Preparation of the Conceptual Design

of complete isolation, re-cultivation of I and II cells in Tbilisi Household Solid Waste Landfill, arrangement gas collection system and turning biogas into a valuable product, preparation of the Conceptual Design the in-service cell III in accordance with the exploitation-development and final re-cultivation, procurement organization, construction supervision and project management

Volume 2

Conceptual Design

Part II

Project: NAT190002890

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Contents

Abbreviations

HDPE - High density polyethylene

PEH - Polyethylene

PN - Pression Nominal

Ltd. – Limited Liability Company

Introduction

The basis of the curent document is the State Procurement Agreement N30-212 signed between Tbilservice Group Ltd and Geo-Consultant Ltd on May 22, 2019, with the aim of improvement of waste management at Tbilisi's Didi Lilo Household Solid Waste Landfill by developing systematic approaches in line with national legislation and European standards.

The Project Beneficiary	**Tbilservice Group Ltd**
Duration	**22.05.2019 – 21.06.2021**
Cost	**1 390 646.52 GEL (including VAT)**
Place of implementation	**Tbilisi Solid Waste Household Polygon**
The Executor	**Geo Consultant Ltd**
The Financial supporter	**The municipal budget**

Conceptual project for the cancellation of biotermic (animal corps) pit located on the Polygon

The Legal Framework

In Georgia the animal waste management system is under development. The process of harmonization of the existing national legislation with the EU Directives, as part of the Association Agreement between Georgia and the European Union, is underway. On the basis of which, Government of Georgia on December 29, 2017 issued the Technical Regulation # 605 - **Rules for the recognition of the non-food products of animal origin (including animal waste) and the second-hand products not intended for human consumption, health and business operator-related rules**.

In accordance with the Waste Management Code of landfills with Environmental Impact Asesment, it's forbidden to place untreated waste on the polygon, but Resolution of Government of Georgia #160, On the "Approval of the Waste Management 2016-2030 National Strategy and the 2016-2020 National Action Plan" provides for gradual reduction in the placement of organic waste at the landfill.

Nowadays, the animal waste generated during the production process is placed on the existing landfills, which are strictly controlled by the Ministry of Agriculture of Georgia, together with LEPL National Food Agency.

The brief review of the current situation

In the Environmental Impact Assessment Document for the construction of the Landfill in Tbilisi in 2010, by the Conceptual Project was provided the incinerator with capacity of 200 kg/h, designed to neutralize the biological (anatomical, veterinary) waste generated in the city. However, instead of the incinerator, in Didi Lilo area, on the plot of 147.5 m^2, was placed the 6 feet deep sarcophagus for the corpses of animals (Fig. 1), which has been managed by the LEPL Animal Monitoring Agency since 2014, which is subordinate to Tbilisi City Hall. Its construction is associated with the observance of sanitary and

hygienic standards caused by the carcass of homeless animals in the capital, as well as with the prevention and reduction of risks to the health of the population and animals.

The sarcophagus is the sealed reinforced concrete structure, which is divided into the wells and metal hatches are installed on the surface. The surface of the biothermal pit is covered with the layer of clay and gravel. According to the information received from the management of the Polygon, the staff of the LEPL Animal Monitoring Agency is still placing the carcass in the sarcophagus. Despite communication with agency staff over the phone and by email, could not get information on the number and treatment practices of the carcass, as well as laboratory information about animal carcass. In the light of the foregoing, experts should consider ways to eliminate the risks associated with the spread of various types of diseases, due to the closure of the sarcophagus.

Fig. 1. Biothermal pit located on Didi Lilo Landfill

The exist waste disposal practices do not comply with the requirements of technical regulation # 605. In order to ensure proper waste management and compliance with the national legislation on the animal waste management, Didi Lilo management decided to close the sarcophagus of the animal carcasses. In order to prepare the Conceptual Project for its closure, Geo Consultants Ltd experts conducted field studies on site and made the necessary recommendations.

Conceptual project for closing of the animal corps sarcophagus

On Didi Lilo Landfill, the animal corps sarcophagus, which planed be closed, has been working without permission since 2014. Since no competent authority has produced the necessary documentation for the construction, operation and closure of the sarcophagus in advance, there are therefore no conditions for its closure. Nor does national law regulate the procedures for closing such facilities. Works to prepare the new Environmental Impact Assessment (EIA) report for Didi Lilo landfill is underway, in which by the executor will be developed the detailed project of sarcophagus closure based on the Conceptual Design. It will be submitted to the Ministry of Environment and Agriculture of Georgia for further coordination, together with the updated EIA of the Landfill.

The sarcophagus of Didi Lilo Polygon is the hermetically sealed monolithic, reinforced concrete structure that eliminates the penetration of human or other living organisms and the contamination of groundwater and soil with waste. No unpleasant odors were detected during field studies. In 2015, Gamma Consulting Ltd developed the sarcophagus closure recommendations, which were also reviewed by the expert in Geo-Consultants Ltd.

The opinions of both expert groups coincide, and they recommend:

1) Spray the disinfectant solution (dry chlorine lime) through the hatches of the pit onto the surface of the animal carcass;
2) Three days after disinfection by dry chlorine lime, pour concrete onto the surface of the animal carcass forming the coating of 0.50 m thick;
3) All six hatches of pit should be seal. The gaps between the hatch and its frame should be weld by the welding with the help of reinforcing bars;
4) The site of the pit should be covered with the two-meter layers of the following

content: Clay layer - 0,5 m; local soil - 1,1-1,2 m; Fertile soil - 0,2-0,3 m;

5) Sowing perennial herbaceous plants on the fertile surface of 420 m^2.

The alternative to the aforementioned closure procedures is the exhumation of waste, followed by the incineration and placement of ash on the Landfill.

Investigation of the landfill gas composition

In June 28-29, 2019, in order to determine the composition of gases emitted at Didi Lilo test site, Geo-Consultants expert group conducted the study using in advance calibrated in Great Britain equipment. The following chapters provide the brief overview of the situation at the Polygon, results of the conducted research, and the conclusions and recommendations based on the research results.

The brief review of situation at «Didi Lilo" Polygon

The total area of the I and II cells intended for waste disposal on Didi Lilo is 17 ha. Currently, no waste disposal takes place on these cells. Between the July 2010 and July 2019, into the both cells were disposed the 2.8 million tons of municipal solid waste.

Cell I is closed, including the layer which should be restored, although its one slope is destroyed and needs rehabilitation. Near the collapse area, is observed the convexity of the upper overlap layer — the geomembrance — by the emitted gases from the waste. The I cell has the 39 units of the vertical gas collecting well. The gas collecting well is the thick-walled D160 perforated HDPE pipe. Each well reaches in length about 40 meters and is surrounded by the 1 m diameter channel filled with thick gravel to prevent clogging of the perforated pipe sections.

Fig. 2. View of the cell I on Didi Lilo Polygon

Waste in the II Cell is no longer disposed of, although it is covered with the layer of earth and requires closure in accordance with Technical Regulation No. 421. Thise cell has 54 units of the vertical gas collecting wells with the same technical characteristics as have cell I.

The upper part of the gas collection wells is non-perforated and visually you can see the pipe protruding 1 meter from the surface of the waste. The non-perforated upper part of the pipe is equipped with the sealed adapters D600/D110. The upper part of the channel filled with gravel around the gas collecting well of cell I, is located under the drainage system. Closing the surface of the cell II is in the active phase, so the perforated sections of the gas collection pipes are not completely covered. This circumstance prevented the measurement of the composition of gases from the wells of cell II.

Disposal of the waste in cell III at Didi Lilo Landfill began in July 2019.

Landfill gas composition study was carried out in the two stages:

1. Express pumping and determination of the gas composition;
2. Powerful pumping and determination of the composition of gases (the composition of the test well was determined from 3 to 8 different samples).

Results of research

Express pumping of the Landfill gases was carried out by the team of specialists during the 2 minutes using the integrated pump with capacity of 1 l/s. The composition of the gases was analyzed by means of the multi-channel GEOTECH GA5000 gas analyzer, which is specially used in the Waste Disposal Sites - on Polygons, for the determination of critical gas concentrations in gas emissions. GEOTECH GA5000 gas analyzer (Fig. 3.) determines the concentration of O_2, CH_4 and CO_2 in the gas samples, and measures the content of H_2S, NH_3, H_2 and CO in ppm. The analyzer is calibrated by the manufacturer until June 14, 2022.

Fig. 3. „GEOTECH GA5000" Gas analyzer

From the 42 gas wells of Polygon I and II cells, the composition of the gases was determined by express pumping. On the Fig. 4 is shown the location of the analytical wells, and the exact coordinates are determined by the integrated GPS and presented in Appendix 1.

The composition of the gases was determined by powerful pumping in wells # 1 and # 24 in the pre-selected analysis area, of which # 1 is located in the I cell and # 24 located in the II cell. The wells were selected by express pumping during the analysis. The concentration of methane (CH_4) in the gas sample from well # 1 was 55%, and the concentration of methane in the sample # 24 was relatively low. Pumping was performed for 1 hour using the pump at 10 l/sec (see Fig. 5 and 6). The detailed results are presented in the Appendix 1.

Fig. 4. The location of the analytical wells on the I and II cells

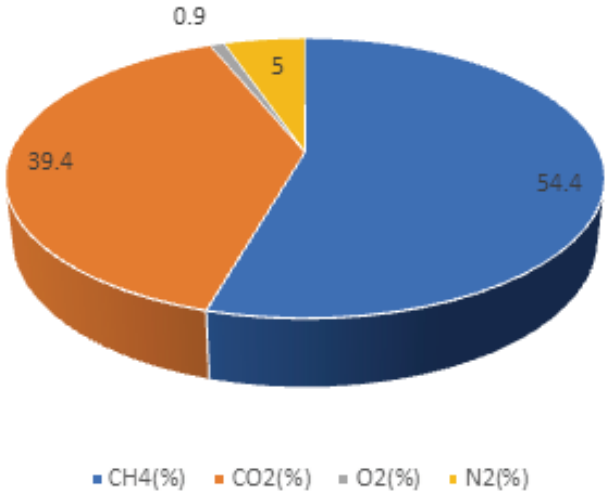
Fig. 5. Process of determining composition of the gases pumped from the analytical well

Fig. 6. Pump installed in the analytical well

The average composition of the gases emitted by the express pump from Polygon's gas collection wells of I cell is given in Table 1 and Graph 1. The obtained data are consistent with the data of Solid Waste Landfills in the continental climate zone. The 16 out of 17 gas wells are functioning normally and from them is possible collection of the gas. The 1 gas well is damaged and needs repair. The gas composition of the main macrocomponents (characteristic of biodegradation of the waste) and the amount of air in the gas indicates the proper functioning of the gas wells and the drainage layer. The average of methane (CH_4) in gas samples was 54.4%.

Basic components	CH_4(%)	CO_2(%)	O_2(%)	NH_3(ppm)	CO(ppm)	H_2(LMH)	H_2S(ppm)	Flow Power (L/sec) After Pump Disconnection
Average	54.4	39.4	0.9	192	12.9	63.2	413	0.6
Max	58.9	42.6	7.6	550	27.0	208.0	798	1.1
Min	34.2	24.8	0.1	68	5.0	3.0	110	0.1
Total number of analytical samples	16							

Table 1: The average rate of composition of gases emitted from the I cell by express pump



Graph 1: The average rate of composition of gases emitted from the I cell

Was conducted the study of the gas composition powerful pump from the # 1 gas collection well of the I cell. When using this method of determining the composition of the gas, there was the decrease in the concentration of the main components in the sample and an increase in air content. In particular, the methane concentration in the sample decreases and

the oxygen (O_2) content increases. When strong pumping was carried out at the power of 10 L/sec for 1 hour the methane concentration in the gas sample decreased from 58.9% to 31.3%.

See Table 2 for the results of gas pumping studies, taken from the #1 gas collection well.

Date/Time	CH_4 (%)	CO_2 (%)	O_2 (%)	NH_3 (ppm)	CO (ppm)	H_2 (ppm)	H_2S (ppm)	Pumping power (l/s)	Note
	58.9	39.8	0.3	257	5	3	738	10	Active pumping phase
6/28/2019 15:12	37.6	27	6.1	148	21	21	349	10	Active pumping phase
6/28/2019 16:01	31.5	24.7	6.5	78	19	73	67	10	Active pumping phase
6/28/2019 16:02	31.3	24.5	6.4	80	21	83	57	10	Active pumping phase

Table 2: Results of study of the composition of gas sample obtained by the powerful pumping from the well # 1 of the I cell

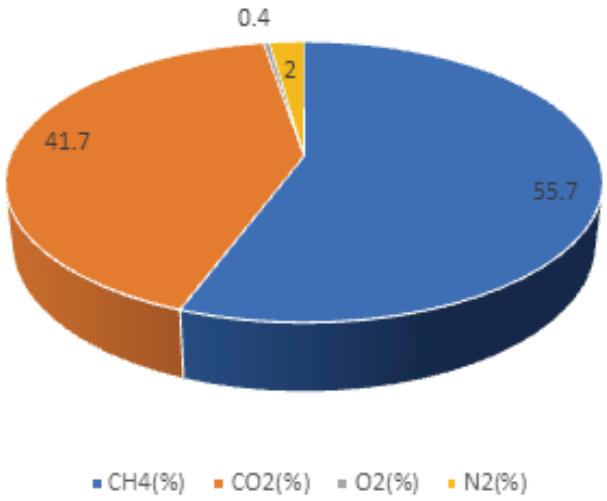
The average composition of the gases emitted by the express pump from the Polygon's gas collection wells of II cell is given in Table 3 and Graph 2. Examining 25 wells for the gas collection, experts were able to collect and analyze gas samples from only 7 wells. In the remaining gas wells, the methane and carbon dioxide content was very low, due to the fact, that the II cell closure was not completed yet and most of the wells perforated areas were not fully protected from the air penetration.

In the gas wells, where the composition of the landfill gas was analyzed, the concentration of the methane (CH_4) ranged from 52.3% to 59.2%. Its average rate was 55.7%. The minimum and maximum concentrations of carbon dioxide (CO_2) in the samples were 37.5% and 44.7%, with an average of 41.7%. The oxygen concentration ranged from 0.1% to 1.6%, with an average of 0.4%. The results of the composition of the II cell Landfill gases are consistent with the data of Solid Waste Landfills in the continental climate zone.

Basic components	CH_4(%)	CO_2(%)	O_2(%)	NH_3(ppm)	CO(ppm)	H_2	H_2S(ppm)
Average	55.7	41.7	0.4	193	28	575	380
Max	59.2	44.7	1.6	418	51	1621	650
Min	52.3	37.5	0.1	12	18	68	24
Total number of analytical samples	7						

Table 3. Investigation of the composition of the gas sample obtained by express pumping from

the II cell well



Graph 2. The average rate of composition of gases emitted from the II cell

During the exploration of gas composition by powerful pumping from gas collecting well #24 of the ***II cell,*** there was the ***sharp decrease*** in the concentration of the main components in the sample and the significant increase in air content. The measures to improve the well sealing were not effective, because of the large amount of air mixing due to the close proximity of the perforated part of the pipes covered by the gravel during pumping.

The results of the gas composition study by powerful pumping from the gas collecting well #24 are given in Table 4.

Date/Time	CH_4 (%)	CO_2 (%)	O_2 (%)	NH_3 (ppm)	CO (ppm)	H_2	H_2S (ppm)	Pumping power (l/s)
	26.5	25.2	6	3	30	75	4	
6/28/2019 16:25	9.1	6.8	15.3	60	15	96	45	10
6/28/2019 16:31	5.5	4.1	16.9	67	13	113	95	10
6/28/2019 16:36	4.8	3.6	17.2	63	13	115	94	10
6/28/2019 16:44	5.4	4.1	17.1	62	14	125	94	10

6/28/2019 16:47	5.7	4.3	17.1	62	13	127	95	10
6/28/2019 16:48	5.6	4.2	17	62	13	124	58	10
6/28/2019 16:50	5.8	4.4	17	62	13	130	95	10
6/28/2019 16:56	5.5	4.1	17.2	62	13	138	93	10

Table 4. The results of the gas composition study by powerful pumping from the gas collecting well #24 of the II cell

Conclusions and Recommendations

- The 42 out of 100 gas collection wells of Polygon I and II cells were studied;
- composition of the landfill gases was studied by express pumping method from the 42 gas collection wells;
- Composition of the landfill gas was studied by powerful pumping in the two gas wells (# 1 and # 24);
- During the strong pumping of landfill gases, the concentration of the main components of waste generated during biodegradation was reduced and the air concentration was increased;
- The obtained data are consistent with the data of Solid Waste Landfills in the continental climate zone;
- The average value of the landfill gas composition for cells I and II is as follows: CH_4 – 51-54%; CO_2 – 39.4-41.7%; O_2 – 0.4-0.9%; N_2 – 3.4-9.2%; H_2S – 380-413 ppm; CO – 12.9-28 ppm; NH_3 – 193-200 ppm;
- 16 out of the 17 gas collection wells in the cell I are functioning properly and it is possible to collect landfill gases;
- All gas collection wells in the II cell should be corrected and the II cell is in the closing phase;
- For efficient operation of the gas collection system in the future, it's recommended to

identify the existing gas stock in each gas collector well in order to optimize its extraction process.

Determination of the total gas emissions at Didi Lilo landfill 2021-2150

The methodology used

Landfill gas emissions were determined based on the mathematical modeling method using the software LANDGEM - Landfill Gas Emissions Model V 3.02, developed by the US Environmental Protection Agency. This model allows the determination of the total number of Polygon emissions during the entire life cycle of the Landfill, from the active phase of its waste disposal, to the closure and post-closure care phase. The duration of the forecast period is determined by the amount of residual emissions, which should not exceed 0.5% of the maximum gas volume. In this case, the forecast period of Didi Lilo Landfill, starting from the period of active waste disposal, is 110 years.

The following parameters were used to calculate the gas emissions:

- Quantity of the waste deposited on the polygon from 2010 to 2018 (for details see Table 5);
- Polygon Operation Start Year - 2010 წ;
- The Polygon Operation Completion Year - 2040 წ;
- Quantity of the waste disposed annually from 2018 to 2040 - 350 000 t;
- Duration of the forecast - 2150 წ;
- Methane generation coefficient (k) – 0.05;
- Methane Production coefficient (L_0) – 170;
- Concentration coefficient of other organic compounds besides the methane- 4.00.

Obtained Results

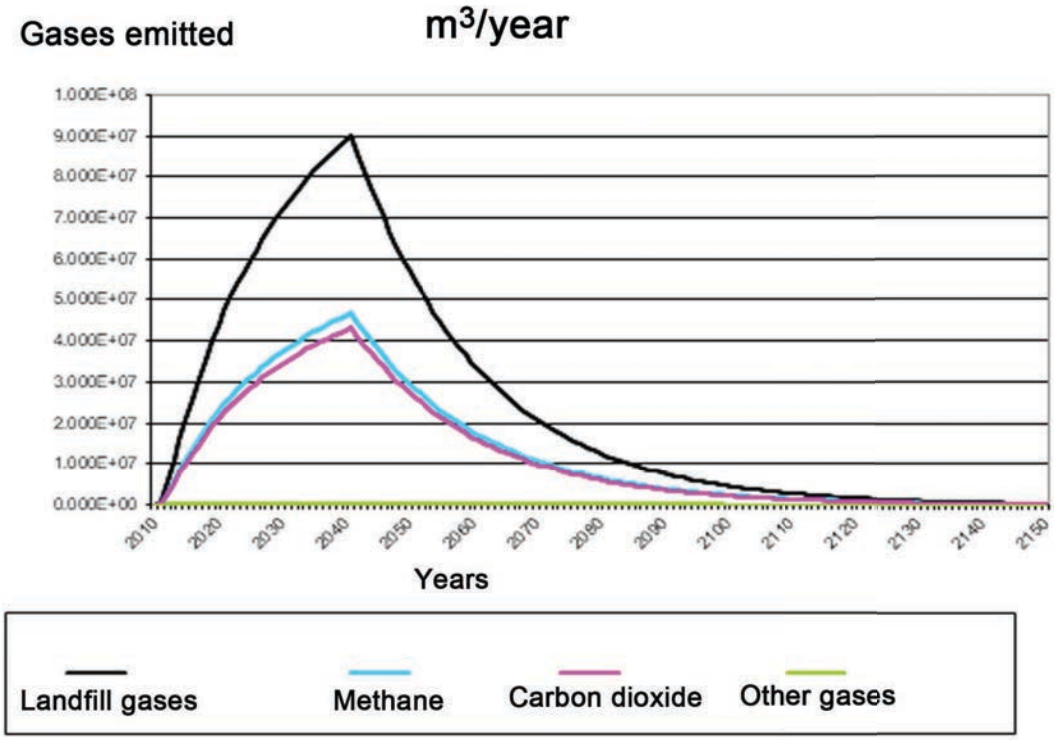
Results of landfill gas emission modeling detailed are given in Table 5. Figure 3 shows the intensity of emissions generated by years. The modeling results show, that the maximum

emission rate is expected in 2040, which is also the year of completion of the polygon operation. The overall emission rate for 2040 and the projected volumes of its constituents are as follows:

- The total amount of the waste to be disposed of at the landfill - **10 672 844 t**;
- Total volume of the landfill gases - **88 704 896 m³**;
- Methane (CH_4) – **46 126 547 m³**;
- Carbon dioxide (CO_2) – **42 578 350 m³**;
- Other gases - **354 820 m³**.

