SOLID WASTE MANAGEMENT SCENARIOS FOR CETINJE IN MONTENEGRO

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ABSTRACT

This study, which was executed in the scope of the Western Balkan Investment Framework and has been financed by the EU to develop EU-standard integrated sustainable solid waste management in the city of Cetinje at Montenegro, presents the options for source-segregation and selective collection of recyclable waste fractions and establishment of equipment for pre-processing and preparing the waste for recycling, with the aim of meeting the EU 50% waste recycling target in 2023. To this end, three options; 1) source separation and separate collection of dry recyclable materials and central sorting of residual waste; 2) source separation and collection of co-mingled dry recyclable materials and central sorting in a clean material recovery facility of comingled recyclables and central sorting of residual waste; 3) collection of mixed waste and subsequent central sorting were considered. Scenario 1 and 2 were found to meet the EU 50% recycling target in 2023 provided that a fast implementation of the new separate collection schemes to fine sort the co-mingled collected recyclable materials is available. Finally, a financial evaluation was made for the options and the investment and operational costs over a 20 year period were estimated. Unit investment and operational costs for Scenario 3 were found to be lower than for Scenario 1 and 2. Knowing that Scenario 3 will not meet the future EU recycling targets, Scenario 2 has been pointed as the most feasible scenario for Cetinje with reference to the expected lower total costs compared to

Scenario 1. The major reason for the lower total costs of Scenario 2 compared to Scenario 1 are lower collection costs and higher revenue from sale of recyclable materials.

Key words: Solid waste management, recycling, optimum scenario.

INTRODUCTION

Montenegro applied to join the EU on 15 December 2008. In December 2011, the Council launched the accession process with a view to initiate negotiations in June 2012 and the European Commission identified 7 key priorities that would need to be addressed for negotiations to begin. Waste management is a key priority for the Montenegrin Government in the course of the accession negotiations. Currently, most of the municipal waste is disposed of in open sites or illegal dumps, which remains one of the most challenging problems for the country.

Cetinje is located in southern Montenegro very close to Podgorica, which is the present capital (Figure 1). Presently, collected waste of Cetinje is being transported and disposed at the Vrtijeljka dump-site 6 km far from the city centre.

Figure 1

Strategic Waste Management Plan of Montenegro (SWMP, 2005) and its revision (RSWMP, 2012) propose a regional approach towards waste management. In accordance with the proposed strategy; one of the regional centers; the 'Livade' landfill, which is located at 5 km southeast of Podgorica city centre, is to be used for the disposal of the waste from Cetinje. Construction of a composting facility is planned for this landfill site. The prepa-

ration and sorting of separately collected waste fractions (paper, plastic, glass, metal, and bio-waste) is also to be done at this site.

This study, which was executed in the scope of the Western Balkan Investment Framework (WBIF) and has been financed by the European Union (EC DG Enlargement) from Regional IPA Funds for Western Balkans, presents the options for source-segregation and selective collection of recyclable waste fractions and establishment of equipment for pre-processing and preparing the waste for recycling, e.g. balers and other equipment at the chosen site in the Municipality of Cetinje with the aim of meeting the EU 50% waste recycling target in 2023. To this end, three options; 1) source separation and separate collection of dry recyclable materials and central sorting of residual waste; (2) source separation and collection of co-mingled dry recyclable materials and central sorting in a clean material recovery facility (MRF) of comingled recyclables and central sorting of residual waste; (3) collection of mixed waste and subsequent central sorting were considered. For each scenario, waste flows and facilities needed were evaluated and a financial analysis was carried out. Based on the results from the financial analysis, the most feasible scenario was selected.

DEMOGRAPHY AND WASTE GENERATION

According to the latest census from 2011, the Old Royal Capital Cetinje has a population of 16,757 inhabitants, which is 2.67% of the total population of Montenegro (1). The census indicates that 84.54% of this population is urban and 15.46% is rural. The average number of inhabitants per household is reduced by around 15% from 3.81 members in 1958 to 2.92 members in 2011, which is lower than the average Montenegrin household number. In this study the average household size in the Old Royal Capital Cetinje was considered as 2.92, the number of single housing in Cetinje was foreseen as 85 % of population where rest of 15% are living in multi storey houses. The yearly variation in the number of single and multi-family housing based on the assumptions and data is as shown in Table 1 and Figure 2.

