RECYCLABLE WASTE TRANSPORTATION
ANALYSIS REPORT

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INTRODUCTION

Following the waste composition studies carried out in summer 2019 and winter 2020, this transportation analysis aims to evaluate whether it could be relevant to transport Khishig-Undur's main recyclable waste (glass and PET bottles) to urban recycling facilities.

This study aims to compare several transportation opportunities depending on 3 variables: the destination (Ulaanbaatar and Bulgan city), the vehicle (different trucks available in Khishig-Undur), and the recyclables' form (compressed, shredded, crushed, undamaged).

The analysis is carried out both from an economic standpoint (costs and profitability) and an environmental perspective (CO_2 emissions). Considering significant approximations and margins of error, figures should be considered as rough estimates rather than precise numbers.

ANALYSIS VARIABLES AND WORK HYPOTHESES

DESTINATION OF TRANSPORTATION

Two potential destinations were selected for this study:

- **Ulaanbaatar**, because although Mongolia's capital city is relatively far from Khishig-Undur and transportation costs were expected to be high, most recycling opportunities are located there.
- **Bulgan**, because although this city is much smaller and recycling opportunities are fewer, it is also much closer to Khishig-Undur and transportation costs were expected to be lower.

CHARACTERISTICS OF AVAILABLE TRUCKS IN KHISHIG-UNDUR

The transportation analysis aims to be practical and realistic, which is why it considers trucks that are in fact available in the soum. We visited several drivers in Khishig-Undur to check availability and ask about their trucks' characteristics. Five different trucks were found (see pictures in Annex 1):

- **Hyundai Porter** (private owner): this typical Mongolian herder's truck has a carrying capacity of approximately 2.5 tons and 13 m^3. It runs on Diesel with an average consumption of 10 L/100km.

- **Hyundai Mighty** (private owner): this truck has a carrying capacity of approximately 4 tons and 26 m^3. It runs on Diesel with an average consumption of 18 L/100km.

- **Kama** (owned by soum): this truck has a carrying capacity of approximately 5.5 tons and 23 m^3. It runs on Diesel with an average consumption of 19 L/100km.

- **Hyundai Mighty 2** (private owner): this truck has a carrying capacity of approximately 8 tons or 33 m^3. It runs on Diesel with an average consumption of 20 L/100km.

- **Daiso** (private owner): with its trailer, this truck has a total carrying capacity of approximately 20 tons or 122 m^3. It runs on Diesel with an average consumption of 40 L/100km.

Overall, all five trucks turned out to run on Diesel. Gas consumption increases fourfold from the smallest to the largest truck (from 10 to 40 L/100km). But when absolute gas consumption is correlated with carrying capacity, the largest truck shows the lowest relative consumption. In such relative terms, gas consumption varies between 2 and 4.5 L/100km/ton. Information about each truck is summarized in ***Table 1*** below.

Truck	**Hyundai Porter**	**Hyundai Mighty**	**Kama**	**Hyundai Mighty 2**	**Daiso**
Ownership	Private	Private	Public	Private	Private
Maximum tonnage in truck (ton)	2.5	4	5.5	8	20
Maximum volume in truck (m^3)	13	26	23	33	122
Type of gas	Diesel	Diesel	Diesel	Diesel	Diesel
Gas consumption (L/100km)	10	18	19	20	40
Gas consumption per transported ton at full carrying capacity (L/100km)	4	4.5	3.5	2.5	2

Table 1 : Summary table of characteristics of trucks available in Khishig-Undur

TRANSPORTATION DISTANCES AND COSTS

From Khishig-Undur, a one-way trip to Ulaanbaatar is approximately 300 km (600 km round-trip) and a one-way trip to Bulgan is approximately 75 km (150 km round-trip).

The main difference in transportation costs comes from the type of ownership. Since the Kama truck is owned by the soum's administration, the only transportation cost is gas (as driver's salary and truck's maintenance costs are already budgeted by the soum). With an average consumption of 19 L/100km and Diesel price currently established at about 2,350 MNT per liter, transportation costs can be approximately estimated at 450 MNT/km. For this public truck, this analysis will consider round-trips because it is most likely that the truck will come back empty to Khishig-Undur right away after unloading its shipment of recyclable in the urban industry. With such a hypothesis, transportation costs should thus obviously include the way back.

When it comes to the private trucks, the question of taking into account one-way or round-trip is irrelevant because it turned out from drivers' interviews that each of them charges the same standard price, based on transported weight rather than kilometer. With private trucks, transportation costs from Khishig-Undur are commonly established at 80,000 MNT/ton to go to Ulaanbaatar and 50,000 MNT/ton to go to Bulgan. This standardized price leads to neutralize one of the analysis variables: with the same transportation costs per ton and recyclables' purchasing prices also based on weight (see below), the choice between the private trucks has no impact on the economic balance. In other words, cost per ton of transported recyclable is the same regardless of the private truck. Incidentally, the costs per transported ton with private truck also remain identical regardless of the fact that the truck would be full of recyclable or not, since drivers don't charge per trip but per ton (but this is not true for the public truck, which needs to be full to have low cost per transported ton).

ENVIRONMENTAL IMPACT EVALUATION

To evaluate environmental impact of transporting recyclables to urban industries, we chose to estimate CO_2 emissions directly associated with transportation.[1] All trucks considered in the study run on Diesel, which simplifies the CO_2 emission analysis. Since Diesel emits about 2660 g of CO_2 per consumed liter[2], CO_2 emissions for each truck only vary depending on its own consumption per kilometer. *Table 2* below shows the average CO_2 emission per kilometer for each truck.

Truck	**Hyundai Porter**	**Hyundai Mighty**	**Kama**	**Hyundai Mighty 2**	**Daiso**
Gas consumption (L/100km)	10	18	19	20	40
Average CO_2 emission (g/km)	266	479	505	532	1064

Table 2: Estimations of average CO_2 emissions of the trucks available in Khishig-Undur

For the public truck, which will almost always come back empty, it is obviously necessary to take into account the CO_2 emissions associated with the way back, just like we have to include gas expenses for the way back in our cost assessment.

For the private trucks, a fair estimation of CO_2 emissions is more complicated. If the driver finds other customers to fill his truck for the way back to Khishig-Undur, CO_2 emissions will obviously fall on these new consumers and we should only take into account the emissions linked to the one-way. But if on the other hand the driver cannot find other customers and has to come back empty (or, at least, not at full capacity), then like for the public truck the CO_2 emissions should be included in our calculation (at least the part associated with the empty space). Since it is impossible to predict if drivers will find new consumers after each trip to urban recyclers, we chose as a work hypothesis to take into account half (50%) of the way back's emissions. This imperfect approximation considers that a private driver is more likely to find customers than the public driver, but that in reality he will not always manage to fill his truck at full capacity.[3]

PET TRANSPORTATION FORM

Before transporting PET, it is preferable to reduce its volume, either manually or mechanically, so more PET can be loaded in a truck.