Actual and projected emissions of Landfill gases between 2010 and 2150 are as follows:

- Total volume of landfill gases - **3 490 389 950 m³**;
- Methane (CH_4) – **18 150 027 748 m³;**
- Carbon dioxide (CO_2) – **1 675 387 176 m³;**
- Other gases - **13 961 560 m³**.



Graph 3. Emission intensity by years

Year	*Average amount of the waste disposed*	Total amount of the waste disposed	Landfill gases (total)	Methane	Carbon dioxide	Other gases
	(t)	*(t)*	*(m^3/sec)*	*(m^3/sec)*	*(m^3/sec)*	*(m^3/sec)*
2010	40262	40262	0	0	0	0
2011	313970	354231	643546	334644	308902	2574
2012	345175	699406	5630690	2927959	2702731	22523
2013	349950	1049356	10873397	5654167	5219231	43494
2014	368725	1418081	15936737	8287103	7649634	63747
2015	360363	1778444	21053237	10947683	10105554	84213
2016	380380	2158824	25786538	13409000	12377538	103146
2017	397505	2556329	30608949	15916653	14692296	122436
2018	416515	2972844	35469906	18444351	17025555	141880
2019	**350000**	**3322844**	**40397649**	**21006777**	**19390871**	**161591**
2020	350000	3672844	44021874	22891375	21130500	176087
2021	350000	4022844	47469344	24684059	22785285	189877
2022	350000	4372844	50748679	26389313	24359366	202995
2023	350000	4722844	53868079	28011401	25856678	215472
2024	350000	5072844	56835344	29554379	27280965	227341
2025	350000	5422844	59657894	31022105	28635789	238632
2026	350000	5772844	62342786	32418249	29924537	249371
2027	350000	6122844	64896735	33746302	31150433	259587
2028	350000	6472844	67326126	35009585	32316540	269305
2029	350000	6822844	69637034	36211258	33425776	278548
2030	350000	7172844	71835238	37354324	34480914	287341
2031	350000	7522844	73926234	38441642	35484592	295705
2032	350000	7872844	75915251	39475931	36439321	303661
2033	350000	8222844	77807263	40459777	37347486	311229
2034	350000	8572844	79607000	41395640	38211360	318428
2035	350000	8922844	81318963	42285861	39033102	325276
2036	350000	9272844	82947433	43132665	39814768	331790
2037	350000	9622844	84496481	43938170	40558311	337986
2038	350000	9972844	85969981	44704390	41265591	343880
2039	350000	10322844	87371617	45433241	41938376	349486
2040	**350000**	**10672844**	**88704896**	**46126546**	**42578350**	**354820**
2041	0	10672844	89973149	46786037	43187111	359893
2042	0	10672844	85585107	44504255	41080851	342340
2043	0	10672844	81411072	42333757	39077314	325644
2044	0	10672844	77440607	40269116	37171491	309762
2045	0	10672844	73663784	38305168	35358616	294655
2046	0	10672844	70071159	36437003	33634156	280285
2047	0	10672844	66653748	34659949	31993799	266615
2048	0	10672844	63403006	32969563	30433443	253612

Year	*Average amount of the waste disposed*	Total amount of the waste disposed	Landfill gases (total)	Methane	Carbon dioxide	Other gases
	(t)	*(t)*	*(m^3/sec)*	*(m^3/sec)*	*(m^3/sec)*	*(m^3/sec)*
2049	0	10672844	60310805	31361619	28949187	241243
2050	0	10672844	57369413	29832095	27537318	229478
2051	0	10672844	54571473	28377166	26194307	218286
2052	0	10672844	51909991	26993195	24916796	207640
2053	0	10672844	49378311	25676722	23701589	197513
2054	0	10672844	46970102	24424453	22545649	187880
2055	0	10672844	44679343	23233259	21446085	178717
2056	0	10672844	42500306	22100159	20400147	170001
2057	0	10672844	40427542	21022322	19405220	161710
2058	0	10672844	38455867	19997051	18458816	153823
2059	0	10672844	36580353	19021783	17558569	146321
2060	0	10672844	34796308	18094080	16702228	139185
2061	0	10672844	33099272	17211621	15887650	132397
2062	0	10672844	31485001	16372201	15112801	125940
2063	0	10672844	29949460	15573719	14375741	119798
2064	0	10672844	28488807	14814180	13674627	113955
2065	0	10672844	27099392	14091684	13007708	108398
2066	0	10672844	25777739	13404424	12373315	103111
2067	0	10672844	24520544	12750683	11769861	98082
2068	0	10672844	23324663	12128825	11195838	93299
2069	0	10672844	22187105	11537295	10649811	88748
2070	0	10672844	21105027	10974614	10130413	84420
2071	0	10672844	20075723	10439376	9636347	80303
2072	0	10672844	19096619	9930242	9166377	76386
2073	0	10672844	18165265	9445938	8719327	72661
2074	0	10672844	17279335	8985254	8294081	69117
2075	0	10672844	16436612	8547038	7889574	65746
2076	0	10672844	15634989	8130194	7504795	62540
2077	0	10672844	14872461	7733680	7138782	59490
2078	0	10672844	14147123	7356504	6790619	56588
2079	0	10672844	13457160	6997723	6459437	53829
2080	0	10672844	12800846	6656440	6144406	51203
2081	0	10672844	12176542	6331802	5844740	48706
2082	0	10672844	11582685	6022996	5559689	46331
2083	0	10672844	11017790	5729251	5288539	44071
2084	0	10672844	10480446	5449832	5030614	41922
2085	0	10672844	9969309	5184041	4785268	39877
2086	0	10672844	9483100	4931212	4551888	37932
2087	0	10672844	9020604	4690714	4329890	36082

Year	*Average amount of the waste disposed*	Total amount of the waste disposed	Landfill gases (total)	Methane	Carbon dioxide	Other gases
	(t)	*(t)*	*(m^3/sec)*	*(m^3/sec)*	*(m^3/sec)*	*(m^3/sec)*
2088	0	10672844	8580664	4461945	4118719	34323
2089	0	10672844	8162180	4244334	3917846	32649
2090	0	10672844	7764106	4037335	3726771	31056
2091	0	10672844	7385446	3840432	3545014	29542
2092	0	10672844	7025253	3653132	3372122	28101
2093	0	10672844	6682628	3474966	3207661	26731
2094	0	10672844	6356712	3305490	3051222	25427
2095	0	10672844	6046692	3144280	2902412	24187
2096	0	10672844	5751791	2990931	2760860	23007
2097	0	10672844	5471273	2845062	2626211	21885
2098	0	10672844	5204436	2706307	2498129	20818
2099	0	10672844	4950612	2574318	2376294	19802
2100	0	10672844	4709168	2448767	2260401	18837
2101	0	10672844	4479499	2329340	2150160	17918
2102	0	10672844	4261032	2215736	2045295	17044
2103	0	10672844	4053219	2107674	1945545	16213
2104	0	10672844	3855541	2004881	1850660	15422
2105	0	10672844	3667504	1907102	1760402	14670
2106	0	10672844	3488638	1814092	1674546	13955
2107	0	10672844	3318495	1725617	1592877	13274
2108	0	10672844	3156650	1641458	1515192	12627
2109	0	10672844	3002698	1561403	1441295	12011
2110	0	10672844	2856255	1485253	1371002	11425
2111	0	10672844	2716954	1412816	1304138	10868
2112	0	10672844	2584446	1343912	1240534	10338
2113	0	10672844	2458401	1278369	1180033	9834
2114	0	10672844	2338504	1216022	1122482	9354
2115	0	10672844	2224454	1156716	1067738	8898
2116	0	10672844	2115966	1100302	1015664	8464
2117	0	10672844	2012769	1046640	966129	8051
2118	0	10672844	1914605	995595	919010	7658
2119	0	10672844	1821229	947039	874190	7285
2120	0	10672844	1732406	900851	831555	6930
2121	0	10672844	1647916	856916	791000	6592
2122	0	10672844	1567546	815124	752422	6270
2123	0	10672844	1491096	775370	715726	5964
2124	0	10672844	1418374	737555	680820	5673
2125	0	10672844	1349199	701584	647616	5397
2126	0	10672844	1283398	667367	616031	5134

Year	*Average amount of the waste disposed*	Total amount of the waste disposed	Landfill gases (total)	Methane	Carbon dioxide	Other gases
	(t)	*(t)*	*(m^3/sec)*	*(m^3/sec)*	*(m^3/sec)*	*(m^3/sec)*
2127	0	10672844	1220806	634819	585987	4883
2128	0	10672844	1161267	603859	557408	4645
2129	0	10672844	1104631	574408	530223	4419
2130	0	10672844	1050757	546394	504364	4203
2131	0	10672844	999511	519746	479765	3998
2132	0	10672844	950765	494398	456367	3803
2133	0	10672844	904395	470286	434110	3618
2134	0	10672844	860287	447349	412938	3441
2135	0	10672844	818331	425532	392799	3273
2136	0	10672844	778420	404779	373642	3114
2137	0	10672844	740456	385037	355419	2962
2138	0	10672844	704344	366259	338085	2817
2139	0	10672844	669993	348396	321596	2680
2140	0	10672844	637317	331405	305912	2549
2141	0	10672844	606234	315242	290992	2425
2142	0	10672844	576668	299867	276801	2307
2143	0	10672844	548543	285243	263301	2194
2144	0	10672844	521791	271331	250460	2087
2145	0	10672844	496343	258098	238244	1985
2146	0	10672844	472136	245511	226625	1889
2147	0	10672844	449109	233537	215573	1796
2148	0	10672844	427206	222147	205059	1709
2149	0	10672844	406371	211313	195058	1625
2150	0	10672844	386552	201007	185545	1546
Total:	**10672844**		**3490389950**	**1815002774**	**1675387176**	**13961560**

Table 5. Results of landfill gas emissions modeling

The total amount of the waste deposited on Didi Lilo Polygon will be 10 672 844 t by 2040, of which the total gas emissions are expected to be 1 653 104 901 m^3. The volume of Methane from the total amount of gases, will amount to 859 614 548 m^3. During the whole forecast period until 2150 the total volume of gases emissions will reach 3 490 389 950 m^3 of the biogas, of which 1 815 002 774 m^3 will be Methane.

Capacity of the gases emitted at Didi Lilo landfill 2010-2040

The methodology used

The productivity of the emitted gases was calculated on the basis of the intensity of biogas emissions in 2010-2040, based on the data given in Tables 5 and 6, and the parameters listed below. These parameters are:

- The average biogas recovered from the polygon will be - 80%;
- The average methane concentration in biogas will be - 51-55%.

Obtained Results

The amount of the biogas recovered from the polygon is characterized by an upward trend (see Table 6; Graph 4). The capacity of the gases emitted on Polygon in 2010-2040 varies from 59 m^3/h to 8101 m^3/h (5032 m^3/h on average).

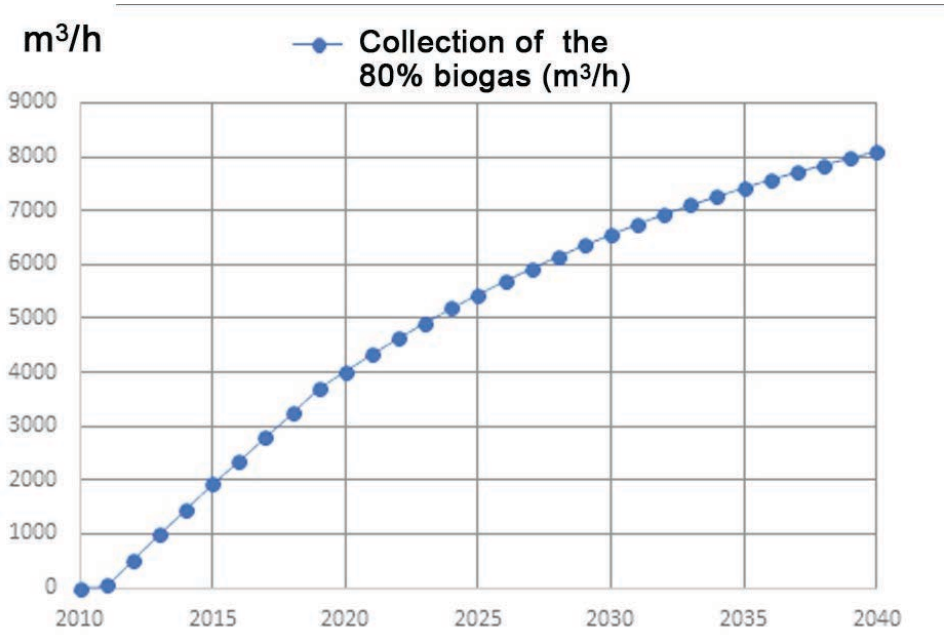
The average rate of the biogas emissions on Polygon is 10-11 m^3/hr per ton of the waste during the year. If there is the increase in the amount of biogas emissions in 2016, then it is expected to gradually decrease in 2016-2040 (see Table 6; Graph 5). The expected decline is about 0.2% per year. The intensity of landfill gas emissions in 2040 per ton of the waste will be 8 m^3/hr (see Table 6), which is related to the increase in the waste compaction and the reduction of the gas flows.

Year	The Landfill gases emitted from per ton of the disposed waste	Total number of landfill gases emitted from the Polygon		The amount of gases collected from the landfill
	(m^3/h)	*($m^3/Year$)*	*(m^3/h)*	*(m^3/h)*
2010	0	0	0	0
2011	1.8	643546	73	59
2012	8.1	5630690	643	514
2013	10.4	10873397	1241	993

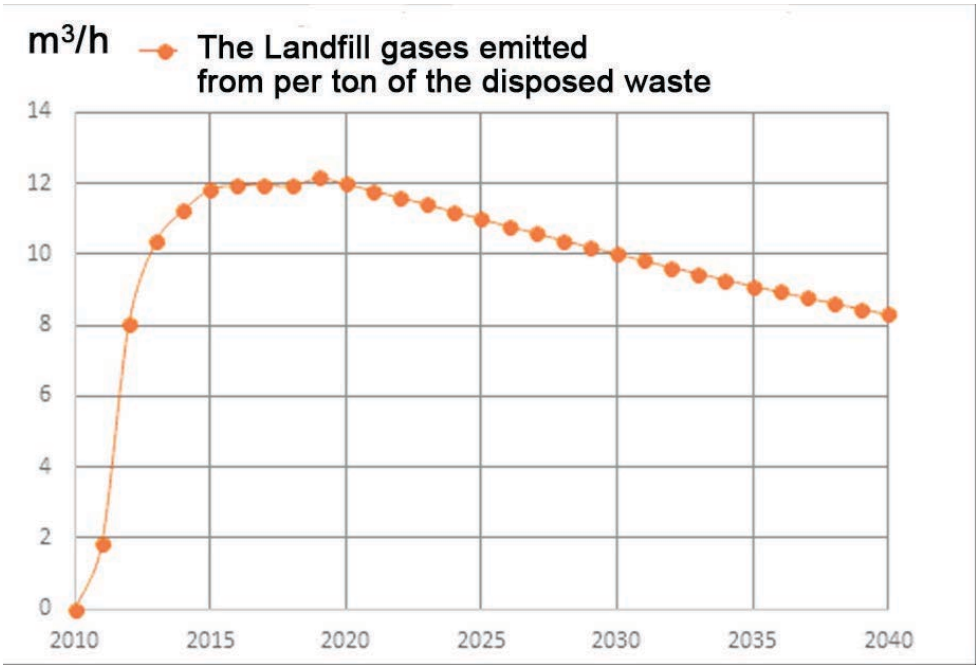
Year	The Landfill gases emitted from per ton of the disposed waste	Total number of landfill gases emitted from the Polygon		The amount of gases collected from the landfill
	(m^3/h)	*(m^3/Year)*	*(m^3/h)*	*(m^3/h)*
2014	11.2	15936737	1819	1455
2015	11.8	21053237	2403	1923
2016	11.9	25786538	2944	2355
2017	12.0	30608949	3494	2795
2018	11.9	35469906	4049	3239
2019	12.2	40397649	4612	3689
2020	12.0	44021874	5025	4020
2021	11.8	47469344	5419	4335
2022	11.6	50748679	5793	4635
2023	11.4	53868079	6149	4919
2024	11.2	56835344	6488	5190
2025	11.0	59657894	6810	5448
2026	10.8	62342786	7117	5693
2027	10.6	64896735	7408	5927
2028	10.4	67326126	7686	6149
2029	10.2	69637034	7949	6360
2030	10.0	71835238	8200	6560
2031	9.8	73926234	8439	6751
2032	9.6	75915251	8666	6933
2033	9.5	77807263	8882	7106
2034	9.3	79607000	9088	7270
2035	9.1	81318963	9283	7426
2036	8.9	82947433	9469	7575
2037	8.8	84496481	9646	7717
2038	8.6	85969981	9814	7851
2039	8.5	87371617	9974	7979

Year	The Landfill gases emitted from per ton of the disposed waste	Total number of landfill gases emitted from the Polygon		The amount of gases collected from the landfill
	(m^3/h)	*(m^3/Year)*	*(m^3/h)*	*(m^3/h)*
2040	8.3	88704896	10126	8101

Table 6. The Landfill gases emitted from 1 ton of the disposed waste from 2010 to 2040.



Graph 4. Intensity of collecting of the biogas



Graph 5. The amount of the released biogas (m^3/h) by the years

Conceptual Design of the Mini Meteor Station

(Control of the air temperature, wind power, precipitation, humidity and other parameters)

In accordance with the technical regulation # 421 of the national legislation, during the operation, closure and subsequent maintenance phases of the Polygon it is mandatory to control the environmental parameters in order to minimize the adverse impacts and to take timely preventive measures. It's also noteworthy that Didi Lilo Polygon is the permit-based infrastructure facility that, in accordance with the Environmental Impact Assessment Document, has set environmental and water control parameters in accordance with the schedule. Thus, it's recommended for the polygon to purchase the portable tools to measure air and water parameters. Some of the technical features are presented in tables.

Technical characteristics of the metro station arrangement at Didi Lilo Polygon are as follows:

No.	Technical specification	
1	Air temperature and relative humidity sensor	Measuring range 0 to 100% rh, from - 50 °C to + 150 °C. Polyethylene insert in polycarbonate shell.
2	Precipitation meter	With double bowl and measuring accuracy of not more than 2 mm.
3	Leaf moisture sensor	Digital determination of moisture content with filter paper.
4	Global radiation sensor	Waterproof, made of stainless steel with acrylic diffuser.
5	Wind speed sensor	Measuring range from 0 to 50 m/s.
6	Soil temperature sensor (20 cm depth)	Working temperature - 55oC to +125oC.
7	Topsoil temperature sensor	Measuring range from - 55oC to +125oC. Polyethylene insert in polycarbonate shell.
8	Soil moisture sensor	Working temperature from - 40oC to +50oC.
9	Data transmission	With built-in GSM modem.
10	Access to meteorological data	Online work mode in the Internet and mobile application.