Table 1

Figure 2

SWMP (2005) indicated the specific waste generation in Montenegro as 1 kg per inhabitant per day (~ 365 kg per inhabitant per year). In the revision of SWMP (RSWMP, 2011), regional and also the average waste generation were calculated based on purchasing power parity index. The predicted average generation rate for Montenegro was indicated in RSWMP as 0.85 kg per capita per day.

In the RSWMP (2011), for the Central Montenegro Region where Cetinje is located, the forecasted municipal waste composition was given as in Figure 3.

Figure 3

This composition was projected considering expected economic developments as presented in Figure 4. The change in municipal solid waste composition originates from the increase in purchasing power, which results from the increase of percentages of paper, plastic, and metal wastes and bulky waste. Bio-waste portion of the municipal waste is not expected to change as home-composting practices are expected to increase in future, in suburban districts of Cetinje.

Figure 4

Waste generation projections for the City of Cetinje for the period 2014-2034 are presented in Table 2. In Cetinje, all waste producers are not covered with waste collection and transportation service. Waste collection estimations given in Table 2 are based on the following assumptions with reference to a previous report: i) urban and rural populations are as indicated in Table 1, ii) the connection rate to collection service will be 100 % in urban areas and 75% in rural areas up to 2020 and 80 % thereafter (COWI-IPF, 2012).

Table 2

ANALYSIS OF THE SCENARIOS

While analysing the possible scenarios, it was assumed that sorting efficiencies at households will increase in a step-wise manner. The non-sorted recyclables (in Scenario 1 and 2), or recyclables which cannot be sorted (in Scenario 3) will be collected with the residual waste. Also, it was assumed that sorting efficiency in dirty MRF will increase to 60% for bio-waste in the year of 2023.

Three recycling scenarios were proposed for the Old Royal Capital Cetinje for the period of 2014 – 2034. The considered scenarios are described below.

Scenario 1: Source separation and separate collection of dry recyclable materials (paper and cardboard, metal, plastic and glass) – and central sorting of residual waste

This scenario focuses on separate collection of source separated recyclable materials.

- Dry recyclable materials are separated at source and collected separately. In single family housing areas kerbside collection is applied. In multi-storey housing areas and general areas bring banks/drop off centres are applied (high density of drop off containers). All materials are collected and brought to a local reception centre equipped with a baler for paper, plastics and cardboard. No sorting takes place but all frac-

tions are sold to the recycling industry directly. The recycling industry will fine sort the received materials in individual types of plastics and metals.

- Residual fraction is transported to the dirty MRF plant in Podgorica. This plant is refurbished with a biological treatment unit to compost the bio-waste fraction sorted out at the plant.
- Household Hazardous Wastes (HHW), Waste Electrical and Electronic Equipments (WEEE), bulky wastes and large recyclable items (metal, plastics, cardboard) are brought to civic amenity sites (community recycling yard).

Table 3

Scenario 2: Source separation and collection of co-mingled dry recyclable materials (paper, card, metal, plastic and glass) – central sorting (clean MRF) of co-mingled recyclables – and central sorting of residual waste at Podgorica

This scenario focuses on collection of source separated co-mingled recyclable materials.

- Dry recyclable materials are separated at source and collected in a co-mingled form. In single family housing areas kerbside collection and in multi-storey housing areas and general areas bring banks/drop off

centres are applied. All the recyclable materials are brought to a central sorting facility (clean MRF), where fine sorting takes place into individual types of materials (paper & cardboard, ferrous metal, aluminium, glass and different types of plastics (PE, PP, PET, PS). Fine sorted materials are sold to the recycling industry at high prices.

- Residual fraction is transported to the dirty MRF plant in Podgorica. This plant is refurbished with a biological treatment unit to compost the bio-waste fraction sorted out at the plant.
- HHW, WEEE, bulky wastes and large recyclable items (metal, plastics, cardboard) are brought to civic amenity sites (community recycling yard).