SCENARIO N°1: MANUAL COMPRESSION

In the first scenario, we will consider that PET is transported without previous mechanical transformation, but only with manual compression. Since PET is light and quite voluminous, even

[1] Nevertheless, it should be noted that this necessary simplification tends to decrease the real total CO_2 emissions linked to transportation. On a Life Cycle Assessment basis, transportation emissions should also include indirect emissions such as those associated with trucks manufacturing and maintenance, oil extraction and so on.

[2] https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/oee/pdf/transportation/fuel-efficient-technologies/autosmart_factsheet_6_e.pdf

[3] Keep in mind that these considerations regarding finding other customers or not is irrelevant for the cost analysis: whether or not drivers come back with an empty truck, they will not charge more (or less) for the one-way than the agreed price (80,000 MNT/ton to Ulaanbaatar and 50,000 MNT/ton to Bulgan).

manually compressed, it was likely that we would reach maximum volume of the trucks much before we could reach maximum tonnage.

To estimate how much manually compressed PET could actually fit in each truck, we tested manual compression ourselves and extrapolated results to find that 1 ton of PET would occupy a volume of approximately 37 m^3. In other words, 1 m^3 of manually compressed PET weighs about 27 kg.[4]

It turns out that in the manual compression scenario trucks are indeed far from reaching their maximum tonnage. Depending on the truck, when they reach maximum volume, they reach only 11-18% of their maximum tonnage (see *Table 3* below). Therefore, in the analysis, we will use the real maximum carrying capacity for manually compressed PET (0.3 to 3.3 tons) instead of trucks' theoretical maximum tonnage.

Truck	**Hyundai Porter**	**Hyundai Mighty**	**Kama**	**Hyundai Mighty 2**	**Daiso**
Estimated real maximum carrying capacity of each truck (ton)	0.3	0.7	0.6	0.9	3.3
Estimated tonnage-filling rate of each truck (% of maximum tonnage)	14%	18%	11%	11%	17%

Table 3: Estimated real carrying capacity of trucks for manually compressed PET

SCENARIO N°2: MECHANICAL COMPRESSION OR SHREDDING

In the second scenario, we will consider that PET is transported after having been mechanically compressed or shredded. In order to make sure that mechanically compressing or shredding PET would allow us to reach the maximum tonnage of each truck, we estimated the volume occupied by 1 ton of compressed and shredded PET. We selected the following figures:

- Compressed PET: 3.23 m^3/t (or 0.31 t/m^3)[5];
- Shredded PET: 4.15 m^3/t (or 0.24 t/m^3)[6].

Based on these figures and considering the ratio tonnage/volume of each truck, we found that, for both options (compressed or shredded), each truck could indeed reach its maximum tonnage before to exceeds its maximum volume. Depending on trucks, PET at maximal tonnage would occupy 50-78% of the truck's total volume if compressed, and 64-100 % if shredded.

Estimated volume of compressed and shredded PET at maximum tonnage is summarized for each truck in *Table 4* below.

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[4] For this test, we compressed PET bottles until we could fit a 1.8 m^3 bag. We weighted how much PET it contained and found approximately 50 kg, which corresponds to 37 m^3/ton or 27 kg/m^3.

[5] This estimation is based on information shared with us by Ikh-Uul soum's administration (Zavkhan aimag), where they compress PET bottles with originally a wool compressor. Each compressed unit weighs 60 to 70 kg (average: 65 kg) and occupies a volume of approximately 0.21 m^3 (0.5 m x 0.6 m x 0.7 m).

[6] This estimation is based on personal tests: we shredded PET until we could fit a 1 L container and weighed how much PET was contained in it. Since there can be a significant variation of weight depending on the manual compression applied while filling the container, we repeated the operation twice and averaged the results. After extrapolating the measurements to 1 ton, we found that the occupied volume would be 4.0 to 4.3 m^3.

Truck	Hyundai Porter	Hyundai Mighty	Kama	Hyundai Mighty 2	Daiso
Estimated volume of **compressed** PET in truck at maximum tonnage (m^3)	8	13	18	26	65
Estimated volume-filling rate of each truck if PET is **compressed** (% of maximum volume)	63%	50%	78%	78%	53%
Estimated volume of **shredded** PET in truck at maximum tonnage (m^3)	10	17	23	33	83
Estimated volume-filling rate of each truck if PET is **shredded** (% of maximum volume)	81%	64%	100%	100%	68%

Table 4: Estimated real carrying capacity of trucks for mechanically compressed or shredded PET

PET PURCHASING PRICES

In Ulaanbaatar, purchasing price used in this analysis for both scenarios is the one offered by private industry Mog Plastic, which is currently established for PET at 500 MNT/kg.

In Bulgan, it turns out that there is no recycling facility that purchases plastic waste. Bulgan's only plastic recycler is the public administration, which accepts plastic from outside the city but does not purchase it. Therefore, transportation to Bulgan would necessarily be done in economic deficit. But since CO_2 emissions would be lower due to smaller distance, this option will be considered anyway in the analysis.

GLASS TRANSPORTATION FORM

When it comes to glass waste, two main options can be considered: reusing intact bottles or recycling glass after crushing.

SCENARIO N°3: TRANSPORTING INTACT BOTTLES FOR REUSING

Obviously, if alcohol industry is to reuse their bottles, these need to be intact. Therefore, they need to be transported safely in appropriate containers to limit damage on the way. With a mix of 0.5 L and 0.75 L bottles (the most common), taking into account the weight and volume of a typical container for such bottles (box for 20 bottles), we calculated that 389 bottles could fit in 1 m^3 while 1 ton would correspond to the weight of 1,843 bottles (including the weight of previously mentioned containers). Based on such figures, we could estimate that 1 m^3 of bottles in their containers would weigh 0.21 ton, while correlatively 1 ton of bottles in their containers would occupy 4.7 m^3.[7]

Like for PET in previous scenarios, we verified whether full tonnage in each truck could be reached without exceeding volume limit. We found that full tonnage can indeed be reached in 3 of the trucks (Porter, Mighty and Daiso) but not in Mighty 2 and Kama, which can only reach 87% of their maximum tonnage when they reach their maximum volume. Therefore, for these 2 trucks, the analysis takes

[7] These calculations are based on parameters that we measured ourselves on bottles and containers samples. We found that average weight of 0.5L and 0.75 L vodka bottle are respectively close to 350 g and 550 g. Containers weight and volume are approximately 1.7 kg / 42 L for 0.5L bottles containers and 2.0 kg / 62 L for 0.75 L bottles. We considered in our estimation that half of the transported bottles would be 0.5 L while the other half would be 0.75 L. (We also performed the calculation with only 0.5 L bottles and only 0.75 L bottles and found similar results.)

into account the real maximum tonnage they can accommodate, respectively 4.8 ton (instead of 5.5 ton in theory) and 7 ton (instead of 8 ton in theory). Estimated real maximum carrying capacity is summarized for each truck in *Table 5* below.