11	Power	6V battery and solar panel.
12	Possibility to connect the weather forecast for at least 7 days	Must provide.
13	The product must comply with EU requirements and be certified accordingly	Must provide. *The certificate of conformity should be attached, when shipping the product, the EC sticker should be on the product.*
15	Installation and training	Upon delivery of the goods, the applicant must ensure that the goods are installed in the working (using) order
14	Delivery time	No more than 90 days (the applicant must indicate the proposed delivery date)
16	Documentation to be added	Technical documentation and work description
17	Warranty	Not less than 24 months. *The applicant must indicate the warranty period offered.*
18	Outdoor service provision during warranty	Must provide.

As an example, the meteorological station **„iMetos AG IMT 300„** can be considered. operate with solar panels, have a built-in battery and transmit real-time weather data via GSM / GPRS, thus allowing for no additional infrastructure installation at the observation site. iMetos AG IMT 300 also allows you to send SMS alerts (user-defined via the Internet) alerting you to frost, rain, temperature and other conditions.

All data is regularly uploaded to FieldClimate, the world's first and most respected weather data platform (password protected). In addition to viewing historical weather data and daily evaporation values, FieldClimate also provides access to other decision support solutions, such as localized weather forecasts, plant disease models, and irrigation management.

iMetos AG IMT 300 is equipped with all the essential sensors for obtaining advanced meteo data, as well as everything needed for recording and even forecasting weather conditions:

- air temperature sensor
- relative humidity sensor
- precipitation meter
- leaf moisture sensor
- global radiation sensor
- wind speed sensor
- soil temperature measurement

Fig. 7. „iMetos AG IMT 300" Meteo Station

Conceptual design of the Mini Lab for leachate quality control

Mini-laboratory for determination of basic parameters of leachate

Considering that most of the pollution indicators are determined in laboratory, in situ indicators include pH, electrical conductivity and temperature measurements. The composition of infiltrate characterizes with high mineralisation. Stationary multi-parameter instruments differ with complicated electrode treatment system. To ensure effective control of aforementioned parameters it is recommended to use portable instrumentation.

Below are pointed out the technical characteristics that are necessary to determine the basic parameters for solid waste landfill operation.

No.	Technical specification	
1	pH	from -2.000 . to. .+19.999 pH
2	mV	from -2500 . to.. +2500
3	ISE (mg/l, µmol/l, mg/kg, ppm, %)	from 0.000 to 999999
4	Conductivity	from 0.000 µS/cm . to.. 1000 mS/cm
5	Salinity	from 0.0 . to.. 70,0
6	TDS	from 0 mg to … 199.9 g/l
7	t°C	from - 20 °C to + 80 °C.
8	Calibration memory	up to 10 calibrations retrievable
9	AutoRead	Automatic/manual switchable
10	Celsius/Fahrenheit	Must ensure
11	Display	LCD graphic, backlit
12	Data memory	manual 200/5000 automatic
13	Logger	manual/timer-controlled
14	Power	6V battery and solar panel.
15	Waterproof	IP 67

16	Warranty	Not less than 24 months. *The applicant must indicate the warranty period offered.*
17	Delivery date	Not more than 90 days
18	Documentation to be added	Technical documentation and work description

As an example, consider a portable multimeter kit ,,MultiLine® Multi 3620 IDS.

Fig. 8. MultiLine® Multi 3620 IDS portable multimeter

MultiLine® Multi 3620 IDS is universal multi-parameter portable meter with two inputs for pH, mV, ISE and conductivity measurements for demanding applications, two inputs for the simultaneous measurement of pH/mV/ISE and conductivity, backlit graphic display for the parallel display of the measured values, perfect for monitoring process applications The pH/Cond 3320 has a robust, waterproof housing (IP67) and is equipped with a memory as well as a data logger with an adjustable interval between 1 s and 60 minutes. All entries contain GLP-supporting data, like the date, time and ID number. The modern, waterproof USB

interface is used for easy and quick data transfers. It can be used almost anywhere - in process chemistry, Life Science, food and beverage industry all the way to the pharmaceutical industry

Assessment-study of migratory bird migration, proximity to the airport and associated risks and based on the results prevention of their impact, if necessary, development of the conceptual project for mitigation and preventive measures

A meeting was held between representatives of Geo Consultant Ltd and TAV Urban Georgia to determine the migratory route of migratory birds in the vicinity of the Airport and in the immediate vicinity of the study area and the associated risks. The meeting discussed in detail the problems of bird collisions with aircraft and aircraft damage. It turned out that the number of such cases has recently increased significantly.

The crash statistics for 2018-2019 are as follows:

- ✓ In 2018 there were 36 collision cases;
- ✓ There have been 15 cases in the first six months of 2019.

It is noteworthy that the number of similar incidents varied within 2-3 years prior to the placement of Tbilisi Solid Waste Polygon near the village Lilo. The size of birds has also increased compared to previous years. According to representatives of TAV Urban Georgia, the size of the birds involved in earlier incidents did not exceed the size of the raven. Over the past 2-3 years, collisions with gulls have increased, and consequently the degree of aircraft damage has increased.

The consultant obtained the current legislative framework for a working meeting with representatives of the relevant agencies of the “Civil Aviation Agency” LEPL.

According to ICAO aerodrome management rules, landfills and potential bird landing sites should be at least 13 km away from the aerodrome center. In this case the Solid Waste Polygon of "Didi Lilo" is 7 km away from Tbilisi International Airport runway.

The situation for ICAO could be the reason for the ban on international flights to Tbilisi International Airport.

By Geo-Consultants Ltd. expert was conducted an ornithological security risk

assessment of Tbilisi Didi Lilo Household Waste Polygon. The results of the research are presented in the following chapters.

General Overview

Landfills (dumps) of household waste in settlements are a kind of anthropogenic biotopes, where the abundance of food and its easy access attracts many living organisms, including birds. Landfills are attractive for bird species, which can easily switch from natural food to organic residues of anthropogenic origin (ducks, gulls, sleighs, pigeons, corns, grasses, sparrows). The abundance of these species in turn attracts predators, especially during migrations and in winter. Therefore, in most cases, in a relatively small area, a significant number of some bird species accumulate almost all year round.

The mass concentration of birds at landfills and the waste feeding is relatively poorly studied. Although this concentration of birds has the significant impact on environmental and social factors. They damage agricultural fields and warehouses located near the Polygon and pollute houses and architectural monuments, carry infectious diseases, endanger airplanes, and so on. In this regard, the Aviation Ornithological Safety is especially important.

According to official data, the first plane crash took place in 1912 in the US. According to the International Civil Aviation Organization (ICAO), currently, there are more than 5,000 bird-related incidents worldwide each year. Observations show that more than 70% of collisions occur in the daytime, and collisions at heights of up to 100 m are considered the most dangerous. Such cases account for 52 to 80% of the total number of collisions. At the same time, 47-57% of collisions occur at aircraft-landing and 30-47% at takeoff-altitude stages. Often than others with planes crash seagulls - 35%, followed by small sparrows and swifts - 17%, collisions with pigeons consist - 16%. The proportion of raptors and waterfowl is 10%, and the share of crows is 7%.

The biggest threat to airplanes from migratory and local birds is autumn, when most of

the birds in the air are the young individuals. The so-called annuals, those who have the least individual life experience. Consequently, they are less able to avoid collisions in critical situations and are more likely to be involved in the incident.

With the exception of periods of migration, the concentration of birds in and around airports is increasing for various reasons:

- ✓ Local daily movement (between overnight stay and food);
- ✓ Due to certain meteorological phenomena, for example, After rain, birds accumulate on the runway, where there are many invertebrates on a relatively warm surface: worms, insects, etc.

The report summarizes the results of observations on the congestion of gulls at the Waste Polygon and their possible impact on the ornithological safety of Tbilisi Airport.

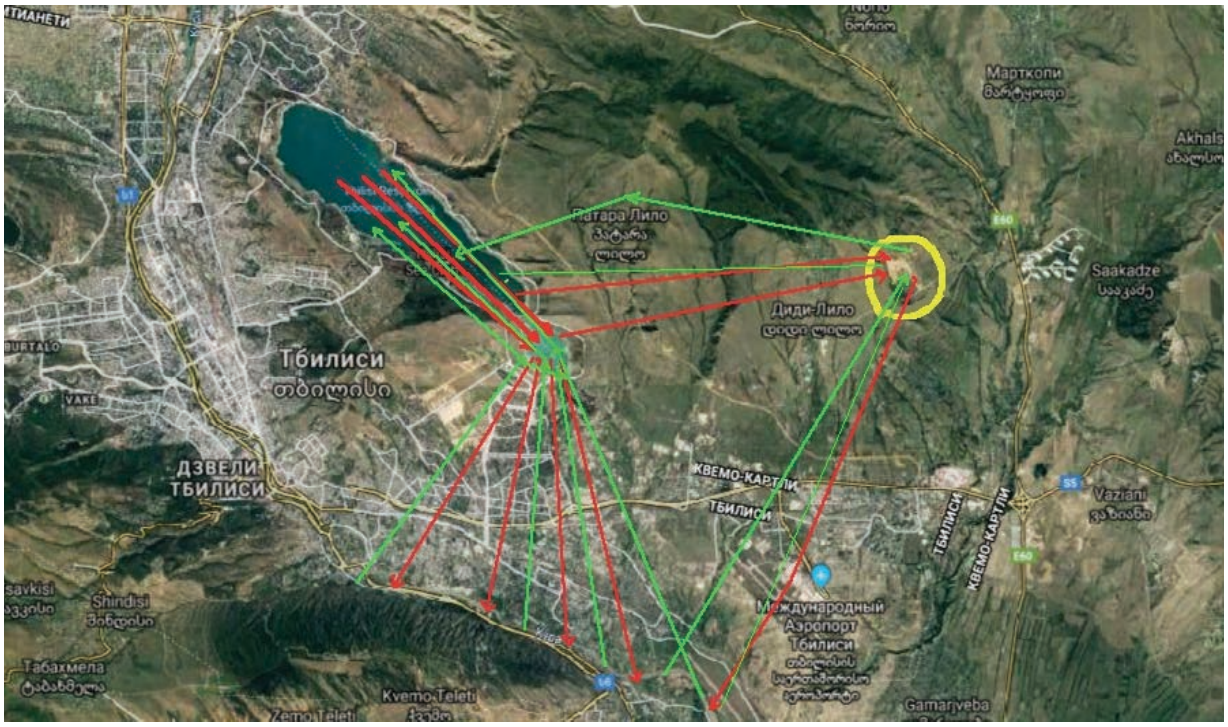
The methodology used

The observations at Didi Lilo Polygon were carried out on August 30, 2019, September 3 and 4, all day round, from dawn to sunset. The observation area included the neighborhood of Tbilisi Airport, the gorge of Mtkvari River from Ortachala Bridge to Gachiani Bridge, Tbilisi Sea and landfill of «Didi Lilo". The gulls (Larus) were the object of observation. During the research, the time, height and direction of movement of the gulls between these points were recorded, as well as their quantitative changes at the same points throughout the day. During the work it was used:

- ✓ Binocular "Nikon Action 10 x 50";
- ✓ Sibir 30 x 50 telescope;
- ✓ Digital camera "Nikon P610".

Observations showed that the movement of gulls is subject to patterns of movement in a circle, during the day they regularly circled the study area. This cycle is simplified as follows: overnight, in the morning, flight to feeding areas, and return in the evening back to the overnight (see Map 1). A more detailed picture is as follows: gulls spend the night on Tbilisi Sea, on the surface of the water. At dawn, when the sky is dimly lit, birds awakening, the gulls voices are heard, some of them begin to fly up, and then the number of flying birds increases with increasing daylight. Some of the seagulls sit on the illuminated by the sun coastal areas (see Fig. 9-10).

About an hour after sunrise, most of the birds leave the surface of the water, some generally flying to east and south-east, most of them flying in the direction of the River Mtkvari. Approximately 30–40% of seabirds taking off from the sea surface fly to the neck of Tbilisi Sea and the beginning of the "Small Sea", then sharply turn east and, as observations have shown, head to the landfill through Small and Big Lilo (Fig. 11-12) , where their maximum number is collected at 7 - 9 pm (Fig. 15-16). At the same time, with the advent of new groups of birds, separate groups of seagulls leave the landfill and flying over the city of Tbilisi in the direction of the Mtkvari River. Some of them fly over the airport and its vicinity. A certain number of gulls remain at the Polygon all day. Among them there are young chicks who, due to inexperience, find it difficult to get food from the river.



Map 1. The general scheme of flights of gulls during the day. The paths of the morning hours are indicated in red, and the evening routes are shown by green lines.

Fig. 9 – 10. The first awakened seagulls leave Tbilisi Sea.

Fig. 11 – 14. Some group of seagulls fly in the direction of Didi Lilo

Fig. 15 – 16. In the morning hours the number of seagulls at the Polygon reaches its maximum

From 5 p.m. to 6 p.m. flocks of gulls again fly out of the Mtkvari Gorge in the direction of Tbilisi Sea and the Polygon, and some of them again fly over the airport. By this time, their number in the landfill is still increasing, but at a comparatively slower pace than in the morning, probably because the seagulls are already full and head straight to the shelters. The flights towards Tbilisi Sea continues until sunset (see Fig. 17 – 18).

Fig. 17 – 18. In the morning hours the number of seagulls at the Polygon reaches its maximum

Fig. 19 – 20. Flights towards Tbilisi Sea continues until sunset

It is noteworthy, that large and small teams of gulls are found during the day-time on the Mtkvari River, both within and outside the city (Figs. 21 – 22.). The number of seagulls in the Mtkvari River is also large during those time periods, when their number reaches the maximum in the landfill. Their number on the Mtvari River exceeds the number of seagulls, which visit the landfill. During the day they fly in different directions, and their appearance on the territory of the airport and its environs is not so rare, especially since Mtkvari is located not far from the airport. Particularly high is the likelihood that the seagulls that are currently flying from Krtsanisi down the Mtkvari River will cross the airport in order to fly to Tbilisi Sea. Based on the foregoing, the risks associated with migratory birds, caused by the proximity of the landfill are only partially true.

Fig. 21 – 22. The group of seagulls at the Mtkvari site near the airport.

The fact is that landfill is very attractive to birds and to some extent affects their behavior and itineraries, which increases the risks to air traffic safety, but if it did not exist, the movements of the seagulls would exist at least twice a day, from the sea to the river and vice versa. The refinement of the technological process at the landfill and even its closure cannot fully solve the problem.

Conclusions and Recommendations

To address this, it's necessary to establish the Airport Ornithological Security Service as subordinate link to the Flight Safety Staffed by ornithologists and engineering-technical personnel with relevant skills and the technical support. Such unit exists at many airports, which monitors the ornithological situation on and around the airport and takes appropriate action if necessary.

To solve the above problem experts at Geo Consultants recommend the use of an additional bird repellent system at the Polygon. During the operation of the landfill the species diversity of the birds is constantly changing and accurate identification of the species is done through long seasonal research.

Consequently, during the development of landfill infrastructure only the initial bird repellence system can be recommended, which can be modified based on actual observations.

Typically, landfills use:

1. Propane cannons
2. Bioacoustic devices
3. Laser repelling
4. Visual-optical means
5. Repelling with dogs
6. Repelling with dead birds
7. Repelling with predator birds

At the initial stage it's recommended to use classic method that is guaranteed to produce repellent effect – propane cannons. Upgrades and optimization of this system can be done in the future based on observed data.

The following technical features provide the bird repellent effect necessary for landfill operation.

#	**Technical specification**	
1	Number of sets.	Depends on 2. position. Must ensure bird repellence in 40 ha territory.
2	Repellence territory for one set.	At least 4 ha
3	Sound volume	Up to 96 dB
4	Shooting substance	Propane
5	Amount of shooting substance (balloon)	At least 12 l

6	Number of shots per minimal balloon	15000 shots
7	Operation	6-12 V accumulator
8	Types of shots	At least 3 different types
9	Operational control (time interval between shots and shot type)	Automatic or electronic
10	Weight of the set (with minimal balloon)	Up to 50 kg
11	Temperature range of operation	From -40 to 70 ^{O}C
12	Delivery	DDP
13	Delivery time	Less than 90 days ??? (*the tenderer must provide the proposed delivery time*)
14	Attached documentation	Technical documentation and job description
15	Warranty	At least 24 months. *The tenderer must indicate the warranty period offered.*

The example of bird repellence equipment **is Purivox Carousel Triplex V bird repellent:**

Purivox Carousel Triplex V bird repellent - is a specially designed bird control device

for large areas of 4-5 hectares. Depending on the crop and the environment, it is possible to protect almost 25 hectares with one Purivox Carousel Triplex V.

The electronic device produces 3-type projectiles. Its sequence of shots is ideal for controlling birds and wildlife.

Purivox Triplex V is used::

- For industrial equipment
- At airports
- In agriculture
- Landfills,
- and etc.

The sound tube and electronic unit are mounted on the top stand. The tripod is rotated by means of projectiles. This allows to cover a full 360 ° around the device. Purivox is on a tripod at 2 meters. Thanks to the tripod it can be mounted on any surface.

An electronic device gives you many options to set up the device as you wish. The electronic control unit allows the following settings::

- Set the switch-on interval
- Determine the number of shots
- Set the volume

Gas cylinder and battery are not included.

The second example is **Digital bird repellent,** an electronic device that emits alarms characteristic to different bird species.

The coverage of this device is up to 4000 m². The device is powered by a power supply

(included with the device) and a 12-volt battery (not included with the device). It is most effective if used in combination with a bird repellent / dragon-like hawk or "Bird repelling ball with 3D effect".

Conceptual design of utility buildings

General Overview

At the initial stage of construction, instructions will be given on the organization and construction of the site. The site will be initially prepared and temporary structures will be located inside the area. Temporary fencing of the construction site is required. During the construction of the foundation pit, its should be accepted by the geological engineer. The power supply of the construction site will be provided by electricity from existing grids. At the last stage of construction, the area will be improved.

At the initial stage, the project of the construction organization should be presented, with the construction calendar. The construction and installation works should be provided in the continuous rhythm, using flow methods, which involves the movement of employees to perform the assigned work on individual parts of the building. Obviously, the technological intervals between work should be observed.

The work should be implemented under instrumental control, which should be carried out in accordance with the requirements of SN and R 3.02.07-87 "Geodetic work in construction". The sites and territories within the red lines should be confirmed by the Architecture Service of Tbilisi Municipality along with the axial marking of the building in accordance with the established procedure and drawing up the relevant act.

Construction should be carried out in full compliance with the approved project. In case of changes to the drawings for objective reasons during the construction process, the decisions should be agreed with the authors, with their official permission and the release of new drawings.

Construction will be carried out under copyright and technical supervision. The closed work should be submitted under the control of authors in accordance with the established procedure.

Rules and methods for construction works

Construction organization and construction-installation work should be carried out on the basis of applicable building standards and norms.

Foundation pits and leveling of the site should be performed mechanized in accordance with CN and R 3.02.01-83.

The most laborious and responsible work is the process of reinforcing and concreting, which should be carried out in accordance with CN and R 111-15-76.

The foundation should be arranged in accordance with CN and R 3.02.01-83.

The following are the applicable rules and regulations to be followed by a construction company during construction and installation:

- CN and R 111-17-78 "Stone constructions";
- CN and R 111-18-79 "Metal constructions";
- CN and R 111-19-81 "Wood Constructions";
- CN and R 111-20-74 "Roof, Waterproofing, Steam Insulation and Thermal Insulation";
- CN and R 111-21-79 “Facing work of building structures”;
- CN and R 111-3-14-78 "Floors";
- CN and R 3.04.03-85 "Corrosion protection";
- CN and R 111-28-79 "Sanitation of Buildings and Facilities";
- CN and R 111-29-79 "Gas Supply, Internal Appliances, External Networks and Buildings";
- CN and R 111-30-79 "Water Supply, Sewage and Heat Supply, External Networks and Structures";
- CN and R 111-33-79 "Electrical works";
- CN and R 111-10-78 “Landscaping”;
- CN and R 111-4-80 "Safety";
- Fire safety rules for construction and installation work;
- CN and R 1.06.05-85 "Authorized Supervision by Construction Design Organizations";
- Instruction "Commissioning of objects completed by construction."