Table 4

Scenario 3: Collection of mixed waste and subsequent central sorting at the Podgorica plant

This scenario expresses a situation where no actions are made locally for source separation (Business as usual).

- Mixed waste is brought to the dirty MRF facility in Podgorica. This plant is refurbished with a biological treatment unit to compost the bio-waste fraction sorted out at the plant. At the plant individual types of materials (paper & cardboard, ferrous metal, aluminium, glass and

plastic) are sorted out. Fine sorted materials are sold to the recycling industry. The recycling industry will further fine sort the received materials in individual types of plastics and metals. Compost is used as final cover material at the central landfill and as soil conditioner if acceptable compost quality is produced at the plant.

- HHW, WEEE, bulky wastes and large recyclable items (metal, plastics, cardboard) are brought to civic amenity sites (community recycling yard).

Table 5

FACILITIES NEEDED

In evaluating facilities needed; all facilities were considered such as containers, vehicles, drop-off sites, clean MRF, dirty MRF, civic amenity sites and reception centre. In all three scenarios, for the final treatment and disposal of bio-waste portion, windrow composting is foreseen. This composting plant is planned to be installed at the regional landfill Livade in Podgorica and to serve other municipalities as well. In cost calculations, it was considered that:

- Dirty MRF at Livade will have capacity of 90,000 t/year and will serve for Cetinje (4,000 tons of residual waste per annum). Cetinje will cover partly the associated costs as corresponding to the quanti-

ty of waste from this city divided by the total input to the plant (= 4,000/90,000).

- Compost Plant will be in service by the year 2018.

Dirty MRF will commence with sorting the bio-waste after compost plant has been put into operation. It will separate 60 % of the biomass in the period of 2018-2034.

Scenario 1 requires the installation of;

- Drop-off sites for the collection of source separated recyclables from multi-storey houses;
- Containers for the kerbside collection of source separated dry recyclables from single family houses;
- A dirty MRF for sorting the incoming residual waste into recyclables (glass, plastic, metal, paper), bio-waste and residual to landfill (already existing at Livade);
- A composting facility for bio-waste; it is to be built at Livade in 2018;
- A civic amenity site for recycling of HHW, WEEE and bulky wastes;
- A simple reception facility or centre where source separated recyclables are baled and stored.

Dirty MRF (already exists), reception centre and compost plant are to be located at Livade Landfill Site whereas civic amenity site is to be built at a location inside Cetinje.

Scenario 2 requires the installation of;

- Drop-off sites for the collection of co-mingled dry recyclables from multi-storey houses;
- Containers for the kerbside collection of co-mingled dry recyclables from single family houses;
- A clean MRF for sorting incoming co-mingled dry recyclables from single family and multi-storey houses;
- A dirty MRF for sorting the incoming residual waste from single family and multi-storey houses into recyclables (glass, plastic, metal, paper), bio-waste and residual to landfill (already exists at Livade);
- A composting facility for bio-waste;
- A civic amenity site for recycling of HHW, WEEE and bulky wastes.

Dirty MRF (already exists), clean MRF and compost plant are to be located at Livade Landfill Site whereas civic amenity site is to be built at a suitable location based on feasibility.

Scenario 3 requires the installation of;

- Containers for the kerbside collection of mixed waste from sources;
- A dirty MRF to separate the incoming residual waste into left-over of dry recyclable (glass, plastic, metal, paper) from sources, bio-waste and others fractions (already exists),
- A composting facility for bio-waste;
- A civic amenity site for recycling of HHW, WEEE and bulky wastes.

The estimations carried out have indicated that ultimately (year 2034) Scenario 1 and 2 will result in a total recycling rate of around 56-59% compared to Scenario 3 having 37% recycling rate. Recycling of bio-waste is contributing with around 12-15% leaving a recycling rate of 41-44% for the dry recyclable materials in scenario 1 and 2 and 22% in Scenario 3. The high recycling rates mentioned above are valid only if the compost from the MBT plant is used for beneficial purposes as replacing of fertilisers or soil conditioners at farm land and in horticulture or viniculture. In case it replaces soil conditioners in gardens and parks as well as e.g. road embankments and golf courses, this application will also add to the recycling rate. In case the compost is used as final cover at landfill or used for reclamation or engineering purposes (e.g. back fill) the use of the compost will not add to the recycling rate according to COM 2011-753 (Note from EU).

