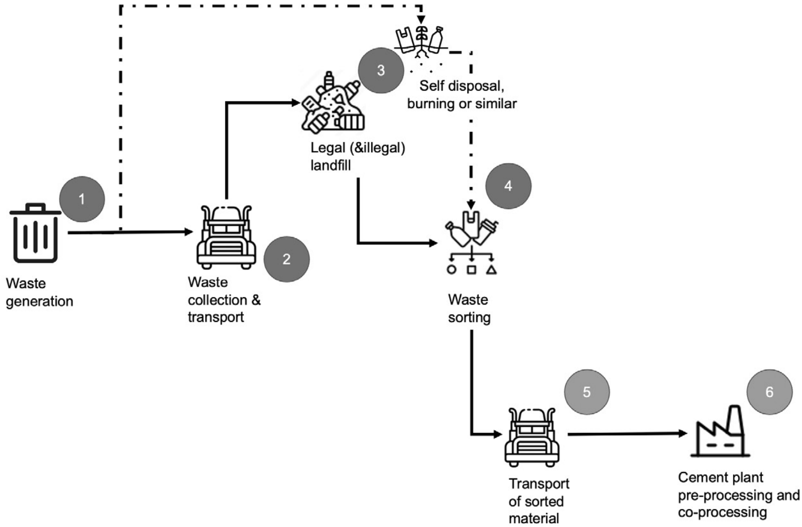

Fig. 20: Excerpt waste flow (own illustration; icon source iconfinder and flaticon; credits to Eucalyp Studio, Freepik, Gregor Cresnar; Chanut-is-Industries)

The basis of the calculation is the amount of expected plastic waste, generated in each household in Lusaka **(1)**. This waste is collected door-to-door by waste collectors. From there the waste is driven directly to the legal landfill named Chunga landfill. **(2)**. The waste is dumped in its entire quantity unsorted on this disposal site **(3)**. Waste Pickers then sort this waste and sell it to collections points, the aggregators **(4)**. From the aggregators, the waste is then transported according to its destination **(5)**. The waste is then transported to the cement plant, which uses the waste as additional material for the cement production process (named as pre- and co-processing) **(6)**. For the calculation, additional administrative costs are also considered. The margins, e. g., for the waste collectors, are not yet included.

The figures used in the following are based on data from the literature research as well as the field study. All prices are in Zambian Kwacha (ZMW) which is the country specific currency. The Euro (EUR) values are based on a currency conversion factor of 0,049 (Status 27.01.23). In some cases, there is only an insufficient data basis, so grounded estimates were used. The source of the figures used is always noted.

6.1.1 Waste generation (1)

The baseline amount of waste is based on Lusaka's population and estimated per capita consumption (see Tab. 17:). There are two calculations below that differ only in the amount of capita. This is based on data relating to an overall development in Zambia (cf. Nyirenda 2019:71; LCC 2022: 2–8). The deviations that may arise in reality must be taken into account in the course of the calculation through any surcharges.

Tab. 17: Estimated amount of waste / plastic waste (based on Kuwema 2022; Chisala n. d.; Nyirenda 2019:71; LCC, personal interview, LCC, Chunga Landfill, Lusaka, 17.10.22, see Annexure 7)

Waste Generation (1)		
Residents (millions)	3,5	3,5
Estimated capita generation (person per day in kg)	0,50 kg/day	0,75 kg/day
Total quantity (day in t)	1.750t	2.625t
Total quantity (year in t)	638.750t	958.125t
40 % of this waste is estimated as plastic waste (year in t)	255.500t	383.250t

6.1.2 Costs waste collection (2)

During the field study, it was observed that the waste ends up in illegal dumps, burned or is collected during door-to-door collections. This is done by waste collectors who drive the waste directly to the legal dumpsite. The waste collection costs, are made up of various cost items (cf. ValuCred 2022: 29–30; see Tab. 18:). The following calculation is based on:

- **Wages for the waste collectors:** The main collection work is done by the waste collectors who ride on the trucks. It is assumed that there are **4 people** on one truck. Each of these permanent employees earns **1.500 ZMW/month**. These employees are assumed to work **20 working** days per month, **12 months** per year. In this model the vacations are assumed as included within the 20 working days (cf. Waste Collector 1, personal interview, Lusaka, 17.10.22, see Annexure 3).