Compliance with the mandatory safety regulations during construction

During construction, safety rules and employee safety precautions should be adhered to at all stages of construction and installation work, in accordance with CN and R 111-4-80 "Safety Equipment in Construction" and other normative acts. Of particular note is the following:

Workplaces should be provided with complex protection and alarms, depending on working conditions and technology.

Daily quantities of easily flammable, paint, coatings and other materials, as well as poisonous substances in the construction work area, shall not exceed the prescribed daily requirement.

Special waterproofing and headgear should be used when performing waterproofing, varnishing and other work.

After installing the timberings, check the reliability of the timberings and fasteners before before pouring concrete into them.

Materials and merchandise should be stored according to technological requirements.

Electrical safety rules are set out in the Georgian Standard 12.1.013-88. The electrical cabinet must always be closed. The electric cables, wires and devices should be insulated, it's forbidden to use the bare wires.

It's forbidden to move a vibrator to another place in the on state. After completion of work, the vibrator should be cleaned and stored in the dry place.

During the operation of mobile and caterpillar cranes, concrete rammers and other mechanisms, the presence of persons not engaged in construction work in the construction zone is prohibited.

Ecology and environmental issues

During construction, special measures should be taken to prevent dust pollution of the surrounding area. For this, construction waste should be removed from the height using the garbage chute. It should be loaded directly onto the body of the dump truck.

During plaster work and lining of facades, it's necessary to cover with the curtain to prevent the spread of dust in the settlement area.

It's unacceptable to pour concrete and other mortars into existing sewer wells and clog them with the construction waste.

Temporary toilets should be installed on the existing sewer. It is not advisable to arrange it on the pits.

It'is forbidden to cut perennial trees or other plants in the construction zone without proper permission.

Construction should be carried out in the compliance with environmental and air pollution measures in accordance with the applicable normative acts.

Polygon infrastructure facilities and the mandatory requirements

Office building

The office building should be the two-storey straight-storey building (see Appendix 1). On the both floors the floor must have the 3 cm thick screed from sand and cement.

The floor should be laminated.

The first floor:

- Living room;
- Meeting room;
- Staff office rooms;
- Archive;
- Server room;

The second floor:

- Conference room;
- Office of the Head;
- Living room;
- Offices of the Deputies of Head;
- Conference hall;

It should be covered with porcelain stoneware and baseboards should be installed.

On the first floor:

- Hall;

- Dining room;
- Canteen kitchen;
- Bath-toilets;
- Changing room;

On the second floor:

- Conference room technical room;
- Toilets;
- Hall;
- Changing room;

Stairs and staircases should be covered with natural granite.

The first floor challenge, and the second-floor verandahs, should be covered with two-component polyurethane cushioned colored flooring consisting of one-component polyurethane waterproofing material, non-absorbent surface waterproof epoxy primer and insulating paste.

Tiled (technical) floor should be arranged in the server room.

The exterior walls of the building should be sandwich panels, partitions should be with plaster-cardboard tiles, walls in the toilets should be tiled, should be arranged amsterdam ceiling, toilets and entrances should be done with aquapanel.

The entire interior walls of the building should be painted with high quality waterproof paint.

The rooms of the building should be arranged (according to the room's purpose), plastic, laminated (MDF), aluminum and metal doors, and the rotating structural doors at the entrance.

Should be made the metal-plastic windows.

Should be arranged structural stained-glass windows, water intake pipes and grooves, glass visors and the platform for the movement of wheelchairs.

In the building should be installed the fire cabinet with the fire hydrants and hoses (L = 20 m). Pipes of the cold and hot water should pass under the floor of the building and should be equipped with the distribution line to the water racks. Sewerage should be connected to the sewer network of the yard.

Smoke detectors should be installed in rooms, toilets and halls on all floors, gas detectors

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hould be installed in the kitchen, fire alarm should be installed on all floors. These schemes should be integrated into control panels and control switches, which should be connected to the PC in the security room.

Heating system should be arranged in every room and hall, number of internal blocks of VRF should be determined according to the area and system should be arranged with NYM-J3 × 1.5 main pipe, heating system shield should be installed on each floor.

Electric shield room should be equipped with 100W moisture resistant lamps, Jade 2 × 26w lamp, rest rooms and conference rooms with Dedra 4 × 14w lamp, dining room, toilets, training center, hall and staircase with Jade 2 × 26w lamps.

Power grids should be installed on all floors, taking into account the room size and workload of each room, with the appropriate number of single or double wall mounted rosettes. Each floor should have the receiver-dispensing device, respectively with NYM-J5 × 6 and NYM-J3 × 2.5 power cables.

In all floors in the each room should be installed RJ-45 rosettes, the one rack and Wi-Fi modem, wiring should be provided by FTP cable.

All rooms should be fitted with an internal telephone cable with a telephone rosette.

In the staircase of the second floor, with the help of the built-in staircase, should be provide passage to the roof of the building.

On all floors: in rooms, toilets and halls, a security alarm detector should be installed, rotating 360 degrees, and an alarm siren should be installed on each floor. The mentioned alarm shoulde be connected to the single control panel, which shoulde be operated via the keyboard from the security room.

Two surveillance cameras should be installed on the first and second floors of the building. These cameras should be connected to the server room with the cable.

Warehouse building

The warehouse building, with dimensions of 24 m x 48 m x 9.56 m, is the sandwichpanel and metal construction (see Appendix 2).

The supporting structure of the warehouse building should be made of steel elements (tubes and tube squares), which should be rest on columns firmly fixed by anchors on point monolithic reinforced concrete foundations.

The technical rooms provided in the warehouse shall be arranged on floor tiles with steel tubing frames mounted on finished wall panels.

The floor should be made as follows: on the pre-compacted layer of gravel, should be laid the wires made of special steel, must be arranged the concrete coating of the grade B-30 and than paved with the floor tiles. The surface of the newly laid floor should be treated with the special solution that provides strength, durability, impermeability of oily or other technical fluids to the tiles when it is wiped. The drainage and sewage systems of various technical purposes should be taken into account when laying the floor.

The walls of the building should be constructed from panels of finished walls of 100 mm thickness, which should be mounted on load-bearing steel poles using a rail from profiles made by cold rolling. The walls should have windows for lighting the building and the doors of different sizes.

The roof should be built on the supporting trusses, constructed from panels of finished roofs of 100 mm thickness, using a rail from profiles made by cold rolling. Roof gutters should be installed on the roof.

In the building should be installed the fire cabinet with the fire hydrants and hoses (L = 20 m). Pipes of the cold and hot water should pass under the floor of the building and should be equipped with the distribution line to the water racks. Sewerage should be connected to the sewer network of the yard.

Smoke detectors should be installed in rooms, toilets and halls on all floors, gas detectors should be installed in the kitchen, fire alarm should be installed on all floors. These circuits should be integrated into control panels and control switches, which should be connected to the PC in the security room.

In the building should be installed the security alarm detector, rotating 360 degrees, and 2 alarm siren. The mentioned alarm shoulde be connected to the single control panel, which shoulde

be operated via the keyboard from the security room.

The entire warehouse building should be connected to the single ground loop.

To the roof of the warehouse should be arranged the Emergency stairs in accordance with appropriate requirements.

The building should have an electric drive door, which should be opened and closed with the constant pressing on the button.

In the building should be installed the fire cabinet with fire hoses (L = 12). Pipes of the cold and hot water should pass under the floor of the building and should be equipped with the distribution line to the water racks. Sewerage should be connected to the sewer network of the yard.

In the building should be installed heat and smoke detectors, should also be fitted with the natural gas detector and the fire alarm. These schemes should be integrated into control panels and control switches, which should be connected to the PC in the security room.

Security room

Internal telephone cable with a telephone rosette and network cable, with the appropriate rosette, should be brought into the security room.

The security and fire alarm control panels shall be located in the security room, which shall be connected to the security and fire alarm circuits. Security room should also be provided with personal computers needed for monitoring with the appropriate software.

Supply of the objects by drinking and technical purpose water

Drinking and household water consumption is q = 50 m³/day. Water distribution wells with shutoff valves are installed on the distribution line. The fire hydrants Ø50 mm are arranged in the yard for the purpose of fire, and in the buildings there are fire cabinets with fire taps and the fire hoses L = 12 m.

Filtration of the technical purpose water

Purification of dischargeв and polluted water during the washing process is provided in the monolithic reinforced-concrete septic pit in the Polygon area, in which should be installed the special filtration equipement.

The equipement purifies technical water from harmful bio-chemical or synthetic impurities (technical fluids, acids) and consequently brings the concentration of the various substances into the water to the permissible level after which the purified water can be re-used for technical purposes.

This equipment must comply with Russian OCT 11.029.003-80 or American ASTM D-5127-90 standards.

Heating-cooling system

VRF The heating and cooling system (Fig. 23) consists of internal and external blocks. Installation of external blocks is carried out on reinforced roof tile specially fitted on the roof. The system itself is energy efficient. It works with electrical energy, which minimizes costs.

Cluster-type indoor units are mounted on the ceiling. It connected to the external unit by the copper pipes. The indoor unit also has condensate drainage, which is connected to the water intake pipe via the corrugated pipe.

Fig. 23: VRF Heating-cooling system

The independent ventilation system for staff, conference and catering rooms is provided. The ventilation system consists of sections of rectangular pipes with different cross-sections (Fig.

24), and ventilation fans with the radial capacity of 200 and 300 m^3/h, with the central rotation built into the external walls of the building, create the exhaust force.

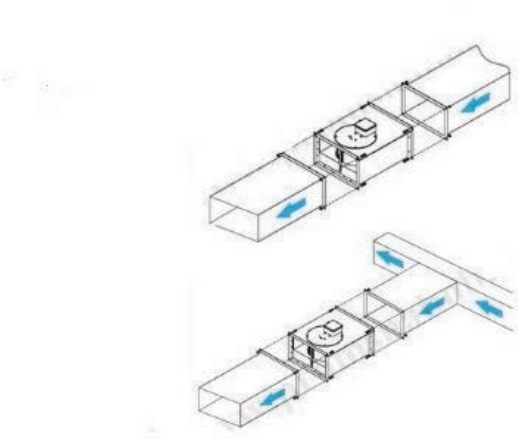


Fig. 24. Sections of rectangular pipes with different cross-sections

The system is governed by the applicable CN and R 41-01-2003 "Heating, Ventilation and Air Conditioning of Industrial Buildings".

Working network voltage - 220±10% V.

Working network frequency - 50 Hz.

Electric power phases - 1 phase working network current- 2,3 A

Noise level 3 meters away from the equipement - 56 dB.

Engine Protection Class - IP-44.

Fire and Security Alarm

Fire alarms should be capable of detecting smoke and high temperatures and must therefore sound the alarm. In order to take appropriate action and to eliminate the risk of fire. The fire alarm control panel should be installed in the Security room. The concept envisages the arrangement of addressable fire alarms, the network of which is organized by a circular topology. The Fire Alarm Cable Network is built with a 2X1.5mm cable at 220V, which joins smoke and heat addressing detectors and alarm sirens.

The siren should be connected directly to the fire alarm. The smoke and heat detectors should be installed on the ceiling from the bottom, in the geometric center (in the case of the

single detector), or on the ceiling of an evenly distributed control area. Alarm buttons are installed at the exit of every staircase cell, 1,2-1,5 m above the floor marker. A fire alarm siren is mounted 0.3m below the ceiling with a ladder cell on the wall, which should give an alarm signal of not less than 100 dB/m^2 (Note - cables should be fitted with corrugated tubes, standard - 25.4 mm).

Security alarms should provide maximum protection for the area. For this purpose, angular coverage of 300 and 360 degrees is used, and concentrated motion detectors are used. The first type shall be mounted on the walls or corner of the room, and the second on the geometric center of the ceiling or on the ceiling of an equally distributed control area.

Server room

In the building should be arranged the server room. This room should be equipped with maximum thermal insulation, metal door, electronic lock which will have Mifare contactless card reader and fingerprint reader. The door controller should be installed, with each user registering with the fingerprint and/or card identifying each access.

The room should be equipped with a special flooring system ≈ 30 cm high.

The room should be equipped with special cable channels for ceilings from the cable entry point to the rack and other communication points.

The room should be fitted with two uninterruptible power supplies (UPS) - one with the minimum power of 5 KVA, which provides 2.5 Kw load for ≈ 30 minutes of continuous operation and the other with the minimum of 15 KVA power, which provides ≈30 minutes of continuous power for 8Kw load. To the first would be connected the server cabinet, server and central switch, while to the other would be connected all cameras, network switches, and server room cooling systems.

The room should be fitted with a precessional cooling system with N + 1 reinsurance (at least 2 air conditioners, in case of damage / shutdown of one the other should provide perfect cooling). The cooling system should be matched to the raised floor and the airflow must blow

downward with the capacity of at least 10,000 BTUs.

The room should be equipped with the rack 19 '' 42U, in which the patch panels and the central switch (main switch) would be mounted. All communication cables (both optical and “copper”) would be connected to the rack (patch panels).

Computer network

The facility should be equipped with a fiber optic and local area network. The fiber optic network must have a circular topology. This network should run along the perimeter of the facility, cross the entire perimeter and return to the server room.

Special perimeter IP66 protection communication cabinets should be installed on the perimeter, industry-wide switches for video cameras that will terminate fiber optic cables.

The power supply of the communication cabinet should be provided from the UPS installed in the server room. To do this, the power cord should be installed on the same track. The power cord should be inserted into each closet where the circuit breakers are installed.

Rooms should be fitted with 2xRJ45 rosettes (for network and internal telephony) prior to the communication cabinets shown in the drawing with the UTP Cat5e cable. These should include a 19 '' wall-mounted communication rack with Path panels and network switches. Network switches must connect to the server room via the gigabit channel - the FTP Cat7 cable. Power supply in these cabinets should be provided from the UPS installed in the server room.

Video surveillance system

Key characteristics

According to the technical instructions, the unit should be equipped with a video

surveillance system. This system should ensure:

- 24 hour recording;
- Enabling IP security cameras located in the area;
- Centralization of the information that they represent in network video recordings.

Each surveillance video camera should be attached with standard mounts.

The monitoring room should contain the personal computers needed for monitoring with the appropriate monitoring software. With this software, the image should be output on two 46' and two 22' monitors. Due to the large distance and the amount of traffic to pass, the connection between the Server room and these computers should be made through the seventh category cable and the gigabit channel.

External cameras can be fed from the network using PoE technology (in this case the appropriate network switches should be PoE or PoE injector hubs) or with an additional power outlet (in this case an additional power cable should be inserted and the power blocks installed in the communication cabinet. Cable cut and power supply quality should ensure normal power supply to the camera).

The indoor cameras should be powered by PoE technology.

Wi-Fi network

On the object Wi-Fi network should be set up with full facility coverage. 2 outdoor and 4 indoor devices (Wi-Fi access point) should be installed on site.

Cable tracks

Along the perimeter of the entire boundary, in the communication wells from Server room to the switch and from the switch to its neighboring switch should be laid communication fiber cables.

In addition to the fiber optic cable, the voltage cable must also be provided to allow all network switches and cameras to receive power from a UPS in the server room. The voltage from the cameras to the network switches should be connected to an FTP cat 6 cable.

On the Polygon territory, up to the surveillance cameras, the FTP cable should be laid in a corrugated plastic pipe.

Equipment for the washing garbage trucks and other specialized machines and generating water recirculation

2 (two) unit washing machines (see Appendix 3)

The automatic washing equipment should be PLC computer-controlled (see Appendix 3), which will completely control the washing process by moving the machine on the rails. The electrical control panel shall be capable of remote control via the appropriate computer software over the Internet, whereby the manufacturer shall, if necessary, be able to carry out the remote monitoring. Software should be support of free programming capability and self-diagnostic function. The machine shuld be capable of connecting to the personal computer to ensure the machine operation repairing. The machine should be capable of washing vehicles of 7400 - 18000 x 2300 - 2800 x 2800 - 4200 mm dimensions. Unit capacity shall not exceed 9.5 kW of electrical energy consumed; Voltage - 380 V, Frequency - 50 Hz.

The device should be able to speed up the washing process. Duration of the one wash for the vehicle of dimensions: 12000-12500 x 2700-2900 x 4100-4300 mm, should not exceed 7 minutes, water consumption should not be more than 300 liters (including recycled water); 9700-10000 x 2400-2600 x 2800-3000 mm, should not exceed 6 minutes, water consumption should not be more than 250 liters (including recycled water); 7200-7500 x 2200-2400 x 2700-3000 mm, should not exceed 5 minutes, water consumption should not be more than 200 liters (including recycled water);

Washing fluid consumption per machine should be - 20 - 90 g (fluid dosage change should be possible). The number of washed cars should be counted electronically and displayed on the

LCD panel of the control panel. It should be possible to display the pictogram and wash settings.

The washing equipment should be able to replace brushes quickly without the use of tools. The machine washing unit should consist of rotating rollers with changing brushes made of polyethylene and star-shaped, of vertical (2 rollers) and horizontal (1 roller) rotating rollers, which should be adjustable depending on the load on the washing surface, length and frequency of nylon brushes from control systems of the machine, depending on the mass of pollution of the washing surface, taking into account its topography. The unit must have a gear inverter for adjusting the speed of the mobile and brush movement. The unit shoud be moved by direct reducer transmission from the engine. Each rotary rollers should be equipped with an electric motor.

Engine data: The engine power of the machine is not more than 2.8 kW; The power of each engine of brush rollers is not more than 1.5 kW.

The kit should include:

- Set of the brushes,
- Washing foam delivery dosing system,
- Self-diagnostics system,
- Brush management system,
- Wired Remote Control Electronic Dashboard,
- Protection against so-called "dry" startups,
- Rollover Prevention Mechanism,
- Guide rail kit 2X24 m,
- Suspension line for pipes and cables,
- Supply water pump with an engine power of not more than 2.2 kW.

Remote control - Electronic, multifunctional control panel, the possibility of free programming, diagnostics, displaying on the LCD monitor the errors and malfunctions.

The unit should be followed by management and monitoring software without restrictions (with full functionality licenses if required). The software should be delivered to the purchaser.

1 (one) unit water circulation regeneration equipment

The water circulation regeneration equipment should work on electricity. The machine should ensure that 60-70% of the water used in the washing process whould be continuously filtered. Unit capacity shall be not less than 3,000 liters per hour, which may, if necessary, serve 1-2 units, with a cleaning capacity of not less than 40 millimicron with the tank of capacity 2000 liters. The system should be equipped with a flooded pump with an attached filter. The permeability of the device filters shall be not less than 3 m^3/h. It should be able to recycle at least 85% of the water used in the wash. Water pumped through the washing drainage system to the pumps should be supplied through the pump filters. The filtered water should be pumped into the tank from where the pump will supply the 1-10 washing machine. The circulation regeneration unit should provide the proper amount of treated water for 1-10 automatic washing machines. Under normal operating conditions, no unit filters need to be replaced.

Installation - The supplier shall complete the entire installation, testing and commissioning of the washing equipment and water circulation regeneration unit.

Service - During the warranty period (full 12 months) the Supplier shoulde provide full technical service of the washing equipment and water circulation regeneration unit (hereinafter "Service"). The service provider must provide its own technical equipment and personnel. The service must include all services (ongoing technical, diagnostic and complete technical services, including both seasonal services and services recommended by the manufacturer until the end of the warranty period) and the provision of all necessary goods (including grease-lubricating materials, filters and parts that require replacement during operation during the warranty period), requiring maintenance of the washing equipment and water circulation regeneration unit in good working order. The service should be carried out in full compliance with the (recommended) operation, regular service and repair instructions provided by the manufacturer of the washing equipment and water circulation regeneration unit. The Supplier is not entitled to claim any

additional remuneration. The cost of the above service does not cover the costs of eliminating defects caused by mechanical damage (vandalism, road accident and natural disasters).