Scenario 1 and 2 are expected to meet the EU 50% recycling target in 2023 conditioned a speedy implementation of the new separate collection schemes with or without construction of a new MRF to fine sort the co-mingled collected recyclable materials (The method for calculating the recycling rate for the 50% target is not clearly defined by EU. This relates to the fractions to include and the type of waste forming basis for the calculation. Each member state is to decide on fraction and type of waste to include). Scenario 3 will according to the estimates made not be able to meet this target. The above remark on the use of compost from the MBT plant is valid also here.

Considering the Landfill Directive requirements on diversion of biodegradable waste from landfilling (25%, 50% and 65% diversion) all scenarios are expected to meet these requirements since the bio-waste and other biodegradable fractions are being composted in all scenarios. It can be concluded from the remarks on use of compost, that the operators of the MBT plant in Podgorica (and other MBT's) should give high priority to produce a good and acceptable quality compost meeting national/international compost standards for application at places mentioned above.

FINANCIAL EVALUATION

Expenditures

The estimated NPV of investment and operating costs all scenarios are presented Table 6. As seen, the unit costs of Scenario 1, Scenario 2 and Scenario 3 are €196.8, €147.9 and €86.6 respectively, per ton of municipal solid waste.

Table 6

Revenues

The financial valuations assume that recyclable materials will be received free of charge and therefore only revenue from the sale of recyclable materials is anticipated. Based on the commodity prices adjusted to the quality of recyclable materials derived from household waste, possible revenues for all scenarios are estimated (Table 7). The unit prices considered in these estimations are on the basis of different unit prices for the materials from the reception centre, the clean MRF and the dirty MRF. The value of recyclable plastic and metal from a clean MRF will always be higher than from a reception centre and a dirty MRF due to higher quality. Plastic delivered to a reception centre moreover will be mixed and therefore has a very much lower price since this plastic is not separated into individual plastic poly-

mers. The same counts for metal, which is not separated into ferrous and non-ferrous metal.

Table 7

CONCLUSIONS

From the waste flow calculations it can be seen that Scenario 1 and 2 ultimately (2034) will result in a total recycling rate of 59% and 56%, respectively compared to Scenario 3 having 37% recycling rate. Recycling of bio-waste is contributing with around 12-15% leaving a recycling rate of 41-44% for the dry recyclable materials in Scenario 1 and 2 and 22% in Scenario 3.

Scenario 1 and 2 will meet the EU 50% recycling target in 2023 conditioned a speedy implementation of the new separate collection schemes with or without construction of a new MRF to fine sort the co-mingled collected recyclable materials. Further conditioned, that the application of compost is accepted as recycling – at least for a certain proportion of the compost. Scenario 3 will according to the estimates made not be able to meet this target. A continuation of this present situation will not fulfil the future EU requirement/recycling targets. In future, elements from scenario 1 and 2 will need to be included in the schemes for waste management in Cetinje. The overall result of the financial assessment is presented in

Table 8.

As can be seen from

Table 8, unit investment and operational costs for Scenario 3 is lower than for Scenario 1 and 2. There are two major reasons for this, namely

- Only one fraction of waste (the mixed residual fraction) is collected from the households. Introduction of any kind of separate collection of recyclable materials will increase the collection costs considerably.
- Cetinje is to be connected to an existing sorting plant (dirty MRF) having been in operation for some years. In the case a new dirty MRF was to be constructed and in the case this new plant would be equipped with advanced automatic sorting equipment the investment costs are expected to be considerable higher (maybe 2 to 3 times higher).

Table 8

Knowing that Scenario 3 will not meet the future EU recycling targets, Scenario 2 will be the preferred future scenario for Cetinje owing to the expected lower total costs than Scenario 1. The major reason for the lower total costs are; lower collection costs and higher revenue from sale of recyclable materials.

The costs of investments and operations in scenario 1 are higher than Scenario 2, which is due to high investment and operational costs for the extended collection services. Separate collection of single source separated materials is expensive and involves purchase of many containers and empty-

ing of same. Such a collection scheme can be designed in different ways and it might be possible to have savings in the scheme by introducing multi chamber containers and combined collection of these. This might narrow in the costs for the two scenarios.