Truck	**Hyundai Porter**	**Hyundai Mighty**	**Kama**	**Hyundai Mighty 2**	**Daiso**
Theoretical maximum tonnage in truck (ton)	2.5	4	5.5	8	20
Estimated tonnage of glass bottles in truck at maximum volume (ton)	2,7	5,4	4,8	7,0	25,7
Estimated tonnage-filling rate of glass bottles in truck at maximum volume (ton)	108%	136%	87%	87%	128%
Theoretical maximum volume in truck (m^3)	13	26	23	33	122
Estimated volume of glass bottles in truck at maximum tonnage (m3)	12	19	26	38	95
Estimated volume-filling rate of glass bottles in truck at maximum volume (m3)	93%	74%	114%	115%	78%

Table 5: Estimated real carrying capacity of trucks for intact reusable bottles in safe containers

SCENARIO N°4: DAMMAGED AND MECHANICALLY CRUSHED GLASS FOR RECYCLING

Reusing would not be an option in many cases, including when a company refuses to reuse their bottles, when bottles are damaged, or when glass waste comes from other items (i.e. jars). In these cases, recycling the glass could be a solution. To date, there is no glass recycling facility operating in Mongolia, but there is a developing project (named Erdes Plasm LLC) that may open by the end of 2020 in Ulaanbaatar's region (the facility will be located in Bagakhangai, but collection points will be opened in Ulaanbaatar).

We interviewed the representative of this future recycling facility and he explained that, although they would have some requirements, they would indeed welcome glass waste from Khishig-Undur. It appears that uncrushed glass would be preferred to crushed glass because it would allow the facility to sort glass (depending on color and other features) and crush it according to their requirements. Nevertheless, if we respect their standards, crushed glass will be accepted.

For this analysis, the question is – like for other scenarios described above – to know whether we could reach maximum tonnage of each truck before to exceed maximum volume. We do not have data regarding the weight/volume ratio of crushed glass. But we can deduct from scenario n°3 that we could indeed reach maximum tonnage capacity in scenario n°4: since undamaged bottles in their safe containers fit in 3 of the trucks, broken or crushed glass would obviously also fit. For Kama and Mighty 2 trucks, only 87% of maximum tonnage could be reached in scenario n°3. But it seems that empty space inside each bottle and between them in the containers represents a volume much greater than the 3 (Kama) to 5 (Mighty 2) m^3 that were lacking in these trucks to reach maximum tonnage.[8] Therefore, we can reasonably assume that broken and crushed glass (and probably even intact bottles without protection containers) would fit in all trucks at full carrying capacity. In our analysis, we thus use theoretical maximum tonnage for all 5 trucks.

[8] For example, we can note that while a container for 20 bottles of 0.5L occupies a volume of 42 L, the 20 bottles themselves represent only 10 L (20 x 0.5L), or less than 25% of the container's volume.

GLASS PURCHASING PRICES

PRICES FOR SCENARIO N°3

We tried to contact some alcohol industries to know their conditions and purchasing prices but they oriented us to waste management intermediary companies, such as Ulaanbaatar-based Tuvshinsaikhan. [9] In this analysis, selling prices for intact glass bottles are thus based on Tuvshinsaikhan's purchasing prices. These prices are bottle-based and vary from one brand to the next (from 10 to 250 MNT per bottle), but as a work hypothesis we will consider the average glass price to be 54 MNT per bottle.[10] Based on such a price, we found that 1 ton of transported bottles (in their safe containers) is worth on average about 100,000 MNT at Tuvshinsaikhan. We used that figure in the economic analysis for transportation to Ulaanbaatar.

To our knowledge, there is no such intermediary glass bottle collector in Bulgan today. But some could open in the future, or alcohol industry could directly organize collection points there. In that prospect, we conducted Bulgan's economic analysis backwards, not to evaluate whether it is economically viable to bring glass bottles there today (like we did for Ulaanbaatar), but to estimate from which purchasing price it could become economically interesting if a collection point opens in the future.

PRICES FOR SCENARIO N°4

In the future glass recycling plant nearby Ulaanbaatar, glass should be purchased for 65,000 MNT per ton, according to its representative.

In Bulgan, it is unclear yet whether there will be collection points and at which price glass could be purchased. Like for scenario n°1, we performed the analysis as to evaluate from which purchasing price it could become economically viable to transport glass waste to Bulgan.

ANALYSIS OF PET TRANSPORTATION

ECONOMICAL ANALYSIS

SCENARIO N°1A: MANUAL COMPRESSION – ULAANBAATAR

In this scenario, due to a too high weight/volume ratio (see above), trucks cannot reach maximum tonnage. But since the truck is full in volume, drivers do charge the full price as if trucks reached their carrying capacity. In this condition, costs per transported ton increase dramatically. The limited amount of manually compressed PET sold to Ulaanbaatar's recycling facility provides relatively limited income, which manages to balance transportation costs only for Mighty, Kama and Daiso trucks (Porter and Mighty 2 are in deficit). Even for the three other trucks, net profit per ton is very limited. The most profitable option appears to be with public Kama (67,637 MNT/ton), due to lower transportation costs per ton. But even in this case profit remains fairly low (41,909 MNT for a full truck).

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[9] Intermediary collectors such as Tuvshinsaikhan (https://www.facebook.com/tuvshinsaikhancenter) purchase various recyclables from individuals and then sell them to recycling industries.

[10] We calculated that figure as the average of all prices provided by Tuvshinsaikhan for all the bottles they purchase (0.5L and 0.75L), regardless of the actual proportion of each kind of bottle in Khishig-Undur's glass waste (unknown data).

Considering margins of error associated with manual compression and variability of Diesel price, we should conclude that, with the right truck, transportation costs can be roughly balanced by income from selling PET. But the operation is not likely to be really profitable even in best-case scenario.

Calculations and analyzed figures for scenario 1A are presented in *Table 6* below.

Truck	**Hyundai Porter**	**Hyundai Mighty**	**Kama**	**Hyundai Mighty 2**	**Daiso**
Cost per ton of PET transported to UB (MNT)	574,951	456,395	432,363	711,051	483,692
Cost for trip to UB with full truck (MNT)	200,000	320,000	267,900	640,000	1,600,000
Income for full truck of PET sold in UB's recycling industry (MNT)	173,928	350,573	309,809	450,038	1,653,945
Net profit of full truck transportation to UB (MNT)	-26,072	30,573	41,909	-189,962	53,945
Net profit for 1 ton of PET depending on truck (MNT)	**-74,951**	**43,605**	**67,637**	**-211,051**	**16,308**

Table 6: Economical analysis for manually compressed PET transportation to Ulaanbaatar

SCENARIO N°1B: MANUAL COMPRESSION – BULGAN

Since no facility purchases PET in Bulgan today, transporting PET to Bulgan public recycling plant is necessarily in deficit. The operation is particularly irrelevant with manually compressed PET, because of its low weight/volume ratio. In this scenario, costs and net loss per transported ton are unreasonably high for all trucks. Nevertheless, we should note that if a collection point where PET would be purchased were to open in Bulgan, they would have to pay between 108 and 444 MNT/kg for the operation to be economically balanced (depending on truck). Considering that PET is purchased at 500 MNT/kg in Ulaanbaatar, it is most likely that transporting manually compressed PET to Bulgan could become at least economically balanced, or even profitable in the future (depending on actual purchasing price). Calculations and analyzed figures for scenario 1B are presented in *Table 7* below.