Traning - The Supplier shall ensure that the system service personnel (at least 2 specialists) are trained, with proper certification, for the proper and effective operation of the system. Training should include training of service personnel using appropriate software and equipment. The Supplier is not entitled to claim any additional remuneration for these training programs, regardless of where the training is conducted. Provider should provide training in Georgian language. If training is provided by foreign specialists, the supplier must provide translation of the training text into Georgian in sync.

Security alarm

300 degree - Motion detector Working Power -0,4W;
Working voltage - 230V AC;
Frequency - 50/60Hz;
Working temperature - -25°C + 55°C View distance -11m;
Height of vision - 3მ Type of protection - IP55;
360 degree - Motion detector Working Power -0.33W;
Working voltage - 230V AC;
Frequency - 50/60Hz;
Working temperature - -25°C + 55°C View distance -8 m;
Height of vision - 3 მ Type of protection - IP55.

Control Panel

Interface - 2x X-BUS (1); 2x RS232 (RJ45 ports, for X-10);
1 x USB (For connecting to a computer and working with software), 1x SPS For fast programming;
1x Ethernet (RJ45)
Power supply - 230 w;
Power required - 200 KVA Battery - Max.7A/12B;
Maximum Zones - 512 Maximum Wireless;
Zones - 120 relays - 1 30 V / 1A;

Level of protection - IP30;
Maximum outs - 512 programmable;უბნები - 32;
Number of bars - 512 (for 1 user) Number of users- 512;
Maximum number of keyboards - 32;
Working temperature - +5 ^{0}C – +40 ^{0}C;
Marking - CE.

Fire alarm

Control Panel
The maximum number of connecting devices - up to 125;
Signal contour maximum resistance - 100Ω;
Maximum number of devices connected in one channel -32;
Number of zones - 250;
Number of devices in one zone - 60;
Reaction time to detector signal - 10 sec;
Number of reports of fire occurrences 9999 Events Archive - 1023;
Power supply - 220/230VAC 50/60Hz;
From the accumulator - 2x12VDC, 18 Ah;
The required power in the electrical network - 1A;
Interface: RS 232 ან RS 485 – 1 CAN – 2;
Working temperature - -5°C +40°C;
Working Humidity - 93%;
Level of protection - IP 40 Standard - EN54-2;

Addressable Smoke Detector.
Working voltage - 15–30 V DC;
Level of protection - IP 43;
Working temperature - – 10°C – + 55°C;
Humidity - 93%;
Diameter of protection zone - 15 m;
Height of protection zone- 11 m;
Standard - EN54-7;

Gas leak detector
Power supply - 230V/50Hz;

Power required - 1,5 W;
Diameter of vision - 30 m;
Fire Network Integration Controller Interface - Central processor AMR;
Network port Interface - Ethernet 10/100Base-T;
Type of port - RJ-45;
Number of ports - 2;
Additional Interfaces - USB (2); RS-232 (3); RS-422/485 (1);
Level of protection - IP22;
Number of receiver control type control channels - 1;
Work Frequency - 433,92 MHz;
Action range - 200 მ – 400 m;
Voltage constant current - V, 10,0 – 15,0;
Working temperature - -20°C +40°C.

Revolving drum doors

Dimensions: diameter - 2100 mm, height - 2400 mm. (Fig. 25);

Number of wings: 4 unit. The wings are the prefabricated structure made of aluminum profile, which includes 10 mm thick ESG tempered glass panels (one or several wings can be folded to ventilate the room).

Drum Door Walls: it the 10 mm thick VSG tempered glass panel with outer radius.

Closing the Doors: Inner side – Metallic Decorative Sheet. Outer side – stainless steel sheet, with two drains. Profiles: anodized stainless steel E6 / EV1. Door locking mechanism: with a mechanical shutter.

Ring for the floor: The solid drum structure mounted directly on the floor, on the rectangular 360 ° stainless steel (V2A) profile, with dimentions 30 mm x 30 mm x 2 mm.

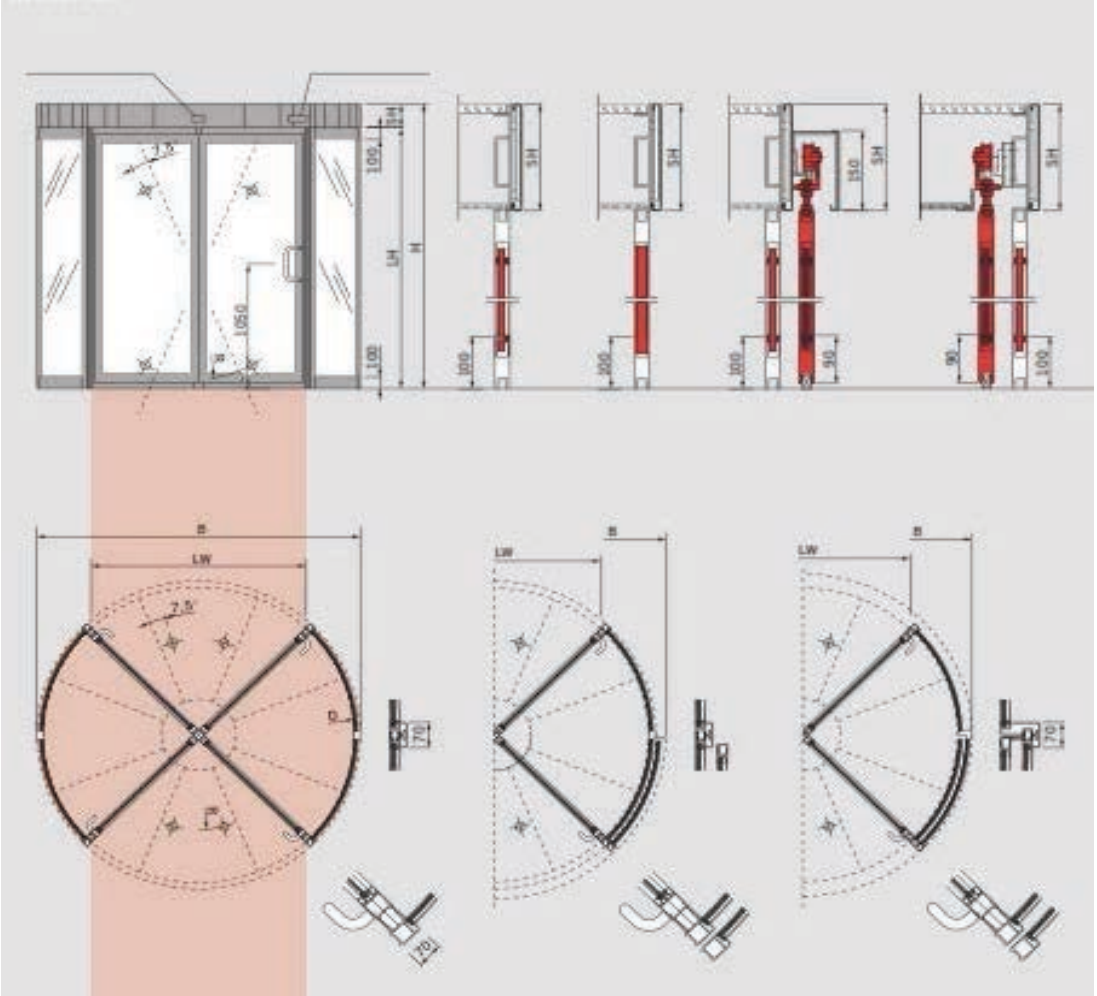


Fig. 25. Glass revolving drum door

Electric motor Tech Door

In the warehouse for the movement of vehicles are provided, the technical doors with dimensions of 4000 mm x 5000 mm with the electric motor.

The door is made of polystyrene insulation in two-layer steel sheets. To maintain the desired thermal insulation in the building, the insulation layer should be at least 25 mm thick.

The mechanism that drives the door - is a button on the control panel working on the principle of constant pressing connected to an electric motor. When button pressed, the door opens vertically upward.

The design requirements of CN and R 30109-94 "Engineering structures, doors and

gates" shall be taken into account during design.

The manufacturing company should have the ISO-9001 Standard Certificate.

Platform for movement

For people with disabilities, in the office building, the project provides for the arrangement of a self-propelled platform moving up the stairs. The platform runs from the first floor to the second, along the monolithic reinforced concrete staircase. Especially for it, rails for moving the platform are installed on the supporting beams.

The platform comes into effect after the wheelchair stands on it, by pressing the button working on the principle of constant pressing.

Technical Specifications:

The guide rails must withstand the load of at least 250 kg.

Minimum width of the staircase should be 1320 mm. Platform stop min. distance should be 1920 mm.

The single-phase 220 V power source with the frequency of 50 Hz and power consumption of up to 1 kW is used as the power source. The circuit is protected by the 16 A circuit breaker. To the switchboard is connected by the copper electric cable 3 mm x 1.5 mm.

It's necessary to install: the network fuse, clamp to ensure the "dry" connection. The socket should be installed at the distance of no more than 2 m from the device.

CN and R 35-01-2001 "Accessibility of Buildings for Persons with Disabilities" should be taken into consideration when designing the project.

The manufacturing company must have the relevant quality protection certificate, the equipment should meet UNIEN ISO-9001 international standard.

Server

Central Concentrator (CORE SWITCH);

19" Form-factor for installation in standard rak;

Productivity: Forwarding rate 32 Gbps, 38 Mpps;

Memory 128MB DRAM;

Number of VLANs up to 255;

VLAN ID – up to 4000;

jumbo frames 9000;

Up to 12,000 configurable MAC addresses;

Protocols, standards and certificats - IEEE 802.1D Spanning Tree Protocol, IEEE 802.1p CoS Prioritization, IEEE 802.1Q VLAN, IEEE 802.1s, IEEE 802.1w, IEEE 802.1X, IEEE 802.1ab (LLDP), IEEE 802.3ad, IEEE 802.3af, IEEE 802.3at, IEEE 802.3x full duplex on 10BASE-T, 100BASE-TX, and 1000BASE-T ports, IEEE 802.3 10BASE-T specification, IEEE 802.3u 100BASE-TX specification, IEEE 802.3ab 1000BASE-T specification, IEEE 802.3z 1000BASE-X specification, RMON I and II standards, SNMP v1, v2c, and v3, RFC 768 – UDP, RFC 783 – TFTP, RFC 791 – IP, RFC 792 – ICMP, RFC 793 – TCP, RFC 826 – ARP, RFC 854 – Telnet, RFC 951 - Bootstrap Protocol (BOOTP), RFC 959 – FTP, RFC 1112 - IP Multicast and IGMP, RFC 1157 - SNMP v1, RFC 1166 - IP Addresses, RFC 1256 - Internet Control Message Protocol (ICMP) Router Discovery, RFC 1305 – NTP, RFC 1492 - TACACS+, RFC 1493 - Bridge MIB, RFC 1542 - BOOTP extensions, RFC 1643 - Ethernet

Interface MIB, RFC 1757 - RMON

Memory - 128 MB DRAM;

At least 24 Ethernet 10/100/1000 Ports at least four gigabit SFP applinks.

Computer network

Outdoor Network hubs (SWITCH);

Switches should be industrial;

With DIN-rail installation capability;

Minimum PROFINET conformance class B compliance Certified;

Protocols, standards and certificats - PROFINET conformance class B compliance, IEEE1588v2, NEMA TS-2, IEC 60950-1, IEC61000-4-4, EN 55024, EN50121-3-2, EN50121-4, EN 50082-2, EN50155, IEEE 1588v2, IEC 60079-15, EN 50021; OSPF, EIGRP, RIPv1, RIPv2, Policy-based routing, IEEE 802.1x, 802.1q trunking, IEEE 802.1d Spanning Tree Protocol;

Mechanical shock: 20 g or more in working condition;

Productivity: 16 Gbps switching fabric, Forwarding rate 6 Mpps (64-byte packets);

Memory - 128 MB DRAM;

jumbo frames up to 9000 Bytes to gigabitic applink;

Up to 8000 Configurable MAC Address;

Up to 3,000 Configurable unicast route;

Two dual-use applique (dual-purpose uplink) - 10/100/1000 Ethernet port and SFP-based Gigabit port

Minimum Ethernet 10/100 ports

Working Mode: -40 to +70ºC, Humidity 95%;

Indoor Network hubs (SWITCH);

19'' Form-factor for installation in standard rak; Productivity: Switching bandwidth 170 Gbps, Forwarding bandwidth 88 Gbps; Memory 128MB DRAM;

NUMBER OF VLANS UP TO 255;

VLAN ID – up to 4000;

jumbo frames up to 9000 bytes;

Up to 8000 Configurable MAC Address;

Protocols, standards and certificats - IEEE 802.1D Spanning Tree Protocol, IEEE 802.1p CoS Prioritization, IEEE 802.1Q VLAN, IEEE 802.1s, IEEE 802.1w, IEEE 802.1X, IEEE 802.1ab (LLDP), IEEE 802.3ad, IEEE 802.3x full duplex on 10BASE-T, 100BASE-TX, and 1000BASE-T ports, IEEE 802.3 10BASE-T specification, IEEE 802.3u 100BASE-TX specification, IEEE 802.3ab 1000BASE-T specification, IEEE 802.3z 1000BASE-X specification, RMON I and II standards, SNMP v1, v2c, and v3, RFC 768 – UDP, RFC 783 – TFTP, RFC 791 – IP, RFC 792 – ICMP, RFC 793 – TCP, RFC 826 – ARP, RFC 854 – Telnet, RFC 951 - Bootstrap Protocol (BOOTP), RFC 959 – FTP, RFC 1112 - IP Multicast and IGMP, RFC 1157 - SNMP v1, RFC 1166 - IP Addresses, RFC 1256 - Internet Control Message Protocol (ICMP) Router Discovery, RFC 1305 – NTP, RFC 1492 - TACACS+, RFC 1493 - Bridge MIB, RFC 1542 - BOOTP extensions, RFC 1643 - Ethernet Interface MIB, RFC 1757 - RMON

At least 24 Ethernet 10/100 ports

At least two gigabit apps available: -5 to +45ºC, Humidity 95%;

Indor POE hubs (SWITCH);

19'' Form-factor for installation in standard rak; Productivity: Switching bandwidth 170 Gbps, Forwarding bandwidth 88 Gbps; Memory 128MB DRAM;

NUMBER OF VLANS UP TO 255;

VLAN ID – Up to 4000;

jumbo frames up to 9000 Baits;

Up to 8000 Configurable MAC Address;

Protocols, standards and certificats - IEEE 802.1D Spanning Tree Protocol, IEEE 802.1p CoS Prioritization, IEEE 802.1Q VLAN, IEEE 802.1s, IEEE 802.1w, IEEE 802.1X, IEEE 802.1ab (LLDP), IEEE 802.3ad, IEEE 802.3x full duplex on 10BASE-T, 100BASE-TX, and 1000BASE-T ports, IEEE 802.3 10BASE-T specification, IEEE 802.3u 100BASE-TX specification, IEEE 802.3ab 1000BASE-T specification, IEEE 802.3z 1000BASE-X specification, RMON I and II standards, SNMP v1, v2c, and v3, RFC 768 – UDP, RFC 783 – TFTP, RFC 791 – IP, RFC 792 – ICMP, RFC 793 – TCP, RFC 826 – ARP, RFC 854 – Telnet, RFC 951 - BootstrapProtocol (BOOTP), RFC 959 – FTP, RFC 1112 - IP Multicast and IGMP, RFC 1157 - SNMP v1, RFC 1166 - IP Addresses, RFC 1256 - Internet Control Message Protocol (ICMP) Router Discovery, RFC 1305 – NTP, RFC 1492 - TACACS+, RFC 1493 - Bridge MIB, RFC 1542 - BOOTP extensions, RFC 1643 - Ethernet Interface MIB, RFC 1757 - RMON

At least 24 PoE/ PoE+ Ethernet 10/100 ports At least two gigabitic apples;

Working mode: -5 to +45ºC, Humidity 95%.

Video surveillance system

All camcorders should be compatible with the Milestone XProtect Corporate system and should be capable of running at least two parallel (any, including maximum configuration) video streams with the system. Camcorders should be equipped with all the necessary accessories (clamps, lenses, jack if needed, etc.)

Wi-Fi network

General Features of WI-FI Network:

It should be managed and configured centrally, with one Interface (with the management module).

Standards Support:

Wi-Fi Standards: IEEE 802.11a, 802.11b, 802.11g, 802.11d, WMM/802.11e, 802.11h, 802.11k, 802.11n, 802.11r, 802.11u, 802.11w, 802.11ac

Network Standards: IEEE 802.3 10BASE-T, IEEE 802.3u 100BASE-TX, 1000BASE-T, and IEEE 802.1Q VLAN Tag

RFC Compliance: RFC 768 UDP, RFC 791 IP, RFC 2460 IPv6, RFC 792 ICMP, RFC 793 TCP, RFC 826 ARP, RFC 1519 CIDR, RFC 1542 BOOTP, RFC 2131

DHCP, RFC 5415 CAPWAP Protocol Specification

Safety Standards: Wi-Fi Protected Access (WPA), IEEE 802.11i (WPA2, RSN), RFC 1321 MD5 Message-Digest Algorithm, RFC 1851 The ESP Triple DES Transform, RFC 2104 HMAC: Keyed Hashing for Message Authentication, RFC 2246 TLS Protocol Version 1.0, RFC 2401 Security Architecture for the Internet Protocol, RFC 2403 HMAC-MD5-96, RFC 2404 HMAC-SHA-1-96, RFC 2405 ESP DES-CBC, RFC 2406 IP (ESP), RFC 2407, RFC 2408 ISAKMP, RFC 2409 IKE, RFC 2451, RFC 3280 X.509 PKI & CRL, RFC 3602 The AES-CBC, RFC 4347, RFC 4346 TLS Protocol Version 1.1.

Encryption: Advanced Encryption Standard (AES): CBC, CCM, CCMP; DES: DES-CBC, 3DES; SSL TLS: RC4 128-bit, RSA 1024-2048-bit; DTLS: AES-CBC

AAA (Authentication, Authorization, and Accounting): IEEE 802.1X, RFC 2548 Microsoft Vendor-Specific RADIUS Attributes, RFC 2716 PPP EAP-TLS, RFC 2865 RADIUS Authentication, RFC 2866 RADIUS Accounting, RFC 2867 RADIUS Tunnel Accounting, RFC 3576 Dynamic Authorization Extensions to RADIUS, RFC 3579 RADIUS Support for EAP, RFC 3580 IEEE 802.1X, RFC 3748 EAP, Web-based authentication

EN 60950:2005, EN 55022, EN 55024, EN 300.328, EN 301.893

Indoor WI- FI Device (WI- FI ACCESS POINT);

Doble Frequency 802.11a/g/n;

Standards 802.11n:

2x2 MIMO, 2x spatial streams;

20- and 40-MHz Channels;

PHY Data transfer speed300 Mbps;

Package aggregation: A-MPDU (Tx/Rx);

802.11 Dynamic frequency selection (DFS) (Bin 5) Cyclic shift diversity (CSD) support.

Receiver sensitivity:

802.11b: -86 dBm @ 11 Mb/s

802.11g: -84 dBm @ 18 Mb/s

802.11a: -88 dBm @ 18 Mb/s

Maximum power:

2.4GHz (802.11b/g/n): 20 dBm, 5GHz (802.11a/n): 20 dBm ability to adjust the power;

External WI-FI transmitting device (WI-FI ACCESS POINT);

Double Frequency 802.11a/b/g/n;

Standards 802.11n:

2x2 MIMO, 2x spatial streams

20- and 40-MHz Channels

PHY Data transfer speed300 Mbps

Package aggregation: A-MPDU (Tx/Rx)

802.11 Dynamic frequency selection (DFS) (Bin 5) Cyclic shift diversity (CSD) support

Receiver Sensitivity:

802.11b: -96 dBm @ 1 Mb/s

802.11g: -93 dBm @ 6 Mb/s

802.11a: -92 dBm @ 6 Mb/s

Transmission Maximum Power: 2.4/5GHz: 27 dBm;

The ability to adjust power;

Working environment: -30 to 65 °

Protection: IEC 60529 IP67, MIL-STD-810F

Composite panel

The inner side of the composite panels is milled and has rectangular grooves. Factory-producer of composite materials should meet ISO9001-2000 standards. Composite panels should be made in accordance with EN 438-7 Standard.