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LIST OF FIGURES

Figure 1


MONTENEGRO
Pljevlja
Bobotov Kuk
(2523m)
Đurđevića
Tara
SERBIA
BOSNIA &
HERCEGOVINA
Durmitor
National
Park
Žabljak
Bijelo Polje
Mojkovac
CROATIA
MONTENEGRO
Berane
Rožaje
Nikšić
Kolašin
Ostrog
Djeravica
(2656m)
Mt Jezerce
(2694m)
Bijela
Herceg
Novi
Kotor
Cetinje
PODGORICA
KOSOVO
Bay of
Kotor
Tivat
Virpazar
Budva
Drin River
ADRIATIC
SEA
Sveti Stefan
Lake
Skadar
Sutomore
Bar
0
50 km
0
30 miles
Ulcinj
ALBANIA

Figure 2

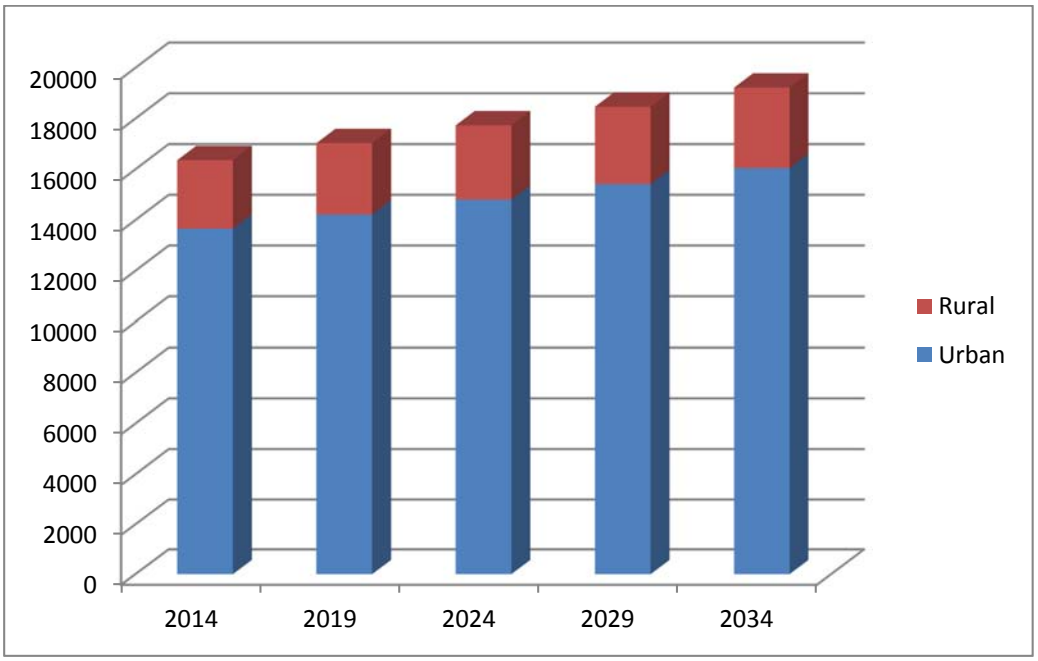
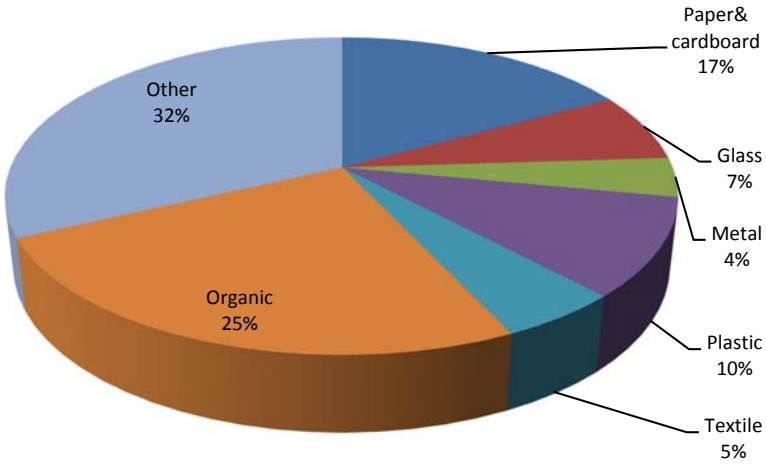