Truck	**Hyundai Porter**	**Hyundai Mighty**	**Kama**	**Hyundai Mighty 2**	**Daiso**
Cost per ton of PET transported to Bulgan (MNT)	359,344	285,247	108,091	444,407	302,308
Cost for trip to Bulgan with full truck (MNT)	125,000	200,000	66,975	400,000	1,000,000
Income for full truck of PET disposed in Bulgan (MNT)	0	0	0	0	0
Net loss of full truck transportation to Bulgan (MNT)	-125,000	-200,000	-66,975	-400,000	-1,000,000
Purchasing price per ton necessary to balance transportation costs to Bulgan (MNT)	-359,344	-285,247	-108,091	-444,407	-302,308

Table 7: Economical analysis for manually compressed PET transportation to Bulgan

SCENARIO N°2A: MECHANICAL COMPRESSION OR SHREDDING - ULAANBAATAR

In this scenario, an initial mechanical processing (compression or shredding) allows to reduce the volume of PET so that full carrying capacity (in weight) can be reached for all trucks. In that case, transportation costs per ton are much lower than in previous scenario and remain significantly lower than potential income with all 5 trucks. Net profit per ton is thus comprised between 420,000 MNT (private trucks) and over 450,000 MNT (public truck). Even considering margins of error, it appears that transporting mechanically compressed or shredded PET from Khishig-Undur to Ulaanbaatar could be not only economically viable but also profitable. Calculations and analyzed figures for scenario 2A are presented in *Table 8* below.

Truck	**Hyundai Porter**	**Hyundai Mighty**	**Kama**	**Hyundai Mighty 2**	**Daiso**
Cost per ton of PET transported to UB (MNT)	80,000	80,000	48,709	80,000	80,000
Cost for trip to UB with full truck (MNT)	200,000	320,000	267,900	640,000	1,600,000
Income for full truck of PET sold in UB's recycling industry (MNT)	1,250,000	2,000,000	2,750,000	4,000,000	10,000,000
Net profit of full truck transportation to UB (MNT)	1,050,000	1,680,000	2,482,100	3,360,000	8,400,000
Net profit for 1 ton of PET depending on truck (MNT)	**420,000**	**420,000**	**451,291**	**420,000**	**420,000**

Table 8: Economical analysis for mechanically compressed or shredded PET transportation to Ulaanbaatar

SCENARIO N°2B: MECHANICAL COMPRESSION OR SHREDDING – BULGAN

In this scenario, like in n°1B, transportation to Bulgan public facility can only be in deficit today. But thanks to previous mechanical processing, net loss is much lower, from about 12,000 MNT/ton (public truck) to 50,000 MNT/ton (private trucks). Here again, if a purchasing center was to open in Bulgan, transporting PET there could easily become profitable, and potentially the best of all options. Calculations and analyzed figures for scenario 2B are presented in *Table 9* below.

Truck	**Hyundai Porter**	**Hyundai Mighty**	**Kama**	**Hyundai Mighty 2**	**Daiso**
Cost per ton of PET transported to Bulgan (MNT)	50,000	50,000	12,177	50,000	50,000
Cost for trip to Bulgan with full truck (MNT)	125,000	200,000	66,975	400,000	1,000,000
Income for full truck of PET disposed in Bulgan (MNT)	0	0	0	0	0
Net loss of full truck transportation to Bulgan (MNT)	-125,000	-200,000	-66,975	-400,000	-1,000,000
Purchasing price per ton necessary to balance transportation costs to Bulgan (MNT)	**-50,000**	**-50,000**	**-12,177**	**-50,000**	**-50,000**

Table 9: Economical analysis for mechanically compressed or shredded PET transportation to Bulgan

SUMMARY TABLE FOR PET TRANSPORTATION SCENARIOS

Thanks to lower transportation costs per ton, the public truck (Kama) is always a better option from an economical standpoint. *Table 10* below summarizes the current maximum net profit or loss per ton transported with this truck (based on current gas prices), to both destinations for both scenarios.

Destination of transportation with Kama public truck	**Scenario 1:** Maximum net profit/loss per ton if PET is previously **manually** compressed (MNT).	**Scenario 2**: Maximum net profit/loss per ton if PET is previously **mechanically** compressed or shredded (MNT).
Ulaanbaatar	67,637	451,291
Bulgan	-108,091	-12,177

Table 10: Summary table of net profit and loss from transporting PET with Kama public truck

ENVIRONMENTAL IMPACT ANALYSIS

Based on average CO_2 emissions of each truck, transportation distances, and real carrying capacity of trucks in each scenario (as detailed in previous section), we calculated CO_2 emissions per ton associated with transporting PET to Ulaanbaatar and Bulgan for each scenario. Results are presented in *Table 11* below.

CO_2 emission per ton of PET	**Hyundai Porter**	**Hyundai Mighty**	**Kama**	**Hyundai Mighty 2**	**Daiso**
Scenario 1A: to **Ulaanbaatar** after **manual compression** (kg)	344	307	489	266	145
Scenario 2A: to **Ulaanbaatar** after **mechanical compression or shredding** (kg)	48	54	55	30	24
Scenario 1B: to **Bulgan** after **manual compression** (kg)	86	77	122	66	36
Scenario 2B: to **Bulgan** after **mechanical compression or shredding** (kg)	12	13	14	7	6

Table 11: CO_2 emissions per ton associated with PET transportation depending on scenarios

Regardless of the scenario, we find that the public truck (Kama), which is always the best option from an economical standpoint, is always the worse when it comes to CO_2 emissions. This fact is easily explained by our work hypothesis: we always took into account 100% of CO_2 emissions associated with the way back for the public truck but only 50% for private trucks (because a public truck is more likely to come back empty than a private truck).

Although Kama is always the most polluting (per transported ton), we should notice that its emissions are really close to the smaller trucks (Porter and Mighty) when we consider the most interesting economical scenario (scenario n°2 – mechanical compression or shredding). In this scenario, these 3 trucks emit 48 to 55 kg of CO_2 per transported ton to Ulaanbaatar, and 12 to 14 kg of CO_2 per transported ton to Bulgan.

The lowest emissions per transported ton always come from the biggest truck (Daiso), in each scenario. In scenario n°2 (mechanical processing), CO_2 emissions are more than twice as low as the previously mentioned three trucks (respectively 24 and 6 kg per transported ton to Ulaanbaatar and Bulgan). This is explained by the fact that, from the smallest to the biggest truck, carrying capacity increases faster than Diesel consumption (and thus than CO_2 emissions).

Finally, we logically observe that CO_2 emissions are always higher for transportation to Ulaanbaatar than it is to Bulgan, because distance is much greater.