Stained glass

Structural stained-glass windows are fixed on an iso-aluminum profile with tinted glass using silicone. Tinted glass should be 30% thick (10 mm thick) and transparency should be 30%.

Anti-corrosion and waterproofing materials

The one component polyurethane filler that is resistant to ultraviolet radiation.

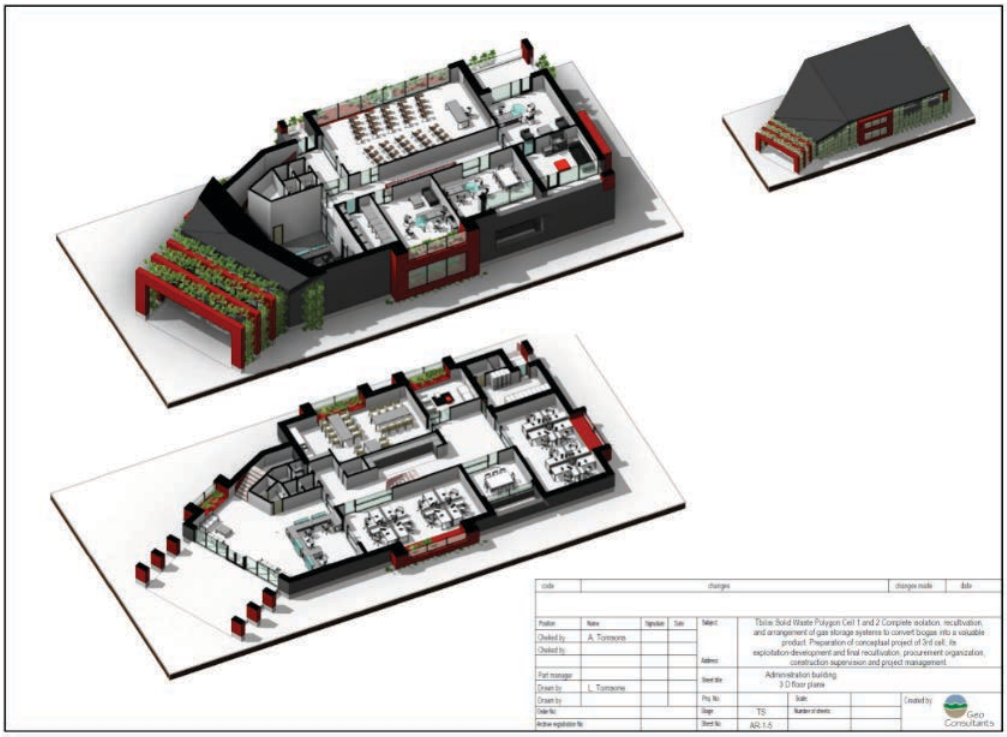
Waterproof epoxy primer for non-stick surface, Purpose: Concrete reinforcing agent that provides ideal bonding between concrete and polyurethane.

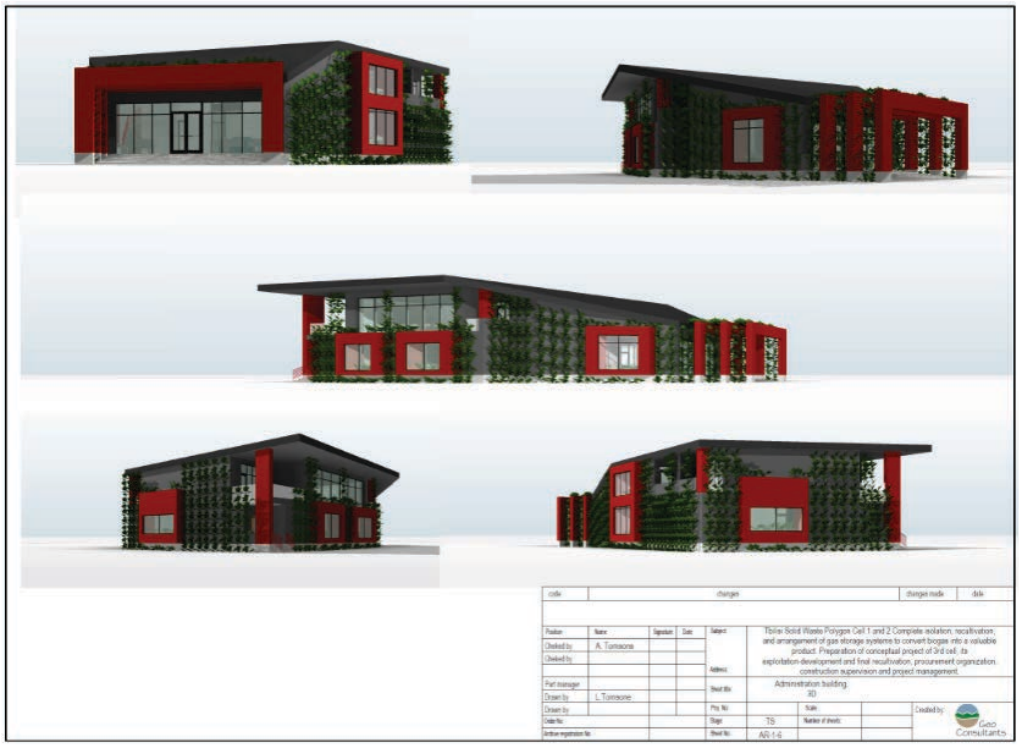
The one-component, fast-drying, polyurethane waterproofing material, temperature range - from - 30 to +90^{0}C, covering with: airless coating method.

Two-component, fast-drying, wear-resistant, color finish based on polyester and adhesive, covering with: airless coating method.

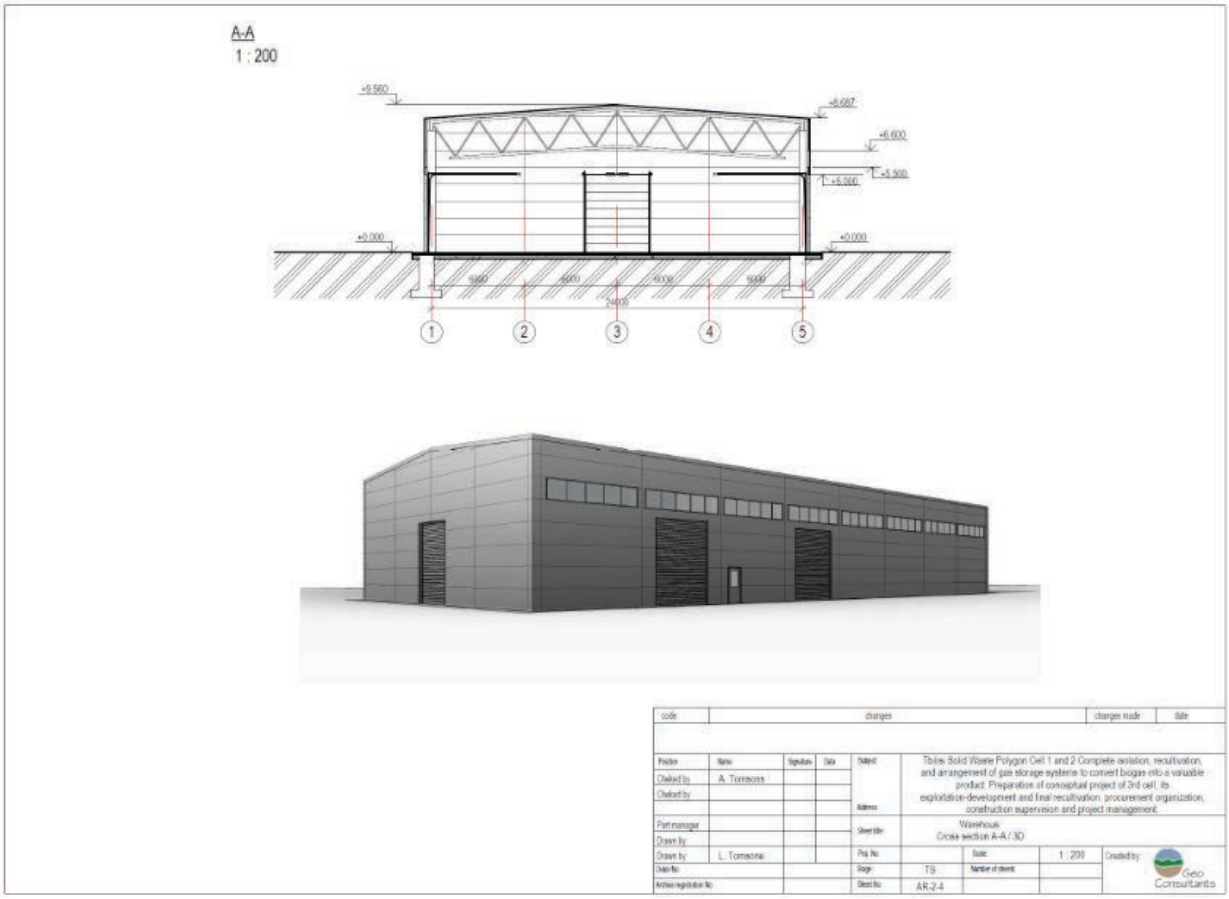
Corrosion-resistant paint, should be high quality and should comply with the requirements of ISO 12944-1.

3D image of office building

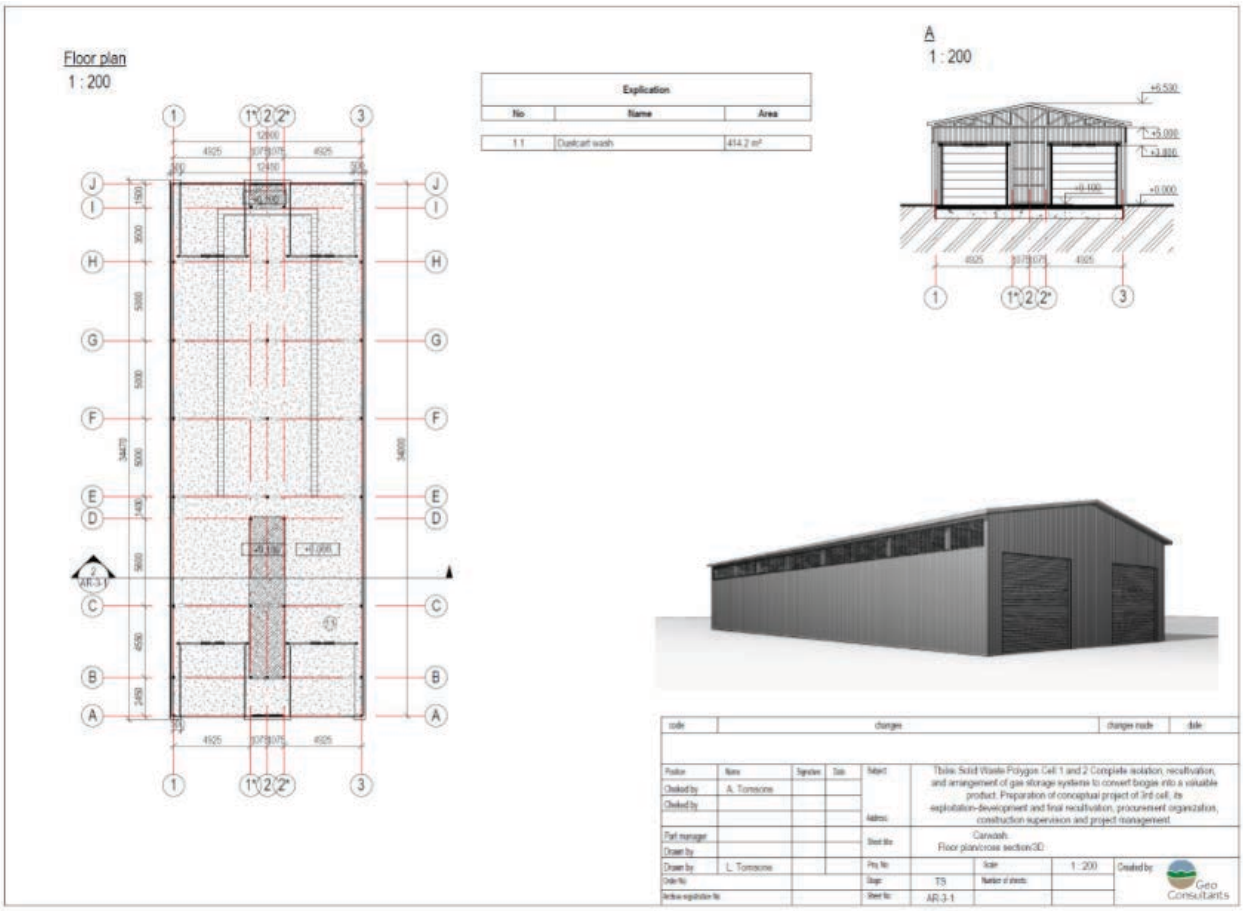




Warehouse building and its transverse section A-A / 3D



3D image of car washing and transverse section of the building



Conceptual Project for 20 year development of the Lilo Solid Waste Landfill

Introduction

The purpose of this document is to develop recommendations for the improvement of Tbilisi's Didi Lilo Municipal Waste Landfill (hereinafter "Landfill"). The preparation of the document required an analysis of the current situation, among others:

- ✓ Number disposed wast on Municipal Waste Landfilled by year and expected changes;
- ✓ Analysis of Landfill's existint infrastructure;
- ✓ Overview of the strategic directions of the waste management sector and the objectives thereof;
- ✓ Analyze relevant tasks to achieve the goals of waste recovery.

When developing the Landfill improvement scenario, the data obtained from the analysis of the existing situation, and recommendations based on existing best practices, were used to achieve effective waste management system functionality.

Analysis of the current situation at Didi Lilo Landfill

General Features

The Landfill located in the northeast of Tbilisi, in the territory of Norio settlement of Gardabani Municipality. The land is situated in the distance of 1,4-1,5 km from village Samgori, 1,2-1,3 km from the village Didi Lilo, and 4.0 km from village Norio. The distance from the nearest districts of Tbilisi is 4.5-5 km. The site is separated by natural barriers from the nearest residential areas, which significantly reduces the risks of possible negative impacts.

Fig. 26. Landfill Location (Source: Google Maps)

The surface of the territory of the land for the project is mostly flat inclined towards the southeast direction. The territory is surrounded by:

- In the southeast – local highway, agricultural land and then in the distance of 350-900 meter main road of Zemo Samgori;
- In the north and northwest – Tselubani slopes and hills, which is separated from the project land by so –called " irrigation channels of Martkopi" and operation road of this channel;
- In the east – agricultural lands and then territory of former poultry-farm;
- In the west – a hill and then agricultural lands

The landfill has been in operation since 2010. By the end of 2018, 2.97 million tons of waste was placed on landfill cells 1 and 2 by the end of 2018. Since July 2019, the III cell of the landfill has started operating. Based on the operation recommended by experts, this capacity can be increased to at least 842 408 m^3. When treated with 0.7 m^3/t of waste in the cell, its capacity would be approximately 588,000 tons. The diagram of the landfill is shown in Fig. 27.

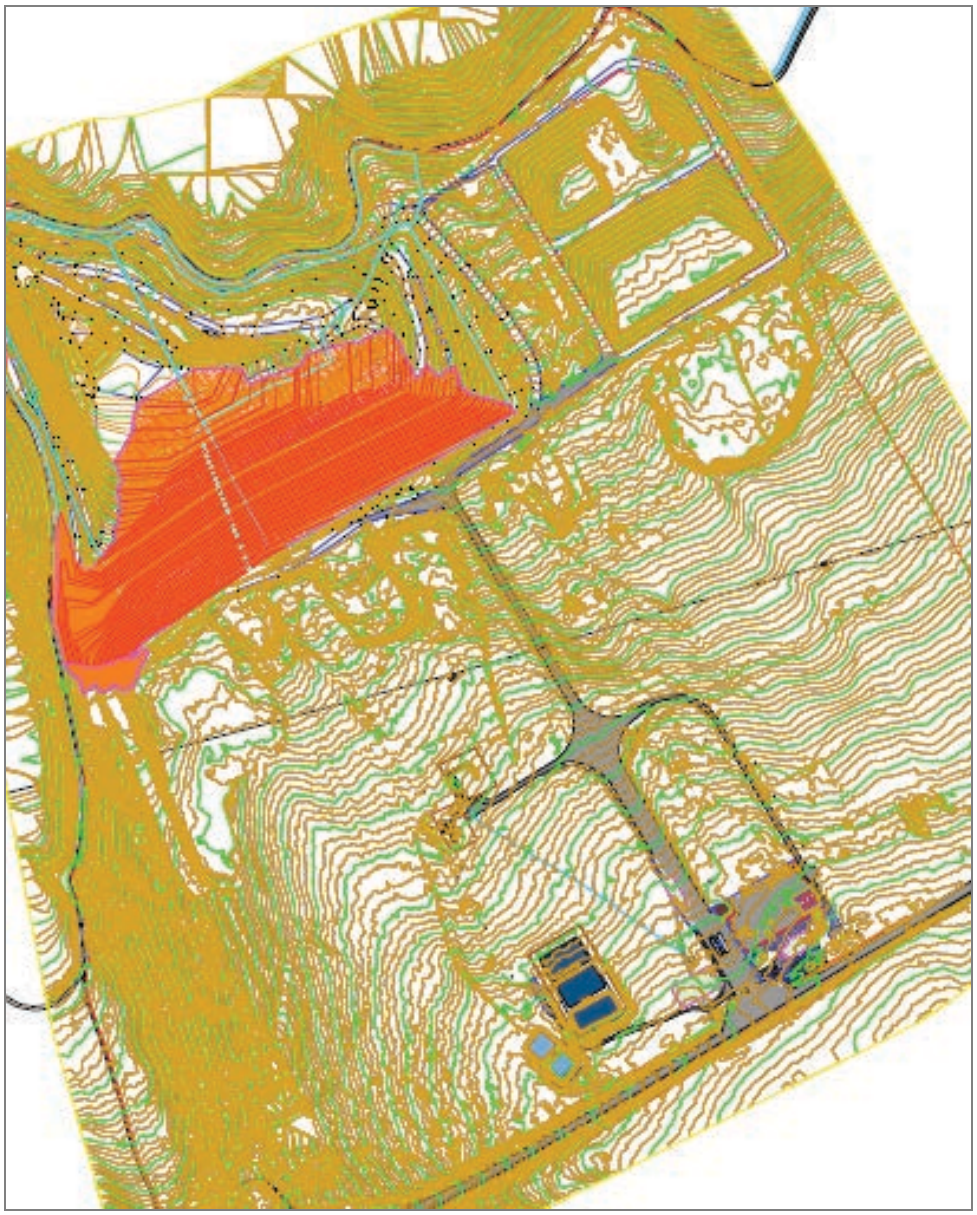


Fig. 27. Didi Lilo Landfill

The existing infrastructure of the landfill is as follows:

- ✓ Landfill cells (the I cell is closed and partially recultivated, the II cell is partially closed and the III cell is operational);
- ✓ Office building;
- ✓ Leachate collection and treatment system;
- ✓ Gutter groove;
- ✓ Bridge scale;
- ✓ Container type buildings for landfill personnel;
- ✓ Desinfaction washing equipment for washing garbage trucks and other machinery (manually operated).

Shortcomings identified by experts in field research are:

- ✓ Lack of the system for collecting and utilizing landfill gases;
- ✓ Malfunctioning system for collecting, purifying and recirculating leachate;
- ✓ Destruction of the closed southern slope of the I cell caused by the ineffective gas collection system and its improper operation;
- ✓ Complete emission of landfill gases from all three cells into the atmosphere and resulting in widespread unpleasant odor spread;
- ✓ The absence of the waste sorting plant;
- ✓ Absence of biodegradable and other recyclable waste separation and recycling practices;
- ✓ Uncomfortable work environment for administration staff and landfill operators;
- ✓ The absence of the laboratory equipment to control environmental parameters.

Improvement projects for the existing Landfill

To address the above mentioned issues, two projects were launched in 2019 to improve the waste management system and improve Didi Lilo landfill.