- **Transport costs:** The largest landfill, Chunga Landfill, is assumed as the destination for the following calculations. The assumed distance between Chunga Landfill and other waste districts **is 30 km and** serves as a one-way route, **60 km** for one round-trip (cf. Google Maps 2023a: Chunga Landfill – Silver Rest). For the calculation **1** tour per truck per day is calculated (cf. Waste Collector 2, personal interview Lusaka, 21.10.22, see Annexure 4).
- **Truck sizes and petrol consumption:** As noted in the field study, different truck sizes are in use. For the further calculation, an average capacity of **15 t** per truck was assumed, based on the rounded up (**14.8 → 15 t**) average value of the following truck sizes: 25 t, 20 t, 7,5 t and 7 t. The average gasoline consumption was determined to be **24 l/100 km**, based on average values of different truck sizes. The inaccuracies resulting from this are acceptable for approximating a PC price (cf. Bridgestone Mobility Solutions B.V. n. d.). The price of petrol amounts to **26,16 ZMW/l** as observed during the field study.
- **Repair and maintenance costs:** The necessary repair and maintenance costs are taken into account by 100 % surcharge. The assumption here is as follows: the mileage rate 50 % and 50 % maintenance inclusive fee and insurance.

Tab. 18: Waste collection costs (own calculation)

Waste collection costs (2)			
Petrol cost / zmw / liter	26,16	zmw	Waste collection
Average petrol consumption l / 100 km	24	l	
Petrol cost per 100 km	627,84	zmw	
Maintenance			
Extra charge for transport maintenance in %	100	%	
Transport maintenance / 100 km	627,84	zmw	
Distance and truck capacity			
Average distance to landfill oneway	30	km	
Average distance to landfill return	60	km	
Average capacity per load in tons	15	tons	
Average tours per truck / day	1	truck	
Distance return landfill / year in km	14.400	km	
Capacity per average truck per year in tons	3.600	tons	
Wages			
Working days per month	20	days	
Wage employee per month / zmw	1.500,00	zmw	
People working per truck	4	pax	
Wage persons per ton in zmw	5,00	zmw	
Wage per person and year in zmw	18.000,00	zmw	
Wage persons per truck and year in zmw	72.000,00	zmw	
Results			
Petrol / maintenance / wages / per year / truck	252.817,92	zmw	
Capacity truck / year (capacity / day * workdays / month)*12	3.600	tons	
Subtotal			
Cost collection / transport per ton (cost 1)	**70,23**	zmw	

This results in collection costs of **70,23 ZMW/t** which results in **3,44 EUR/t**.

6.1.3 Disposal costs legal landfill (3)

Landfill maintenance is the responsibility of the LCC. The maintenance costs base on various aspects: Size of the landfill and its geographic conditions, waste quantity, infrastructure (e.g., roads) as well as the general landfill strategy. Based on figures from Ghana and other comparable numbers, maintenance costs are assumed to be around 560 ZMW/t (approx. 30 USD/t) (cf. Kusi et al. 2016: 19–28).

For the further calculation it is assumed that the waste collectors' contribution to the costs of maintaining the landfill is covered by this license fee and the additional costs of 50 ZMW/per delivered ton (cf. LCC, personal interview, LCC, Chunga Landfill, Lusaka, 17.10.22 see Annexure 7; Waste Collector 2, personal interview Lusaka, 21.10.22, see Annexure 4) see Tab. 19:).

- **License fees for the waste collectors:** Waste collectors must register for official waste collection and pay **15.000 ZMW/year**. For the further calculation it is assumed that every truck has to pay a license, because also smaller companies are active in Lusaka.
- **Landfill fee waste collectors:** Besides the license fee, the waste collectors have to pay **50 ZMW/t** for unloading the waste at the legal landfill.
- **Capacity:** Additionally, the average capacity of **15 t** for a truck is used for further calculations. From this, assuming the above working days and number of daily trips to the landfill, the capacity is **3.600 t/year** delivered by one truck.

Tab. 19: Landfill costs (own calculation)

Landfill costs (3)			
License fee fix per truck / year	15.000,00	zmw	Landfill costs
License fee fix per truck / month	1.250,00	zmw	
Capacity truck / year (capacity / day * workdays / month)*12	3.600	tons	
License fee fix per ton (fee year fix / cap truck year)	4,17	zmw	
License fee variable per ton	50,00	zmw	
Subtotal			
License fix ton + variable per ton (cost 2)	**54,17**	zmw	

If the license fee and the landfill fee are now calculated on the basis of the estimated capacity, the result is a price of **54,17 ZMW/t** (which results in **2,65 EUR/t**) for landfill and license costs.

6.1.4 Costs waste sorting (4)

Waste sorting is currently performed by a large number of waste pickers. At the Chunga landfill alone, there are about 2000 waste pickers. It is important to secure these people from the informal sector by working in PC social projects and also to offer them financial security. In order to approach a valid price for waste sorting, collected waste quantities, sales prices and revenues from sales are considered (see Tab. 20:).