In conclusion, we see that from an environmental perspective, the best option is to transport mechanically compressed PET to Bulgan with the Daiso truck (6 kg of CO_2 per transported ton). The choice of compression method is thus consistent with the one from economical analysis. The choice of truck would be different (Kama is always more interesting economically), but the difference is actually not so important when we calculate net profit per ton, which means choosing Daiso (420,000 MNT/ton) over Kama (450,000 MNT/ton) would still offer significant profit. Finally, choosing to go to Bulgan today would make no economical sense, but if a purchasing collection center were to open in the future it would probably become the best option from all standpoints.

ANALYSIS OF GLASS TRANSPORTATION

ECONOMICAL ANALYSIS

SCENARIO N°3A: TRANSPORTING INTACT BOTTLES FOR REUSING – ULAANBAATAR

In this scenario, although full tonnage is reachable only with three trucks (Porter, Mighty and Daiso), economical analysis shows that potential income from selling intact glass bottles in Ulaanbaatar is slightly higher than transportation costs for all five trucks. However, calculated net profit per ton is relatively low (from about 8,000 to 45,000 MNT/ton). Therefore, considering the significant margins of error of this scenario – mainly due to the averaged purchasing price of bottles and the uncertainty of brand and size of bottles actually transported – we cannot conclude that transporting intact bottles from Khishig-Undur to Ulaanbaatar would be really profitable. We should only consider that, in average, selling intact glass bottles should approximately cover transportation costs, so that the operation is more or less economically viable. Calculations and analyzed figures for scenario 3A are presented in *Table 12* below.

Truck	**Hyundai Porter**	**Hyundai Mighty**	**Kama**	**Hyundai Mighty 2**	**Daiso**
Cost per ton of glass bottles transported to UB (MNT)	80,000	80,000	55,750	80,000	80,000
Cost for trip to UB with full truck (MNT)	200,000	320,000	267,900	640,000	1,600,000
Income for full truck of glass bottles sold in UB (MNT)	250,000	400,000	480,536	698,042	2,000,000
Net profit of full truck transportation to UB (MNT)	50,000	80,000	212,636	58,042	400,000
Net profit for 1 ton of glass bottle depending on truck (MNT)	**20,000**	**20,000**	**44,250**	**8,315**	**20,000**

Table 12: Economical analysis for intact glass bottles transportation to Ulaanbaatar

SCENARIO N°3B: TRANSPORTING INTACT BOTTLES FOR REUSING – BULGAN

Since there is no glass recycling or collection point in Bulgan today, we calculated from which purchasing price transporting glass bottles there could become economically viable in the future.

With private trucks, minimum purchasing price per ton should simply be equivalent to transportation cost per ton. For trucks that can reach their full tonnage (Porter, Mighty and Daiso), that cost is commonly established at 50,000 MNT per ton, which corresponds to an average of 27 MNT per bottle. For the Mighty 2, which cannot reach maximum tonnage before exceeding maximum volume, relative transportation costs per ton becomes slightly higher (57,303 MNT per ton) because drivers charge as if the truck was at maximum weight carrying capacity (because there is no more space to fill the truck with additional cargo). For this truck, we thus find that minimum purchasing price per bottle would be 31 MNT. For the Kama public truck, even taking into account volume limitations, transportation costs are (like for PET scenarios) much lower (13,938 MNT per ton) because we only need to pay for gas. With that truck, minimum purchasing price would be 8 MNT per bottle. Calculations and analyzed figures for scenario 3B are presented in *Table 13* below.

Since average purchasing price in Ulaanbaatar is currently 54 MNT per bottle, we can conclude that transportation to Bulgan would also be economically viable, and probably even more profitable, especially with the public truck.

Truck	**Hyundai Porter**	**Hyundai Mighty**	**Kama**	**Hyundai Mighty 2**	**Daiso**
Cost per ton of glass bottles transported to Bulgan (MNT)	50,000	50,000	13,938	57,303	50,000
Cost for trip to Bulgan with full truck (MNT)	125,000	200,000	66,975	400,000	1,000,000
Purchasing price per ton necessary to balance transportation costs to Bulgan (MNT)	50,000	50,000	13,938	57,303	50,000
Purchasing price per bottle necessary to balance transportation costs to Bulgan (MNT)	**27**	**27**	**8**	**31**	**27**

Table 13: Economical analysis for intact glass bottles transportation to Bulgan

SCENARIO N°4A: BROKEN OR MECHANICALLY CRUSHED GLASS FOR RECYCLING - ULAANBAATAR

In this scenario, all trucks can reach their maximum carrying capacity, so net profit per ton is directly linked to purchasing price per ton. With a purchasing price of 65,000 MNT per ton at future recycling plant, and transportation costs of 80,000 MNT per ton, transporting glass to be recycled in Ulaanbaatar can only be in deficit with private trucks (-15,000 MNT per ton). With the public truck, due to lower transportation costs, the operation could be viable (about 16,000 MNT per ton), but not really profitable. Calculations and analyzed figures for scenario 4A are presented in *Table 14* below.

Truck	Hyundai Porter	Hyundai Mighty	Kama	Hyundai Mighty 2	Daiso
Cost per ton of glass transported to UB (MNT)	80,000	80,000	48,709	80,000	80,000
Cost for trip to UB with full truck (MNT)	200,000	320,000	267,900	640,000	1,600,000
Income for full truck of glass sold in UB (MNT)	162,500	260,000	357,500	520,000	1,300,000
Net profit of full truck transportation to UB (MNT)	-37,500	-60,000	89,600	-120,000	-300,000
Net profit for 1 ton of glass depending on truck (MNT)	**-15,000**	**-15,000**	**16,291**	**-15,000**	**-15,000**

Table 14: Economical analysis for broken or mechanically crushed glass transportation to Ulaanbaatar

SCENARIO N°4B: BROKEN OR MECHANICALLY CRUSHED GLASS FOR RECYCLING – BULGAN

With private trucks, transportation costs to Bulgan (50,000 MNT per ton) is lower than purchasing prices in Ulaanbaatar (65,000 MNT per ton). It is highly unlikely that a recycling plant – which could offer similar prices – will open there in a near future, but it is realistic to expect a simple collection point (from which glass would then be transported to Ulaanbaatar's recycling plant). In that prospect, we can assume that purchasing prices would be lower than 65,000 MNT per ton (because the recycling company would also have transportation costs to cover to go to Ulaanbaatar). Overall, bringing glass from Khishig-Undur to Bulgan would thus be viable at the very best, but definitely not profitable with private trucks. On the other hand, with the Kama public truck, purchasing prices could be as low as 12,177 MNT per ton to balance transportation costs. That figure seams much more likely to make glass transportation economically viable, or even profitable if purchasing price is high enough. Calculations and analyzed figures for scenario 4B are presented in *Table 15* below.