As part of the first project, "The Solid Waste Project in Tbilisi - Support for the implementation of the project, Engineering and design services, Purchasing and supervision of contracts", it's planned to introduce the system for collecting and treating wastewater of appropriate capacity and operating parameters at the landfill.

As for the second project "Preparation of the Conceptual Design of complete isolation, re-cultivation of I and II cells in Tbilisi Household Solid Waste Landfill, arrangement Gas Collection System and turning biogas into a valuable product, preparation of the Conceptual Design the in-service cell III in accordance with the exploitation-development and final re-cultivation, procurement organization, construction supervision and project management" the following problematic issues are planned:

- Rehabilitation of the I and II cells of the landfill (rehabilitation of the destroyed south slope of the I cell), closure and final reclamation;

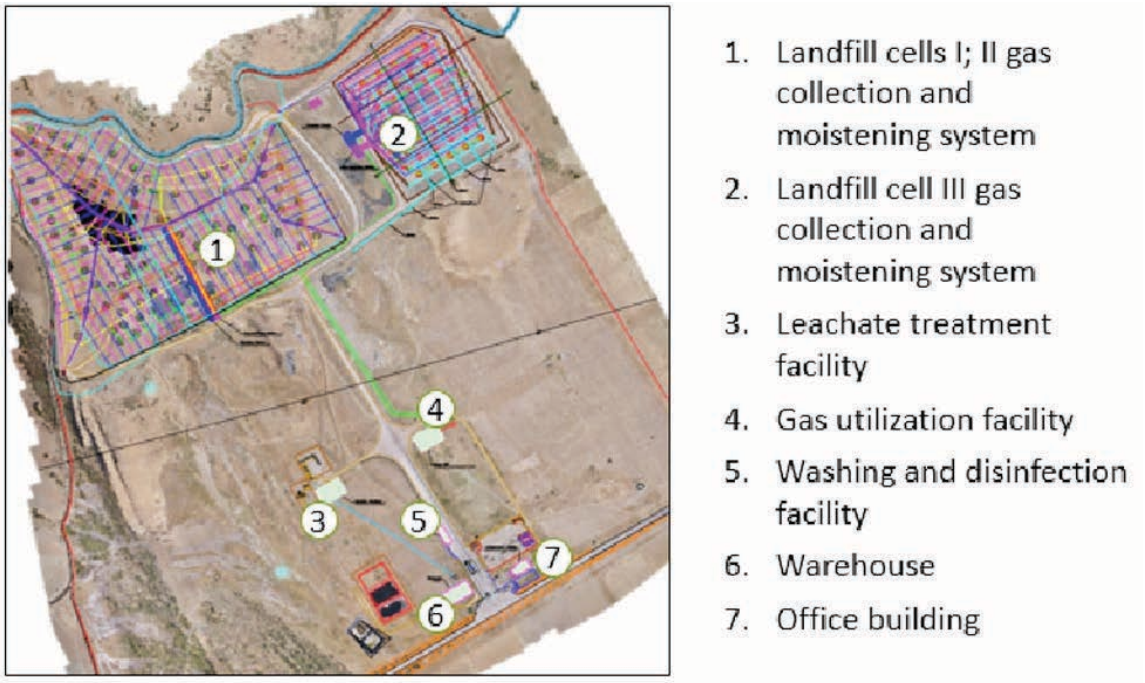


Fig. 28: Didi Lilo Landfill Improvement Project

- Implementation of the technologies horizontal and vertical systems for collecting the landfill gas and further utilization of biogas;
- Rehabilitation of leachate collection and recycling system and development of modern approaches;
- Cancellation of biotermic (animal corps) pit located on the Polygon;
- Construction of the new office building for landfill personnel;
- Introduction of the modern automated disinfection and washing system for garbage trucks and other equipment;
- Arrangement of the additional storage facilities;
- Organization of the laboratory, weather station and bird protection systems at the Polygon.

Quantity and composition of the waste disposed on Landfill

Didi Lilo is one of the largest licensed landfills where the disposal of the household waste (except for construction waste) takes place in Tbilisi. Historically, the amount of waste generated by the population in the capital is characterized by increasing trend. According to landfill statistics, the amount of waste has increased by almost 13% over the last five years. Existing statistics on the waste growth are presented in Table 1. According to the reporting data, the share of municipal waste in the total volume of waste is on average 95%.

	2010	***2011***	***2012***	***2013***	***2014***	***2015***	***2016***	***2017***	***2018***
The waste disposed on the Landfill (2010-2018)	*40 262*	*313 970*	*345 175*	*349 950*	*368 725*	*360 363*	*380 380*	*397 505*	*416 515*
Changes	*Not Avalable*	*Not Avalable*	*9%*	*1%*	*5%*	*-2%*	*5%*	*4%*	*5%*

Table 1. Quantity of waste disposed at Didi Lilo landfill in 2014-2018.

Given the current statistics and the trend of increasing the amount of waste, these figures are likely to continue to increase in the coming years and the amount of municipal waste generated in 2019-2023 will be equal to the data presented in Table 2.

	2019	***2020***	***2021***	***2022***	***2023***
The waste disposed on the Landfill	*433 176*	*450 503*	*450 503*	*450 503*	*450 503*
Changes	*4%*	*4%*	*0%*	*0%*	*0%*

Table 2. Estimated amount of municipal waste to Landfill in 2019-2021.

The total waste characteristics of the Landfill are presented in the Fig. 29.

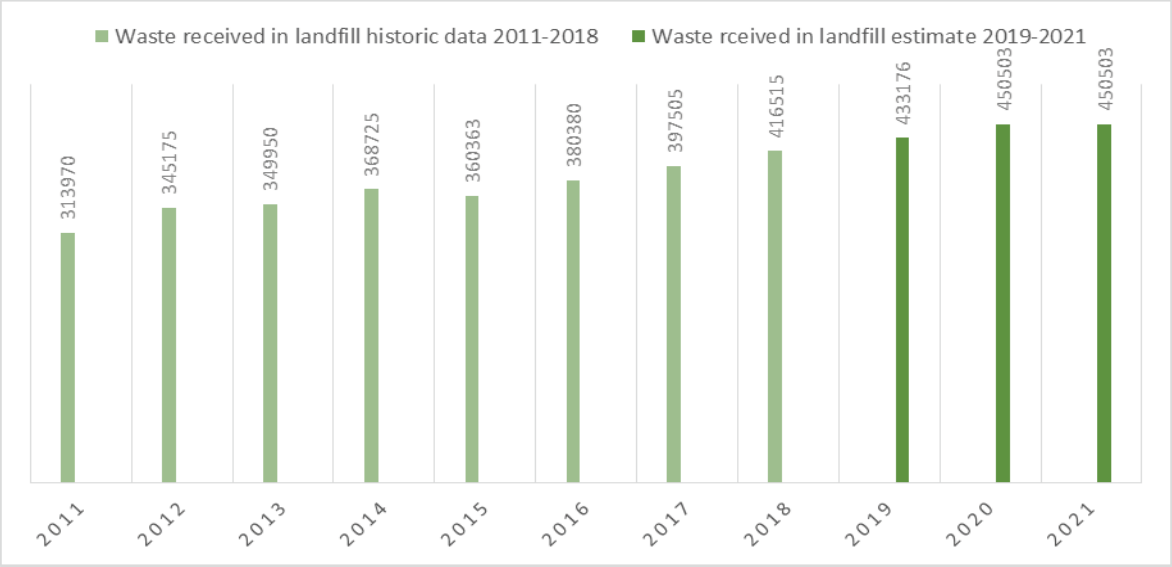


Fig. 29. Estimated amount of municipal waste disposed to landfill in 2019-2021.

Since no detailed forecast of waste generation and collection over the coming years has been made, when developing the landfill development and improvement concept the average volume of disposal waste at 450,000 tonnes, has been taken into account. Following the accurate forecast of Tbilisi Municipal Waste Management Strategy and waste generation in Tbilisi, it may

be necessary to adjust the assumptions presented in the conceptual design. When analyzing the annual change in the amount of municipal waste generated in Tbilisi, there are significant deviations. In particular, based on the analysis of the daily average data for the five-year period, it can be concluded that the difference between the average daily amount of municipal waste generated in January and July is ~ 30%

The average amount of the waste generated daily is less than 1000 tons for 6 months, out of 12, and in the remaining 6 months equal or exceed this value. If we generalize the projected growth rate of the waste generation to the daily waste generation, it's expected that by 2021 the average daily waste generation rate will exceed 1150 tonnes and the July average will be 1353 tons a day. If we analyze the daily figures, the waste may sometimes reach up to 1500 tons a day. This factor should be taken into account when planning the capacity of waste management infrastructure and capacity of production plants.

Another important factor affecting the development of the waste management system is the composition of the municipal waste. The absence of the separation system affects the quality of secondary resources and limits its potential for further use. As of today, no the waste composition analysis has been conducted on Didi Lilo Polygon. However, there is an official source for the results of the 2012 Kutaisi Landfill Mixed Waste Survey. Given that the composition of waste is constantly changing, it is recommended to conduct seasonal waste composition research. The composition of the waste presented in Fig. 31 is based on existing data and experience from the various developing countries, in particular:

- ✓ Large proportion of the unsorted municipal waste is biodegradable - at least 50% of the total volume;
- ✓ The share of the recyclable waste - such as paper-cardboard, plastic, glass and metal - makes up about 30% of the total;
- ✓ Inert fractions (swept, sand, other inert fractions) make up 10-15%;
- ✓ Wood, rubber, hygiene waste is 10-15% of the total amount;
- ✓ The hazardous fraction is ~ 1% of the total amount of waste.

The analysis of the unsorted municipal waste composition is presented in Fig 30. These data were the basis for the development of conceptual projects and need to be corrected after the seasonal analysis of the waste composition.

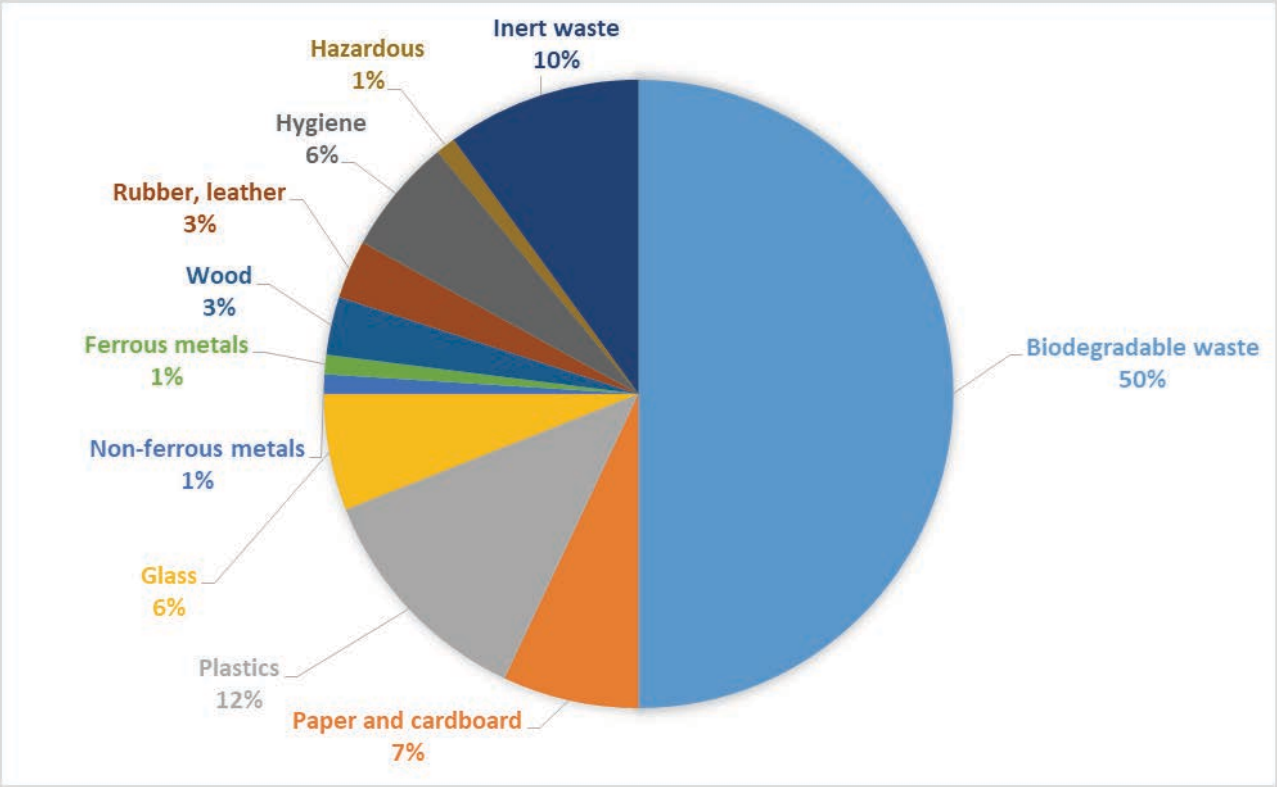


Fig. 30. Analysis of the composition of unsorted municipal waste.

The quantities of individual fractions of waste calculated on the basis of the total amount and composition of municipal waste are given in a Table 3.

Waste stream	% (Mass)	Quantity t/y
Biodegradable waste	50%	225 000
Paper and cardboard waste	7%	31 500
Plastic	12%	54 000
Glass waste	6%	27 000
Waste of non-ferrous metals	1%	4 500
Waste of ferrous metals	1%	4 500

Wood waste	3%	13 500
Rubber and leather waste	3%	13 500
Waste of hygiene products	6%	27 000
Hazardous waste	1%	4 500
Inert waste	10%	45 000
Total:	100%	450 000

Table 3. Composition and quantities of mixed municipal waste by the fractions

Analysis of existing data shows that the amount of biodegradable waste is about 225,000 t/year, secondary resources - paper and cardboard, glass, plastic, and metal - about 120,000 t/year. The total amount of other waste is 100,000 tons a year.

Conceptual vision of the Landfill improvements by 2020-2040

Key Findings

The conceptual view of landfill improvements has been developed taking into account the hierarchy of the Waste Management System, the specific needs and resources available in the waste management field. Presumably, the current goals will be achieved within the framework of ongoing projects aimed landfill infrastructure development - improvement of leachate collection and treatment system, landfill gas collection and utilization system (Phase 1).

Municipal solid non-hazardous waste and separately collected secondary fractions will be collected and transported to landfill for further treatment. Consequently, the regional waste treatment center will be set up at the Polygon and the need to set up waste treatment plants at the new locations will be avoided.

The following goals should be achieved within the scope of Didi Lilo landfill improvements:

- ✓ Promote the achievement of the objectives set out in the waste management strategy; In particular: Reduction of waste disposal and promotion of waste recycling;
- ✓ Ensure sufficient disposal capacity for waste disposal;
- ✓ Reduction of the negative impacts the landfill operations on the environment and human health;
- ✓ Develop sustainable approaches to waste management by adopting modern standards and the best available technologies.

Prerequisites for successful implementation of goals are:

- ✓ Formation of the goals in accordance with the law by the priorities and the correct distribution of responsibilities;
- ✓ The wast treatment and waste management procedures standardization;
- ✓ Financial and institutional support needed to achieve the goals;
- ✓ Exclusive right to receive waste from the municipality.

Polygon Operation Constraints:

- ✓ The costs required for waste management at the Polygon shall not exceed the potential benefits received;
- ✓ Waste management service costs should not exceed the solvency of the waste makers, use the services of the Waste Management Services.

Basic principles

The priority of the waste management system hierarchy is as follows: (a) prevention; (b) reuse; (c) recycling; (d) Recovery including energy and (e) placement. The goals set are in line with the requirements set out in the Waste Management Strategy. Specifically: Reduction of waste disposal to 10% by 2035 and recycling to 60% by 2030. Therefore, special attention should be paid to the waste prevention and recycling. It should also be noted that the achievement of recycling targets for the number of municipal solid waste mixes is associated with the number of limitations.

There are many technological solutions that allow the waste volume to be fully regenerated. However, environmental, economic, and social factors often impede the full realization of decisions.

The fundamental principles should be taken into account:

- ✓ The environmental impacts of waste recycling shall not exceed the impacts of non-recycling;
- ✓ Calculate the waste management costs in accordance with the "polluter pays" principle;
- ✓ Social factors need to be taken into account and the potential for the changing social behavior patterns and habits when planning the Waste Management Improvements.

In general, there are two main strategies for the Municipal Waste Management: 1) the use of secondary resources in cople with incineration or 2) the use of secondary resources through mechanical-biological recycling. With the latter approach, the use of various waste recycling, composting and biological treatment technologies (anaerobic recycling) is of the particular interest. It is advisable to use the latter strategy in Georgia, and in particular at the "Didi Lilo" Polygon, with the following technical approaches in mind:

- ✓ Separation of the waste at the source;
- ✓ Mechanical treatment of mixed waste;

Based on these approaches, to obtain the high-quality secondary resources, the separation of waste at the source is indispensable alternative; However, in this case, the

public plays decisive role, and ongoing campaigns are needed to raise the awareness of citizens.

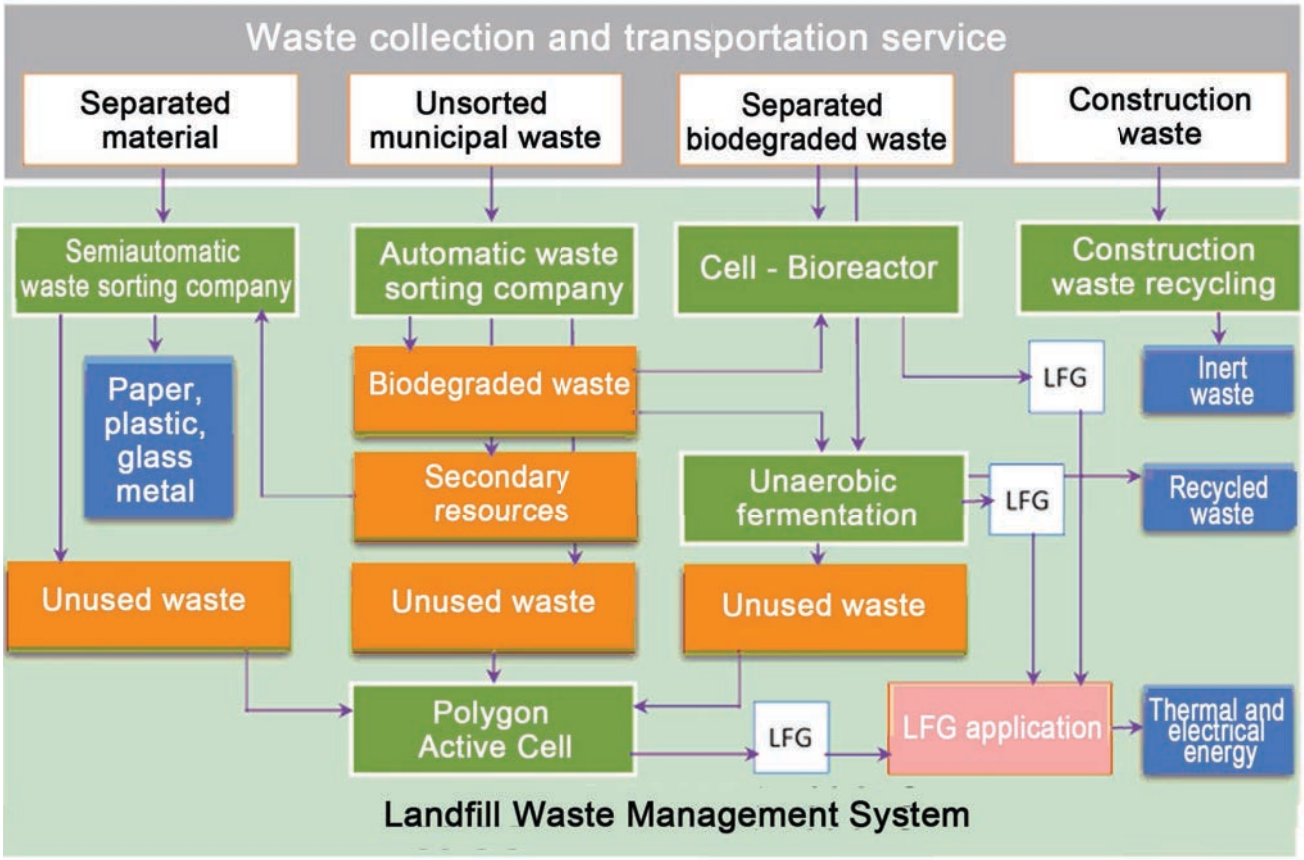


Fig. 32. Technological scheme of the Waste Management Process.