Amount of sorted waste: It is assumed that on average 80 kg can be collected by a waste picker per day. However, since this figure includes metals and other heavy materials, an average collection weight for plastic waste of **25 kg** is assumed for the following calculation (cf. Shunsuke and Tetsuya 2014: 474–480).

Prices: The prices received by the waste pickers vary from 1,5 ZMW/ kg up to 7 ZMW/ kg for plastics, depending on the material. As plastic with a low quality is considered for the incineration and the following calculation, a price of **1,5 ZMW/ kg** can be assumed (cf. Aggregator, personal interview, Misisi illegal landfill, Lusaka, 17.10.22, see Annexure 2).

Revenue: Recycling or even selling to a cement plant generates revenues from the material (estimated 500 ZMW/t). For the following calculation, this is set at approx. 33,33 % of the costs. This profit is directly offset against expenses and results in a price of **1.000 ZMW/t** on average.

Tab. 20: Waste sorting costs (own illustration)

Waste sorting costs (4)			
Average amount of sorted waste per day per waste pickers	25	kg	Waste sorting
Average purchase price for low–value plastic	1,50	zmw	
Estimated revenue from material per t	500,00	zmw	
Cost per ton minus revenue	1.000,00	zmw	

This results in an average sorting price per ton of **1.000 ZMW/t** (**49 EUR/t**).

6.1.5 Transport (5) and pre-and co-processing (6)

For calculation purposes, it is assumed that waste from Chunga landfill must be transported to the cement plant after it has been sorted. In the next step, the waste is forwarded to pre-processing and co-processing (see Fig. 18; see Tab. 21:).

Transport: The one-way distance from Chunga to the Lafarge Holcim is **23 km** for a single trip (cf. Google Maps 2023b). It can be assumed that only **2 persons** are required on the truck.

Pre-and Co-Processing: The cost of pre-treatment and co-processing depends on the type of waste, its quality and the technology chosen. According to Lafarge Holcim, which also operates the cement plant in Lusaka, the operational costs for handling MSW amount to an average of **205,42 ZMW/t** (which results in **10,06 EUR/t**) (cf. Holcim 2020: 44–59).

Tab. 21: Overview costs transport & pre- and co-processing (own illustration)

Transport landfill to cement plant (5)			
Average distance to cement plant oneway	23	km	Transport to cement plant
Average distance to cement plant return	46	km	
Average capacity per load in tons	15	tons	
Average tours per truck / day	1	truck	
Distance return landfill / year in km	11.040	km	
Capacity per average truck per year in tons	3.600	tons	
Wages			
Working days per month	20	days	
Wage employee per zmw / month	1.500,00	zmw	
People working per truck	2	pax	
Wage persons per ton in zmw	5,00	zmw	
Wage per person and year in zmw	18.000,00	zmw	
Wage persons per truck and year in zmw	36.000,00	zmw	
Results			
Petrol / maintenance / wages / per year / truck	174.627,07	zmw	
Capacity truck / year (capacity / day * workdays / month)*12	3.600	tons	
Cost transport / transport per ton (cost 5)	48,51	zmw	
Subtotal			
Cost per ton (petrol / maintainance / License) including sorting / picking / transport to landfill (cost 6)	1.172,90	zmw	
Pre- and co-processing (6)			
Cost per ton cement plant pre- and /co-processing	205,42	zmw	Pre- and co-processing
Cost transport cement plus processing in t (cost 7)	**253,93**	zmw	

This results in a price of **253,93 ZMW/t** (which results in **12,44 EUR/t**) for transport and pre- and co-processing.

6.1.6 PC administrative costs & infrastructure optimization

In addition to the costs for waste management, the costs for handling the plastic credits must also be taken into account (see Tab. 22:).

- For the development of infrastructure, educational campaigns, but also administrative costs, about 20 % can be added to the other costs incurred (cf. Plastic Credit Exchange 2021; Plastic Credit Exchange 2022).

Tab. 22: Overview costs organization plastic credit projects (own illustration)

Administrative costs			
Total costs (collection, transport, sorting, treatment) per t	1.378,32	zmw	Admin costs
Added costs for infrastructure, education and administration in %	20	%	
PC administrative costs & infrastructure optimization per t (cost 9)	**275,66**	zmw	

This leads to a total amount of **275,66 ZMW/t** (**13,51 EUR/t**)

6.1.7 Conclusion

Considering all individual positions, the complexity as well as the uncertainty in determining a valid price becomes clear. All aspects from collection, sorting, transport and pre- as well as co-processing in the cement plant leads to a total price of one PC for **1.653,99 ZMW/t** (**81,05 EUR/t**). Margins are not included yet.