Truck	Hyundai Porter	Hyundai Mighty	Kama	Hyundai Mighty 2	Daiso
Cost per ton of glass transported to Bulgan (MNT)	50,000	50,000	12,177	50,000	50,000
Cost for trip to Bulgan with full truck (MNT)	125,000	200,000	66,975	400,000	1,000,000
Purchasing price per ton necessary to balance transportation costs to Bulgan (MNT)	**50,000**	**50,000**	**12,177**	**50,000**	**50,000**

Table 15: Economical analysis for broken or mechanically crushed glass transportation to Bulgan

SUMMARY TABLES FOR GLASS TRANSPORTATION SCENARIOS

Thanks to lower transportation costs per ton, the public truck (Kama) is always a better option from an economical standpoint. The tables below respectively summarize for both scenarios the current maximum net profit per ton transported with this truck to Ulaanbaatar, and the minimum purchasing price for glass in Bulgan for transportation to be economically viable from Khishig-Undur.

Destination of transportation with Kama public truck	**Scenario 3:** Maximum net profit/loss per ton of **intact glass bottles**	**Scenario 4**: Maximum net profit/loss per ton of **glass to be recycled**
Ulaanbaatar	44,250 MNT per ton	16,291 MNT per ton

Table 16: Summary table of net profit and loss from transporting glass to Ulaanbaatar with Kama public truck

Destination of transportation with Kama public truck	**Scenario 3:** Minimum purchasing price per **intact glass bottle**	**Scenario 4**: Minimum purchasing price per ton of **glass to be recycled**
Bulgan	8 MNT per bottle	12,177 MNT per ton

Table 17: Summary table of net profit and loss from transporting glass to Bulgan with Kama public truck

ENVIRONMENTAL IMPACT ANALYSIS

Based on average CO_2 emissions of each truck, transportation distances, and real carrying capacity of trucks in each scenario (as detailed in previous section), we calculated CO_2 emissions per ton associated with transporting glass to Ulaanbaatar and Bulgan for each scenario. We logically find the same figures as in scenario n°2 for PET because CO_2 emissions per transported ton are directly correlated to distances and gas consumption (which are the same as in scenario n°2, where trucks were also at full weight carrying capacity). The only slight difference concerns Kama and Mighty 2 trucks for scenario n°3 because these trucks could only reach 87% of their maximum tonnage, which makes relative CO_2 emission per ton slightly higher. Results are presented in *Table 18* below.

CO_2 emission per ton of glass	**Hyundai Porter**	**Hyundai Mighty**	**Kama**	**Hyundai Mighty 2**	**Daiso**
Scenario 3A: to **Ulaanbaatar** with **intact glass bottle** (kg)	48	54	63	34	24
Scenario 4A: to **Ulaanbaatar** with **broken or crushed glass to be recycled** (kg)	48	54	55	30	24
Scenario 3B: to **Bulgan** with **intact glass bottle** (kg)	12	13	16	9	6
Scenario 4B: to **Bulgan** with **broken or crushed glass to be recycled** (kg)	12	13	14	7	6

Table 18: CO_2 emissions per ton associated with glass transportation depending on scenarios

CONCLUSION

Despite arbitrary work hypotheses and significant margins of errors that forbid considering calculated figures as precise results, this transportation analysis offers a solid order of magnitude appreciation of transportation opportunities for Khishig-Undur's main recyclables (PET and glass bottles).

For PET, we can conclude that:

- **if transported from Khishig-Undur to Ulaanbaatar:**
  - prior manual compression could allow economical viability but no significant profit;
  - prior mechanical compression/shredding should allow significant profit;
- **if transported from Khishig-Undur to Bulgan:**
  - prior manual compression leads to very high deficit today, but could be viable in the future if purchasing collection centers were to open;
  - prior mechanical compression leads to relatively limited deficit today, and could be very profitable in the future if purchasing collection centers open.

For glass we can conclude that:

- **if transported from Khishig-Undur to Ulaanbaatar:**
  - intact glass bottles could be economically viable, but probably not very profitable;
  - broken or crushed glass to be recycled could barely be economically viable, but definitely not profitable;
- **if transported from Khishig-Undur to Bulgan (if a collection point opens in the future):**
  - intact glass bottles would most likely be economically viable, and probably even profitable;
  - broken or crushed glass to be recycled would probably be economically viable, and maybe profitable (if purchasing price is close enough to Ulaanbaatar's purchasing price).

For other soums, with a public truck like Kama (for which transportation costs are limited to gas expenses), we can calculate that transporting PET to Ulaanbaatar would remain economically viable up to 2,780 km (5,559 km round-trip).[11] This means that, potentially, all soums in Mongolia could bring their PET bottle waste to the capital city's recycling facilities (although it would probably be more problematic from an environmental perspective).

On the other hand, it appears that transporting glass (either intact for reusing or broken for recycling) from Khishig-Undur to Ulaanbaatar would be barely economically viable, and definitely not very profitable. Therefore, it seems that the operation would be complicated for soums located more than 300 km away from the capital city.

[11] This estimation is based on Kama truck's gas consumption (19 L/100km) and current Diesel price (2,350 MNT/L).

Based on our waste composition studies, we can roughly estimate that Khishig-Undur soum's households have an annual production of approximately 50 tons of glass bottles and 17 tons of PET bottles. This corresponds respectively to approximately 10 full Kama trucks of glass and 3 full Kama trucks of compressed PET, or less than 3 Daiso trucks of glass and 1 Daiso truck of compressed PET.

From an environmental standpoint, bringing all Khishig-Undur's glass and PET waste to Ulaanbaatar would thus lead to emit each year less than 4 tons of CO_2 with a Kama truck, or 2 tons of CO_2 with a Daiso truck. In comparison, according to the United States Environmental Protection Agency, one typical passenger vehicle emits about 4.6 tons of CO_2 yearly.[12] Therefore, if it allows to properly recycle all Khishig-Undur's glass and PET waste, we can consider that the overall CO_2 emission linked to transportation would be reasonably acceptable.

Nevertheless, even leaving environmental considerations aside, we should stress that profitability from selling recyclables to urban industry doesn't come without risks. If a soum's waste management system relies exclusively on trading its profitable recyclables, it is dependent on market prices, which are known for their instability. For instance, if oil's international exchange rate increases, the whole profitability of transporting PET from Khishig-Undur to Ulaanbaatar could collapse, and the soum's waste management system with it. Similarly, if urban recycling industries are overwhelmed with recyclables, it may lead to a decrease of purchasing prices, which would also impact the soum's waste management sustainability. In the light of these risks, favoring local recycling may probably be less profitable, but it would most likely be more resilient in the long run.

Another important resilience and sustainability factor lies in the public service nature of a soum's waste management system. A private operator may find interesting to take care of the most profitable recyclables (some middle men already roam soums to buy metal waste), but would most likely show no interest in other types of waste, which would therefore not be managed properly in the soum. More broadly, for a local waste management system to be sustainable, profit made out of the most profitable recyclables should not exit the system to end in a private operators' pockets, but it should be used as an ongoing investment to properly manage less profitable recyclables and worthless ultimate waste.

