Exploring Solid Waste Management Scenarios for the Old Royal Capital Cetinje in Montenegro

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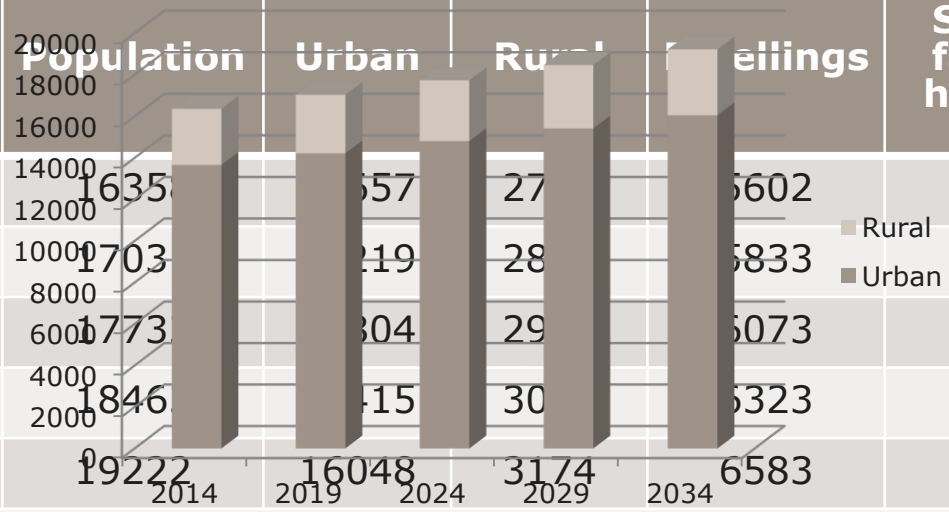
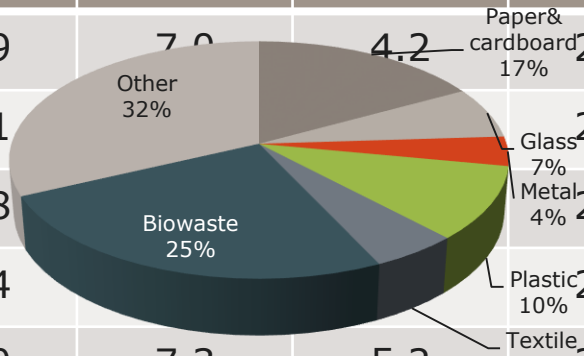
Estimated demographic growth and projected urban and rural populations

Year	Growth	Population	Urban	Rural	Dwellings	Single family houses	Multi-storey houses
2014	-0.8	1635	557	27	6602	4762	56 (840)
2019	+0.81	1703	219	28	6833	4958	58 (875)
2024	+0.81	1773	304	29	6073	5162	61 (911)
2029	+0.81	1846	415	30	6323	5375	63 (948)
2034	+0.81	19222	16048	3174	6583	5595	66 (987)



Expected change in municipal waste composition

Year	Paper	Plastic	Glass	Metal	Biowaste	Other	Total
2014	18.8	10.9	7.0	4.2	25.0	34.1	100.0
2019	21.0	12.1	7.0	4.5	25.0	30.4	100.0
2024	22.3	12.8	7.2	4.7	25.0	28.1	100.0
2029	23.3	13.4	7.3	5.0	25.0	26.0	100.0
2034	24.4	14.0	7.3	5.2	25.0	24.0	100.0



Estimated solid waste generation and collection

Year	Total waste	Urban waste	Rural waste	Urban collection %	Rural Collection %	Total collection
2014	5560	4642	918	100	75	5331
2019	5789	4833	956	100	75	5550
2024	6027	5032	995	100	80	5828
2029	6275	5239	1036	100	80	6068
2034	6533	5455	1079	100	80	6318

HHW, WEEE and bulky waste generation

Year	Population	Hazardous waste, t/y	WEEE, kg/person/y	WEEE, t/y	Bulky waste, t/y
2014	16,358	8.2	4	65	327
2019	17,031	8.5	18	307	1,533
2024	17,732	8.9	20	355	1,773
2029	18,463	9.2	20	369	1,846
2034	19,222	9.6	20	384	1,922

Scenario 1 - Separate collection of source separated materials + Dirty MRF

Year	Total waste (ton)	Residual waste		Sorted at Dirty MRF					% recycling	Landfill
		Single houses	Multi-storey houses	Paper	Plastic	Glass	Metal	Biowaste		
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

- Drop-off sites for recyclables from multi-storey houses
- Containers for the kerbside collection of paper, plastics and metal
- Central Dirty MRF for sorting the collected residual waste
- Composting plant for bio-waste
- Civic amenity site for recycling of HHW, WEEE and bulky wastes
- Reception centre where source separated recyclables are baled and stored before delivery to recyclers.

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Scenario 2 - Collection of co-mingled source separated materials + Clean MRF

Year	Total waste (ton)	Sorted at Clean MRF				Sorted at Dirty MRF					Total recycled				% recycling	To landfill
		Paper	Plastic	Glass	Metal	Paper	Plastic	Glass	Metal	Biowaste	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

- Drop-off sites for recyclables from multi-storey houses
- Containers for the kerbside collection
- Clean MRF for sorting incoming co-mingled dry recyclables
- Dirty MRF for sorting the incoming residual waste
- Composting plant for bio-waste
- Reception centre where source separated recyclables are baled and stored.
- Civic amenity site for recycling of HHW, WEEE and bulky wastes

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Scenario 3 - Collection of mixed waste + Dirty MRF

Year	Total waste (ton)	Co-mingled waste		Sorted at Dirty MRF					% recycling	To landfill
		Single houses	Multi storey	Paper	Plastic	Glass	Metal	Biowaste		
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

- Kerbsite collection of mixed waste
- Dirty MRF to separate the residual waste dry recyclable, bio-waste and other fractions
- Composting plant for bio-waste
- Civic amenity site for recycling of HHW, WEEE and bulky wastes.

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Qualitative evaluation

- Scenario 1 and 2 shall meet the EU 50% recycling target in 2023 conditioned a fast implementation of the new separate collection schemes with or without construction of a new MRF to fine sort the co-mingled collected recyclable materials. Scenario 3 will according to the estimates made not be able to meet this target.
- 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 biowaste and other biodegradable fractions are being composted in all scenarios.

NPV of investment and operational costs

	SCENARIO 1	SCENARIO 2	SCENARIO 3
TOTAL INVESTMENT	10,037,624	6,597,333	3,791,387
INVESTMENT UNIT COST (€/ton)	82.1	54.0	31.0
TOTAL OPERATION/MAINTENANCE	14,018,258	11,474,504	6,788,859
TOTAL COST	24,055,882	18,071,837	10,580,246
TOTAL UNIT COST (€/ton)	196.8	147.9	86.6

Net present value (NPV) of revenues

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

Cost comparison for the scenarios proposed

	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

Conclusions

Unit investment and operational costs for Scenario 3 is lower than for Scenario 1 and 2.

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

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Conclusions

Knowing that Scenario 3 will not meet the future EU recycling targets, Scenario 2 is the preferred future scenario for Cetinje owing to the expected lower total costs than Scenario 1.

- Costs in Scenario 1 high due to high investment and especially high operational costs for the separate collection services. Further revenue from sale of recyclable materials is 1 lower due to sale of mixed plastic and metal fractions (market price low)
- Costs in Scenario 2 lower due to lower costs for the collection of co-mingled fractions and to higher value of the recyclable materials

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Thanks for your attention

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