During the determination of the price, it was often necessary to work with average values and assumptions, as some of the figures could not be validated. It would be desirable if the figures were validated already, but this might also happen during a first pilot project. The concrete project design is of high relevance. Aspects like the number of employees, duration of the project, concrete areas and materials determine the costs as well as the revenues.

For the above price the following uncertainties can be named:

- Concrete revenue from the cement plant for MSW.
- Concrete amount of waste and the amount of potential plastic waste.
- Lost material during the process is not taking into account yet.
- Concrete amount of required money for waste pickers as well as for employees and their wages.
- Concrete margin of the waste collectors.

Nevertheless, this price offers a guideline that a future PC provider could gradually concretize and validate depending on the implementation.

6.2 Estimated environmental, social and economic impacts

In addition to the price calculation for PCs, a consideration of the potential social, environmental and economic impacts is required.

There are several areas that can contribute to improvement at the site. Even though PC projects are business-oriented projects, it is important to consider the possible impacts, both negative and positive. Considering the environmental impacts, one can mention the reduction of waste in nature and the consequent conservation of the soil. The negative impacts can result from different aspects. In the area of collection, it is important to establish sensible, environmentally friendly collection and transport systems. The use of MSW in the cement plant also saves fossil primary energy sources and the associated amount of CO_2. The exact figures depend heavily on the technologies and the composition of the waste. If the money from PC projects is used to expand controlled waste incineration, high CO_2 savings are expected. The social impacts are in job creation, awareness generation, and small business development which are possible through the creation of a reliable income stream. Economically, it can lead to a strengthening of the recycling market, which in turn helps cover the necessary costs or even generates profits that benefit the MSW. Especially with the social and economic components, it is important to create meaningful and locally adapted solutions that do not destroy existing structures and livelihoods, but integrate them. Based on comparable projects, the following impacts (see Tab. 23:) can be defined:

Tab. 23: Overview positive and negative impact (own illustration)

Possible impact		
Impact	Potential positive impact	Potential negative impact
Environmental impact		
Reduction amount of plastic in environment: e. g., through one time collection: **18,5 t/day** **Door-to-Door-Collection:** e. g., by 8 persons **0,2 t plastic/week** (cf. Nguyen 2022: 44)		Negative impacts may be found in transportation costs, but these can be kept low through efficient planning of routes.
Primary fossil fuels: Depending on the availability of materials and their calorific values, primary fossil fuels can be avoided for processing in the cement plant. Typically, **15–20 %** of primary fossil can be replaced by RFD (based of MSW) (cf. Bharadwaj 2016:3).		
Reduction of CO_2 emissions in cement plant: The processing of MSW in the cement plant leads to a reduction of CO_2 emissions compared to fossil fuels. The actual number of reductions varies depending on techniques and composition of the waste and its calorific value. A study from Korea refers to a value of **106,9 kg/CO_2** in one ton of cement which can be saved (cf. Kim and Phae 2022: 1).		Efforts and energy incurred in the course of pre- and co-processing must also be taken into account.
Reduction of CO_2 emission in landfill: The use of waste for waste to energy also offers high CO_2 saving potential between **200–800 kg CO_2** that can be saved per ton if waste to energy replaces landfilling (cf. Clerens and Thuau 2018: 29)		To get these savings, waste to energy plants must be built, which also contributes to emissions.
Protection of soils: By reducing the amount of trash in legal and illegal dumpsites, soils can be protected from pollution.		

Social impact	
Creation of jobs: Depending on the PC project design, the generation of new jobs, especially for waste pickers, is likely. Reliable income enables the promotion of smaller businesses, e. g., small recycling facilities. An improvement in social standing can also be assumed (cf. Chileshe and Moonga 2017: 40–51).	Depending on the project design, individual aspects must be taken into account. In particular, it is important to avoid destabilizing the current structures but to integrate them in a meaningful way.
Economic	
Create revenue and optimize infrastructure and education: It is possible to generate relevant revenue from the materials. When considering a possible sale to the cement plant, it is assumed that at least the costs of collection and transport will be covered and a sufficient amount can be invested in the expansion of infrastructure and education. (cf. Nguyen 2022: 43).	In this area, too, local structures must be taken into account and integrated in the best possible way.

This chapter was about deriving the price of a PC in Lusaka. The calculated price is **1.653,99 ZMW/t (81,05 EUR/t)**. Even if this price should be validated with further figures, it still provides a comprehensible benchmark. Furthermore, possible economic, social and economic impacts are mentioned.