20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
2014
2019
2024
2029
2034
Rural
Urban

Figure 3


Paper&
cardboard
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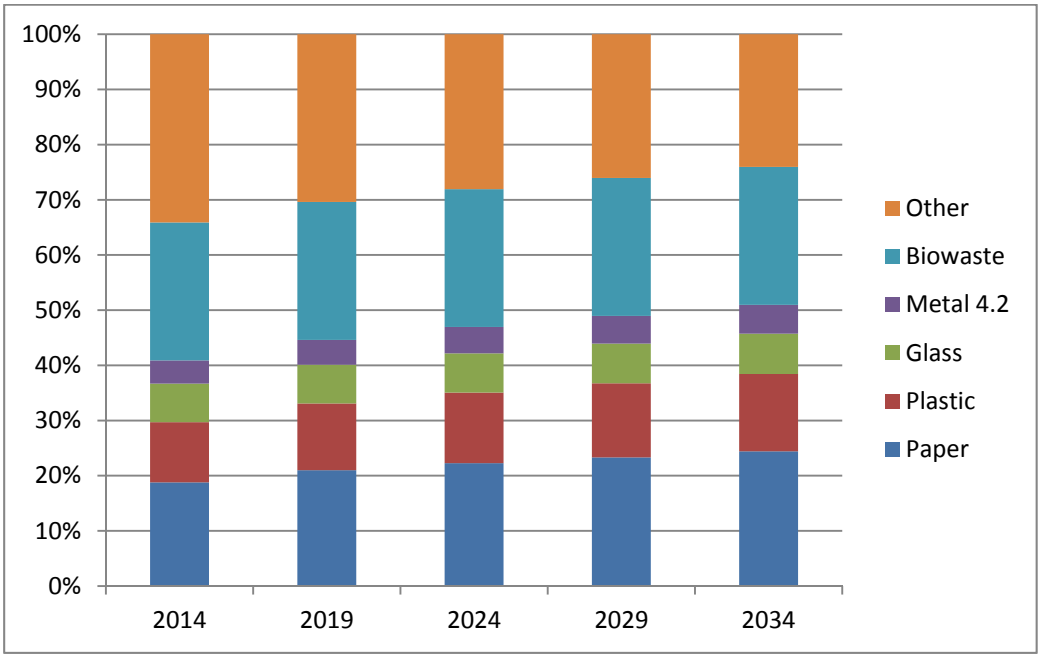
Glass
7%
Metal
4%
Plastic
10%
Textile
5%
Organic
25%
Other
32%

Figure 4


100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
2014
2019
2024
2029
2034
Other
Biowaste
Metal 4.2
Glass
Plastic
Paper

LIST OF TABLES

Table 9

Year	Demographic growth, %	Population	Urban population[2]	Rural Population	Total # of dwellings	# of single family houses	# of multi-storey houses (# of dwellings)
2014	-0.8	16358	13657	2701	5602	4762	56 (840)
2019	+0.81	17031	14219	2812	5833	4958	58 (875)
2024	+0.81	17732	14804	2928	6073	5162	61 (911)
2029	+0.81	18463	15415	3048	6323	5375	63 (948)
2034	+0.81	19222	16048	3174	6583	5595	66 (987)

Table 2

Year	Total waste generated t/y	Waste generation in urban settlement t/y	Waste generation in rural set-tlement t/y	Waste collection in urban areas %	Waste collection in rural areas %	Waste collected from urban areas t/y	Waste collected from rural areas t/y	Total waste to be collected t/y
2014	5560	4642	918	100	75	4642	688	5331
2019	5789	4833	956	100	75	4833	717	5550
2024	6027	5032	995	100	80	5032	796	5828
2029	6275	5239	1036	100	80	5239	829	6068
2034	6533	5455	1079	100	80	5455	863	6318