If investments are too high for soums to manage some specific waste, recycling facilities (or at least collection centers) could be set up in aimags' capitals such as Bulgan city. Our analysis does show that, due to shorter distances, profitability could be higher if we could sell our recyclables in Bulgan rather than in Ulaanbaatar. In a public service transportation-based system, money would not even need to be involved among aimags: rather than purchasing recyclables from soums (which it does not plan to do), Bulgan's public recycling facility could offer back some useful items to the soums that bring their recyclables there. Consecutively, soums would save money from not needing to purchase the said items, and thus use that money to finance transportation to Bulgan or invest in other aspects of their waste management system.

In conclusion, in order to establish an effective, resilient and sustainable waste management system in a soum, we advise that local administration (or another non-profit operator) remain in charge of waste management and look at the profitability from transporting and selling recyclables to urban

[12] https://www.epa.gov/greenvehicles/greenhouse-gas-emissions-typical-passenger-vehicle

industries as a partial or temporary solution. Before proper equipment and infrastructure is available in the soum, valuable recyclables (starting with PET bottles) can be sold in Ulaanbaatar so that the profit can help acquiring this equipment and infrastructure. But local recycling solution should progressively be developed so that, at some point, it can replace transportation permanently or, at least, in the event of a decrease in waste trade profitability.

ANNEX 1: PICTURES OF KHISHIG-UNDUR'S TRUCKS

Hyundai Porter

Hyundai Mighty

Kama

Hyundai Mighty 2

Daiso

ANNEX 2: DATA TABLES

SCENARIO 1: MANUALLY COMPRESSED PET

			Hyundai Porter	Hyundai Mighty	Kama	Hyundai Mighty 2	Daiso
	Truck		**Hyundai Porter**	**Hyundai Mighty**	**Kama**	**Hyundai Mighty 2**	**Daiso**
Ownership	**Ownership** (private or public)		Private	Private	Public	Private	Private
Trucks' carrying capacity	**Maximum tonnage in truck** (ton)		2,5	4	5,5	8	20
	Maximum volume in truck (m3)		13	26	23	33	122
	Estimated tonnage of manually compressed PET in truck at maximum volume (ton)		**0,3**	**0,7**	**0,6**	**0,9**	**3,3**
	Estimated tonnage-filling rate of each truck (% of maximum tonnage)		14%	18%	11%	11%	17%
Economic balance	**to UB**	**Cost per ton of PET transported to UB** (MNT)	574 951 MNT	456 395 MNT	432 363 MNT	711 051 MNT	483 692 MNT
		Cost for trip to UB with full truck (MNT)	200 000 MNT	320 000 MNT	267 900 MNT	640 000 MNT	1 600 000 MNT
		Income for full truck of PET sold in UB's recycling industry (MNT)	173 928 MNT	350 573 MNT	309 809 MNT	450 038 MNT	1 653 945 MNT
		Net profit of full truck transportation to UB (MNT)	-26 072 MNT	30 573 MNT	41 909 MNT	-189 962 MNT	53 945 MNT
		Net profit for 1 on of PET depending on truck (MNT)	**-74 951 MNT**	**43 605 MNT**	**67 637 MNT**	**-211 051 MNT**	**16 308 MNT**
	to Bulgan	**Cost per ton of PET transported to BULGAN** (MNT)	359 344 MNT	285 247 MNT	108 091 MNT	444 407 MNT	302 308 MNT
		Cost for trip to Bulgan with full truck (MNT)	125 000 MNT	200 000 MNT	66 975 MNT	400 000 MNT	1 000 000 MNT
		Income for full truck of PET disposed in Bulgan's public reycling facility (MNT)	0 MNT	0 MNT	0 MNT	0 MNT	0 MNT
		Net profit of full truck transportation to Bulgan (MNT)	-125 000 MNT	-200 000 MNT	-66 975 MNT	-400 000 MNT	-1 000 000 MNT
		Net profit for 1 ton of PET depending on truck (MNT)	**-359 344 MNT**	**-285 247 MNT**	**-108 091 MNT**	**-444 407 MNT**	**-302 308 MNT**
CO2 emission	**Type of gas**		Diesel	Diesel	Diesel	Diesel	Diesel
	Gas consumption (L/100km)		10	18	19	20	40
	Gas consumption per transported ton at maximum carrying capacity for this scenario (L/100km)		28,7	25,7	30,7	22,2	12,1
	Average CO2 emission (g/km)		266	479	505	532	1064
	to UB	**CO2 emission per trip to UB** (kg)	120	215	303	239	479
		CO2 emission per ton of PET transported to UB (kg)	**344**	**307**	**489**	**266**	**145**
	to Bulgan	**CO2 emission per trip to Bulgan** (kg)	30	54	76	60	120
		CO2 emission per ton of PET transported to Bulgan (kg)	**86**	**77**	**122**	**66**	**36**

SCENARIO 2: MECHANICALLY COMPRESSED OR SHREDDED PET

		Truck	Hyundai Porter	Hyundai Mighty	Kama	Hyundai Mighty 2	Daiso
Ownership		**Ownership** (private or public)	Private	Private	Public	Private	Private
Trucks' carrying capacity		**Maximum tonnage in truck** (ton)	**2,5**	**4**	**5,5**	**8**	**20**
		Maximum volume in truck (m3)	13	26	23	33	122
		Estimated volume of compressed PET in truck at maximum tonnage (m3)	8	13	18	26	65
		Estimated volume-filling rate of each truck if PET is compressed (% of maximum volume)	63%	50%	78%	78%	53%
		Estimated volume of shredded PET in truck at maximum tonnage (m3)	10	17	23	33	83
		Estimated volume-filling rate of each truck if PET is shredded (% of maximum volume)	81%	64%	100%	100%	68%
Economic balance	to UB	**Cost per ton of PET transported to UB** (MNT)	80 000 MNT	80 000 MNT	48 709 MNT	80 000 MNT	80 000 MNT
		Cost for trip to UB with full truck (MNT)	200 000 MNT	320 000 MNT	267 900 MNT	640 000 MNT	1 600 000 MNT
		Income for full truck of PET sold in UB's recycling industry (MNT)	1 250 000 MNT	2 000 000 MNT	2 750 000 MNT	4 000 000 MNT	10 000 000 MNT
		Net profit of full truck transportation to UB (MNT)	1 050 000 MNT	1 680 000 MNT	2 482 100 MNT	3 360 000 MNT	8 400 000 MNT
		Net profit for 1 on of PET depending on truck (MNT)	**420 000 MNT**	**420 000 MNT**	**451 291 MNT**	**420 000 MNT**	**420 000 MNT**
	to Bulgan	**Cost per ton of PET transported to Bulgan** (MNT)	50 000 MNT	50 000 MNT	12 177 MNT	50 000 MNT	50 000 MNT
		Cost for trip to Bulgan with full truck (MNT)	125 000 MNT	200 000 MNT	66 975 MNT	400 000 MNT	1 000 000 MNT
		Income for full truck of PET disposed in Bulgan's public reycling facility (MNT)	0 MNT	0 MNT	0 MNT	0 MNT	0 MNT
		Net profit of full truck transportation to Bulgan (MNT)	-125 000 MNT	-200 000 MNT	-66 975 MNT	-400 000 MNT	-1 000 000 MNT
		Net profit for 1 ton of PET depending on truck (MNT)	**-50 000 MNT**	**-50 000 MNT**	**-12 177 MNT**	**-50 000 MNT**	**-50 000 MNT**
CO2 emission		**Type of gas**	Diesel	Diesel	Diesel	Diesel	Diesel
		Gas consumption (L/100km)	10	18	19	20	40
		Gas consumption per transported ton at maximum carrying capacity for this scenario (L/100km)	4,0	4,5	3,5	2,5	2,0
		Average CO2 emission (g/km)	266	479	505	532	1064
	to UB	**CO2 emission per trip to UB** (kg)	120	215	303	239	479
		CO2 emission per ton of PET transported to UB (kg)	**48**	**54**	**55**	**30**	**24**
	to Bulgan	**CO2 emission per trip to Bulgan** (kg)	30	54	76	60	120
		CO2 emission per ton of PET transported to Bulgan (kg)	**12**	**13**	**14**	**7**	**6**