Table 3

Year	Total Waste t/y	Residual waste, t/yr		Sorted at Dirty MRF, t/yr					% recycling	Waste to the Landfill t/y
		Single houses	Multi-storey houses	Paper	Plastic	Glass	Metal	Bio-waste		
2014	5331	3849	679	235	170	63	132	0	26	3927
2024	5828	3237	571	87	137	15	89	874	55	2606
2034	6318	3352	592	103	163	17	106	948	59	2607

Table 4

Year	Total waste t/yr	Sorted at Clean MRF, t/yr				Sorted at Dirty MRF, t/yr					Total Recycled, t/yr				% recycling	Waste to the Landfill t/yr
		Paper	Plastic	Glass	Metal	Paper	Plastic	Glass	Metal	Bio-waste	Paper	Plastic	Glass	Metal		
2014	5331	392	134	154	67	235	170	63	132	0	627	304	217	199	25	3983
2024	5828	1027	342	344	166	87	137	15	89	874	1114	479	359	254	53	2747
2034	6318	1220	407	384	197	103	163	17	106	948	1323	570	547	302	56	2774

Table 5

Year	Total waste t/yr	Co-mingled waste, t/yr		Sorted at Dirty MRF, t/yr					% recycling	Waste to landfill, t/yr
		Single houses	Multi storey houses	Paper	Plastic	Glass	Metal	Bio-waste		
2014	5331	4531	800	400	233	112	192	0	18	4394
2024	5828	4954	874	519	298	124	237	874	35	3776
2034	6318	5370	948	617	354	138	282	948	37	3979

Table 6

	SCENARIO 1	SCENARIO 2	SCENARIO 3
TOTAL INVESTMENT	10,037,624	6,597,333	3,791,387
Collection	5,116,509	1,793,916	1,094,690
Single family houses	4,247,803	1,436,651	820,329
Multi-storey houses	868,706	357,264	274,361
Dirty MRF	0	0	1,240,467
Composting	1,380,007	1,456,968	1,433,104
Reception centre	2,324,332	2,061,816	
Dirty MRF	1,194,506	1,261,122	
Civic Amenity Site	22,269	23,511	23,126
INVESTMENT UNIT COST (€/ton)	**82.1**	**54.0**	**31.0**
TOTAL OPERATION AND MAINTENANCE	**14,018,258**	**11,474,504**	**6,788,859**
Collection	6,212,084	4,680,699	2,154,371
Single family houses	3,887,990	3,590,184	1,505,083
Multi-storey houses	2,324,094	1,090,516	649,288
Dirty MRF			2,204,566
Composting	1,392,427	687,386	688,075
Reception centre	1,431,155	1,946,995	
Dirty MRF	2,206,920	2,202,357	
Civic Amenity Site	382,362	381,571	381,954
Miscellaneous	2,393,310	1,575,495	1,359,892
O & M UNIT COST (€/ton)	**114.7**	**93.9**	**55.6**
TOTAL COST	**24,055,882**	**18,071,837**	**10,580,246**
TOTAL UNIT COST (€/ton)	**196.8**	**147.9**	**86.6**

Table 7

Year	Scenario 1	Scenario 2	Scenario 3
2014	147,583	178,321	117,932
2024	183,412	246,525	120,869
2034	175,135	235,469	115,472
Total	**3,587,258**	**4,693,192**	**2,505,629**
Net unit revenue €/ton	**29**	**38**	**21**

Table 10

	Scenario 1	**Scenario 2**	**Scenario 3**
REVENUE	4,629,007	6,081,125	3,206,590
NPV	3,587,258	4,693,192	2,505,629
Unit Revenue €/ton	29.4	38.4	20.5
INVESTMENT	11,452,899	7,129,913	4,165,681
NPV	10,037,624	6,597,333	3,791,387
Unit Cost €/ton	82.1	54.0	31.0
OPERATION AND MAINTENANCE	17,776,791	14,581,162	8,618,259
NPV	14,018,258	11,474,504	6,788,859
Unit Cost €/ton	114.7	93.9	55.6
NET COST, NPV, €	**20,468,625**	**13,378,645**	**8,074,616**
Net Unit Cost, €/ton	**167.5**	**109.5**	**66.1**