SCENARIO 3: INTACT GLASS FOR REUSING

		Truck	Hyundai Porter	Hyundai Mighty	Kama	Hyundai Mighty 2	Daiso
Ownership		**Ownership** (private or public)	Private	Private	Public	Private	Private
Trucks' carrying capacity		**Maximum tonnage in truck** (ton)	**2,5**	**4**	5,5	8	**20**
		Maximum volume in truck (m3)	13	26	23	33	122
		Estimated tonnage of glass bottles in truck at maximum volume (ton)	~~2,7~~	~~5,4~~	**4,8**	**7,0**	~~25,7~~
		Estimated tonnage-filling rate of glass bottles in truck at maximum volume (ton)	~~108%~~	~~136%~~	87%	87%	~~128%~~
		Estimated volume of glass bottles in truck at maximum tonnage (m3)	12	19	~~26~~	~~38~~	95
		Estimated volume-filling rate of glass bottles in truck at maximum volume (m3)	93%	74%	~~114%~~	~~115%~~	78%
Economic balance	to UB	**Cost per ton of glass bottles transported to UB** (MNT)	80 000 MNT	80 000 MNT	55 750 MNT	80 000 MNT	80 000 MNT
		Cost for trip to UB with full truck (MNT)	200 000 MNT	320 000 MNT	267 900 MNT	640 000 MNT	1 600 000 MNT
		Income for full truck of glass bottles sold in Tuvshinsaikhan (MNT)	250 000 MNT	400 000 MNT	480 536 MNT	698 042 MNT	2 000 000 MNT
		Net profit of full truck transportation to UB (MNT)	50 000 MNT	80 000 MNT	212 636 MNT	58 042 MNT	400 000 MNT
		Net profit for 1 ton of glass bottle depending on truck (MNT)	**20 000 MNT**	**20 000 MNT**	**44 250 MNT**	**8 315 MNT**	**20 000 MNT**
	to Bulgan	**Cost per ton of glass bottles transported to Bulgan** (MNT)	50 000 MNT	50 000 MNT	13 938 MNT	57 303 MNT	50 000 MNT
		Cost for trip to Bulgan with full truck (MNT)	125 000 MNT	200 000 MNT	66 975 MNT	400 000 MNT	1 000 000 MNT
		Purchasing price per ton necessary to balance transportation costs to Bulgan (MNT)	50 000 MNT	50 000 MNT	13 938 MNT	57 303 MNT	50 000 MNT
		Purchasing price per bottle necessary to balance transportation costs to Bulgan (MNT)	**27 MNT**	**27 MNT**	**8 MNT**	**31 MNT**	**27 MNT**
CO2 emission		**Type of gas**	Diesel	Diesel	Diesel	Diesel	Diesel
		Gas consumption (L/100km)	10	18	19	20	40
		Gas consumption per transported ton at maximum carrying capacity for this scenario (L/100km)	4,0	4,5	4,0	2,9	2,0
		Average CO2 emission (g/km)	266	479	505	532	1064
	to UB	**CO2 emission per trip to UB** (kg)	120	215	303	239	479
		CO2 emission per ton of glass transported to UB (kg)	**48**	**54**	**63**	**34**	**24**
	to Bulgan	**CO2 emission per trip to Bulgan** (kg)	30	54	76	60	120
		CO2 emission per ton of glass transported to Bulgan (kg)	**12**	**13**	**16**	**9**	**6**

SCENARIO 4: CRUSHED GLASS FOR RECYCLING

	Truck		Hyundai Porter	Hyundai Mighty	Kama	Hyundai Mighty 2	Daiso
Ownership	**Ownership** (private or public)		Private	Private	Public	Private	Private
Trucks' carrying	**Maximum tonnage in truck** (ton)		**2,5**	**4**	**5,5**	**8**	**20**
	Maximum volume in truck (m3)		13	26	23	33	122
Economic balance	**to UB**	**Cost per ton of glass transported to UB** (MNT)	80 000 MNT	80 000 MNT	48 709 MNT	80 000 MNT	80 000 MNT
		Cost for trip to UB with full truck (MNT)	200 000 MNT	320 000 MNT	267 900 MNT	640 000 MNT	1 600 000 MNT
		Income for full truck of glass sold in UB (MNT)	162 500 MNT	260 000 MNT	357 500 MNT	520 000 MNT	1 300 000 MNT
		Net profit of full truck transportation to UB (MNT)	-37 500 MNT	-60 000 MNT	89 600 MNT	-120 000 MNT	-300 000 MNT
		Net profit for 1 ton of glass depending on truck (MNT)	**-15 000 MNT**	**-15 000 MNT**	**16 291 MNT**	**-15 000 MNT**	**-15 000 MNT**
	to Bulgan	**Cost per ton of glass transported to Bulgan** (MNT)	50 000 MNT	50 000 MNT	12 177 MNT	50 000 MNT	50 000 MNT
		Cost for trip to Bulgan with full truck (MNT)	125 000 MNT	200 000 MNT	66 975 MNT	400 000 MNT	1 000 000 MNT
		Purchasing price per ton necessary to balance transportation costs to Bulgan (MNT)	50 000 MNT	50 000 MNT	12 177 MNT	50 000 MNT	50 000 MNT
CO_2 emission	**Type of gas**		Diesel	Diesel	Diesel	Diesel	Diesel
	Gas consumption (L/100km)		10	18	19	20	40
	Gas consumption per transported ton at maximum carrying capacity for this scenario (L/100km)		4,0	4,5	3,5	2,5	2,0
	Average CO_2 emission (g/km)		266	479	505	532	1064
	to UB	**CO_2 emission per trip to UB** (kg)	120	215	303	239	479
		CO_2 emission per ton of glass transported to UB (kg)	**48**	**54**	**55**	**30**	**24**
	to Bulgan	**CO_2 emission per trip to Bulgan** (kg)	30	54	76	60	120
		CO_2 emission per ton of glass transported to Bulgan (kg)	**12**	**13**	**14**	**7**	**6**