The technological scheme proposed by experts combines both technical approaches to minimize risk factors. Combination of methods: separation at sources and mechanical treatment are shown in the Fig. 32.

Characterization of the infrastructure components as part of the landfill improvement program

Analysis of required capacities

The estimation of the working capacity of the Polygon is based on the projected data on the total amount of waste to be processed and on the calculations of the composition of the waste. It's recommended that the following should be implemented on the Polygon for the recovery of secondary waste materials:

- ✓ An automatic sorting plant with the capacity of 450,000 t/y whose required power will be reduced in direct proportion to the increase in the amount of the waste collected;
- ✓ The 150000-200000 t/y capacity semi-automatic sorting plant (manual sorting of separately collected waste and recyclable waste stream from fractions);
- ✓ The 250000-280000 t/y capacity cell bioreactor and/or anaerobic processing plant for biodegradable fraction, both from the mixed waste and separately collected biodegradable waste;
- ✓ Utilization of the landfill gases by generating thermal and electrical energy, with the initial capacity of 5 MW and subsequently increasing to 10 MW;
- ✓ For the inert waste it's recommended to install at least 50 000 t/y of capacity.

Expected reduction of landfill waste is expected through the separation and recycling of biodegradable and recyclable waste, which is estimated to be the 260000 tons a year. It accounts for 75% of the total waste. Based on the above mentioned, the required throughput of the waste disposal landfill is 190,000 tons a year.

Convert Landfill gas to the thermal and electric energy through the co-generation equipment

The biodegradable fraction of the mixed municipal waste causes biogas production under anaerobic conditions, the major constituents of which are 50-55% methane, 45-50% carbon dioxide, less than 1% organic compounds of the non-methane origin and the small amounts of inorganic compounds. Methane is 25 times more potent greenhouse gas (GHG) than

carbon dioxide. In the landfills where there is the high percentage of organic matters, the biogas emissions are high and therefore the impact on the landfill climate is significant due to the greenhouse effect. To reduce this impact, it's imperative to burn gases in the torch, which is not used as the by-product of energy, or converts biogas into thermal and electrical energy through co-generation equipment. It's possible not only meet the needs of the Landfill for energy, but also get additional income.

Existing legislation mandates the collection, treatment and subsequent disposal of the landfill gases. If the accumulated gases cannot be converted into energy, then their torching method should be burned. Accordingly, the collection and utilization of the landfill gases is integral part of the landfill operation.

Thus, to ensure compliance with legal regulations, the landfill gas utilization system should be equipped with the facility for co-generation of generated landfill gas as part of the landfill improvement project. In order to improve the landfill gas collection and further utilization system, the gas collection (horizontal and vertical) systems, gas control stations, condensate collection and removal system, compressor station and torch should be organized at the first stage. There will also be additional equipment needed to generate the electricity and heat - the co-generating equipment.

Pre-treatment of gases is prerequisite, which involves purification of the biogas prior to co-generation. Biogas H_2S, Cl, F, siloxanes and humidity have the negative impact on the performance of the engines in the co-generation equipment. They produce acids, which cause oil contamination and reduce the life of the unit, corrosion of intermediate coolers and other components.

To reduce the negative impact of the untreated biogas and high humidity on internal combustion engines, the gas purifier is used, which reduces the amount of H_2S, Cl, F and siloxane in the gas by 90% and the moisture content in the gas. Widespread adsorption-absorption technologies are used in processing. Adsorption involves the physical adsorption of the pollutant on the surface of the adsorbent such as activated carbon or silica gel. Adsorption is the common method of removing siloxanes from biogas. Absorption (or wet cleaning) involves the chemical or physical reaction of the contaminant to a solvent or solid reagent. Absorption is the common method of removing sulfur impurities from landfill gases. The design of the landfill gas treatment plant should be developed after thoroughly examining the composition of the landfill gas and the relevant quality standards established by the manufacturer of utilization plant.

Energy from landfill gases is generated using the methane containing landfill gases, which act as the fuel in internal combustion engines and drive electric power generators. The generated electricity may be used as the source of electricity for the needs of the Landfill, or it may be connected to the state power grid and receive appropriate benefits. The by-product of generating electricity is thermal energy. Various types of installations are available with less than 0.2 MW to more than 3.0 MW. Utilizing gases using the heat and electricity co-generating equipment requires at least 50% concentration of methane; As the result, energy value of about 0.005 MW / nm^3 will be obtained. The coefficient of operation of the co-generating equipement converting heat and electricity to 1 MW output is usually about 85%. Including - about 40% of the electricity and about 45% of the thermal energy (it should be noted that the Rankin cyclic system should be used to fully realize the potential of thermal energy, as approximately half of the heat energy is exhaust gas, the other half concentrated in the engine cooling system). The fuel consumed by the co-generating equipement converting heat and electricity to 1 MW is approximately 500 Nm^3/h.

As the rule, several co-generating equipments that convert heat and electric energy to landfill gas flow are utilized to allow continuous energy generation (thus avoiding system failure during maintenance work). For example, for landfill gas flow rates of the 2000 Nm^3/h, four co-generating equipments of 1 MW output will be needed.

Measurement of effective landfill gas flow is based on the modeling results of landfill gas generation for Lilo landfill; The benchmark assumptions take into account the speed of landfill gas collection. Electricity and heat generation for the power generation scenario are calculated on the basis of the calorific value of landfill gases and the technical capacities of the co-generating equipments. The results of the calculations are presented in the Table 4. Expected landfill gas extraction rate is 70%, annual number of working hours - 8760. Output capacity is calculated for the calorific value of landfill gases - 0.005 MW/Nm^3. Indicators of the power generated: Electricity - 40% of bypass capacity, Heat generation - 45% of bypass capacity.

Year	Total landfill gases Nm ³/sec	Landfill gases collected Nm ³/sec	Gas consumption Nm ³/sec	Output Power MW	Max. Power Generation MW/sec	Max. Heat production in MW/sec
2020	30 441 021	21 308 715	2 433	12	42 617	47 945
2021	33 450 600	23 415 420	2 673	13	46 831	52 685
2022	36 228 791	25 360 154	2 895	14	50 720	57 060
2023	38 793 384	27 155 369	3 100	15	54 311	61 100
2024	41 160 802	28 812 562	3 289	16	57 625	64 828
2025	43 346 205	30 342 343	3 464	17	60 685	68 270
2026	45 363 586	31 754 510	3 625	18	63 509	71 448

Year	Total landfill gases Nm ³/sec	Landfill gases collected Nm ³/sec	Gas consumption Nm ³/sec	Output Power MW	Max. Power Generation MW/sec	Max. Heat production in MW/sec
2027	47 225 863	33 058 104	3 774	19	66 116	74 381
2028	48 944 961	34 261 473	3 911	20	68 523	77 088
2029	50 531 889	35 372 322	4 038	20	70 745	79 588
2030	51 996 808	36 397 766	4 155	21	72 796	81 895
2031	53 349 099	37 344 369	4 263	21	74 689	84 025
2032	54 597 420	38 218 194	4 363	22	76 436	85 991
2033	55 749 767	39 024 837	4 455	22	78 050	87 806
2034	56 813 516	39 769 461	4 540	23	79 539	89 481
2035	57 795 481	40 456 836	4 618	23	80 914	91 028
2036	58 701 948	41 091 364	4 691	23	82 183	92 456
2037	59 538 723	41 677 106	4 758	24	83 354	93 773
2038	60 311 164	42 217 815	4 819	24	84 436	94 990
2039	61 024 217	42 716 952	4 876	24	85 434	96 113
2040	61 682 447	43 177 713	4 929	25	86 355	97 150

Table 4: Effective landfill gas flow, electricity and heat generation estimates 2020-2040

The results of the calculations show that the installed capacity of the co-generation plants starts from about 5 MW in 2020, 2021 and increases to 10 MW in 2040. Electricity generated annually increases from 42.6 to 86.4 MWh respectively. Maximum thermal generation during the same period ranges from 47.9 to 97.2 MWh.

Automated sorting plant (for mechanical processing of the mixed waste)

An automated sorting plant is essential for the separation of mixed fractions from municipal waste. Waste treatment is classified into three main streams during the treatment process by the mechanical processing methodology:

- ✓ Biodegradable waste;
- ✓ Secondary Resources (glass, paper, cardboard, plastic, metal);
- ✓ Fraction of waste that is not recyclable.

Separated biodegradable waste is transported to the bio-processing plant, the transportation of secondary resources for the purpose of obtaining the separate fraction - goes to the semi-automatic plant for further processing, the fraction of waste that is unusable for recycling is eventually disposed of on the active landfill cell.

The equipment and special equipment required for mechanical waste treatment in the sorting plant consist of the following components

- ✓ Tractors with the bucket loader to move waste as needed;
- ✓ Loading funnel;
- ✓ Waste pre-breaking system - Bag Opener;
- ✓ Waste sorting system providing sorting of at least the following fractions: cardboard, paper, polyethylene terephthalate (PET), polyethylene (PE), polyvinyl chloride (PVC), other types of plastics, timber, biodegradable waste;
- ✓ Black metal separators mounted at different points in the waste stream;
- ✓ Non-ferrous metal separators mounted at different points in the waste stream;
- ✓ Automatic waste loader system;
- ✓ Press and packing equipment for the recyclable fractions;

- ✓ Forklift truck;
- ✓ Waste storage containers for the sorted waste;
- ✓ Garbage trucks, for disposing of the unusable for recycling waste, on Polygin.

Mixed solid waste transported from the city should be unloaded at the factory's platform for unloading. Factory's platform for unloading should be as far away from the rest of the building as possible, and equipped with lifting gates with the fast closing system to prevent unpleasant odors and dust from spreading.

Main technological characteristics

Deposits and maneuvering areas of garbage trucks, depending on available capabilities, can be organized as the site with simple continuous surface or can be equipped with the trench conveyor that will deliver waste to the bag cutter. The self-propelled excavator equipped with the bucket, will pre-sort the waste and large-sized items and load them into appropriate containers.

Pre-grinding system

The large-sized separated waste is placed in the funnel of the pre-breaking device. At the plant, the waste is opened, crushed and dosed on the conveyor belt. Waste from the inclined conveyor is loaded into the glass collection system.

Glass selection system

The system selects the glass and then distributes it into containers. From the glass removal system, with the help of an inclined conveyor, the waste enters the fraction separation system (fraction size less than 80 mm).

Separation of the fine-grained (biodegradable) fractions

From the incoming materials, the system separates fine-grained fractions of waste (less than 80 mm in size) that contain mainly organic matter. Sorted fractions less than 80 mm in size are fed into the magnetic separator by the inclined conveyor, collecting fine-grained materials. After separation of the small metal fractions and nonferrous metals, the remaining mass is supplied to the warehouse and then transported to the bioreactor cell, or anaerobic processing plant for processing. Larger than 80 mm sifted fractions are fed to the conveyor, which transports them to the automatic sorting system.

Magnetic separator

The magnet embedded in the load direction separates the iron-containing components. Then the waste material of its proper size is transported to the waste storage containers with a conveyor belt.

Induction Power Separator for the Non-Magnetic Metals

Induction current separator is capable of separating the non-ferrous metals such as aluminum, magnesium, copper, silver, zinc, tin, lead. The principle of separator operation is based on induction currents (Foucault currents) generated by high-speed rotating magnetic fields. The separation of inert materials from metals occurs by ejection: all materials move in the conveyor on a magnetic rotor; while non-magnetizable metal waste is thrown forward, others fall down. In this way, the separated non-ferrous metal is deposited in waste containers using the conveyor belt.

Ballistic Separators

The remaining waste stream is divided into two flows by the ballistic separator. First, there is the heavy stream consisting of rubber, leather, biodegradable waste paper,

textiles, etc., which is delivered via the conveyor to the container that will eventually be disposed in the Landfill. Second, there are light fractions, the plastic, paper and other lightweight materials, and delivered to the semi-automatic (with mechanical and manual sorting) plant for higher quality recyclable resources, which will then be sent to the recycling plant.

Semi-automatic sorting plant for fractions separately collected at the source and Automatic sorting plant for the separated recyclable fractions

In the semi-automatic sorting plant recyclable materials - cardboard, macaroon, plastic, nonferrous metals, etc. are sorted manually and processed mechanically. The plant consists of machines for sorting metal and some types of plastics, as well as the platform for manual sorting, where secondary resources are sorted from the roll tape. The sorting platform is divided into sections. The number of sections is determined by the sorting line throughput and the number of secondary resource types to sort. At least the following types of waste should be selected:

- ✓ Timber;
- ✓ Polymeric film;
- ✓ Cardboard boxes;
- ✓ PET (polyethylene terephthalate);
- ✓ HDPE (high density polyethylene);
- ✓ Paper and cardboard.

Workstations should be located in such the way that sorted materials can be unloaded into silos located at the bottom of the platform using funnels installed for this purpose. Items sorted from the savings bins - by quantity - enter the pressing block. Delivery can be carried out by bucket loader or conveyor. The manual sorting site is equipped with the heating and ventilation (vent and clean air supply, lighting and UV disinfection systems) and air conditioning sistem.

Pressing and packing system

Separated recycled materials (paper, corton, plastic) adhered from the respective storage bins should be packed. The equipment of this system consists of the conveyor equipped with the continuous supply function located in the groove and from automatic or manual press. The press is equipped with the device for perforating polyethylene terephthalate container and the mechanism for cutting plastic.

The unused waste leaves the sorting booth and, via the automatic boot system, delivered to the saving containers, from where they are transported to the landfill for disposal.

Cell bioreactor for the disposal of biodegradable municipal waste

The cellular bioreactor is the so-called plant, where biodegradable waste is disposed for processing. Its structure is basically similar to that of the landfill cell. Its main purpose is maximal extraction of biogas, which is preceded by detailed control of the anaerobic biodegradation process, and its optimum conditions. The bioreactor frame consists of the 2 mm thick high density polyethylene geomembrane, 400 g/m^2 geotextile, large-scale sand filter with coefficient of filtration – kf > 3 m/day, 15 cm foundation layer - kf <1 m. The bioreactor also arranged with leachate and gas collection systems.

The bulldozer is constantly operated in the bioreactor zone, which evenly distributes and corrects the waste on the section of 5-10 m wide and about 2-3 m thick. Thus, several horizontal layers are formed, which ensure equal and gradual filling of the bioreactor. No additional compaction is required for the formation of waste layers. In the process of waste disposal, the bioreactor slopes are formed at appropriate angles. Waste is regularly covered with the coatings that do not interfere with biogas extraction, while the elastic polyurethane foam is used to cover the slopes.

After filling the bioreactor with biodegradable waste it begins to overlap with the temporary reclamation layer. The term of operation of the bioreactor depends on how long will be the anaerobic (biogas generation) phase (approximately 10-15 years). The duration of the anaerobic phase depends on many factors, one of the most important of which is temperature.

After completing the bioreactor filling and generated biogas utilization 10-15 year cycle, it's possible to gradually open the bioreactor and further process its digestate to obtain compost. The digestate can be recycled, giving about the 80% compost and 20% non-recyclable or inert fraction. This compost can be fertilized. It can also be used to form the remediation layers of other cells, and unusable inert fraction can be placed on the landfill cells.

Anaerobic recycling plant for the biodegradable waste

Anaerobic recycling is one of the most widely used technologies for biogas production from biodegradable waste. It involves the processing of the biodegradable fraction to obtain biogas in the closed reactor, under controlled conditions, which is subsequently used as the source of energy. The advantage of the anaerobic treatment plant compared to the bioreactor cell lies in the wide range of regulation of parameters, and especially temperature conditions, including psychophilic, mesophilic and thermophilic modes and their control on anaerobic degradation processes. Thermophilic regime is mostly used during bioreactor operation, which enables intensive separation of biogas from biomass and rapid stabilization of the waste mass.

Several technological solutions for the anaerobic fermentation are known: the wet fermentation, partial processing and continuous flow dry fermentation. Of these, it's recommended to apply the dry fermentation of mechanically separable biodegradable fraction (unsorted municipal waste stream) by partial treatment. The mentioned technology is widely used and its investment and operating costs are relatively low. The process itself involves filling the concrete reactor (with the integrated microclimate system) with raw materials - biodegradable waste or other organic substances. It's necessary to seal the reactor with the airtight door and begin the fermentation process. During fermentation, concentrates, including the leachate, are added to the waste to intensify degradation of waste. Then the preheated leachate is added to the reactor with the certain intensity.

Biogas produced by the mentioned technology is used as the fuel in cogeneration plants for its conversion into the thermal energy and electricity. Organic waste undergoes fermentation in the reactor for about 28 days, after the end of the cycle it can be used directly as the compost or fertilizer. After fermentation is complete, the reactor is emptied

and the another cycle can be started, filling the reactor with the new mass of organic waste. The one reactor provides about 12 cycles of fermentation per year. This technology is suitable for the biodegradable waste treatment, with the dry mass content of 15-50% and the minimum biomass content of 30%. In the processing fraction the high percentage content of Biomass provides the intensive biogas separation. It's noteworthy that biomass processing with this technology ensures effective neutralization of pathogens and the obtained processed mass can be used as organic-mineral fertilizer.

It's also worth noting that an anaerobic power plant of any capacity can be deployed depending on the need for the polygon (eg. annual capacity of 5,000 tons).

The Inert waste treatment plant

The inert waste is currently not disposed of at Didi Lilo Landfill and there is the separate area in Gldani. However, given that the "Didi Lilo" Polygon has to be designed and organized as the waste treatment center, certain fractions of inert waste: which consists of the recycled materials (metal, plastic, glass, timber) will be diverted to the "Didi Lilo" landfill. The technological processes for the processing of waste resulting from the construction and demolition of buildings mainly include crushing / grinding of waste, the separation of metals using magnetic separators of induction current, and the separation of inert fractions of the wood and plastic by filtering. The detailed description and throughput of the equipment should be developed in accordance with the amount and composition of the inert waste. However, by the preliminary assessment, should be take into account the following equipment:

- ✓ Tractors with the bucket loader to transportation of the waste and for loading them into the cutting machine;
- ✓ High performance cutting machine capable of cutting the inert materials;
- ✓ Fractionation machine for separating the small, medium and large fractions;
- ✓ Separators for ferrous and nonferrous metals.

The benefits of setting up the waste treatment plant at Didi Lilo landfill for the construction and buildings demolition waste, are linked to its future use for the operational

needs of the landfill, such as the construction of temporary roads, as well as receiving the income from the recycled secondary resources.

Additional activities

In addition to improving infrastructure, it's important to implement measures to promote the arrangement of the integrated waste management system. Particular attention should be paid to the inclusion and further development of research and the educational activities.

Analysis of the waste composition

The seasonal waste composition research is essential for the accurate planning and evaluation of the waste management systems. One of the hindering factors was the lack of the data, so it is important to create the database in the waste management system and to constantly improve/update it. Regular monitoring of the waste composition of the landfill will help to establish the waste management system and also provide information to help improve the technological processes of Landfill.

The Educational activities

The main goal of public information and educational events is to raise awareness of the waste generators and to integrate them into the segregated collection system. Since the effectiveness of the segregated collection system depends not only on the availability of these services, but also on the public's self-perception of waste, which is unthinkable

without the well-organized training programs and campaigns. Although landfill is not directly related to the improvement of the segregated collection system, it is recommended to participate in the public, educational and information activities, as one of the key components of the Waste Management System.

Establishment of the Waste Management Information Center

As part of the landfill improvement program, the number of technological solutions will be presented to introduce the best waste management practices. This will help to achieve the objectives set in the field of waste management. The combination of state-of-the-art technology and industry professionals using these technologies provides the good opportunity to set up the waste management information center to facilitate the sharing of knowledge across other regions of the country, which in turn will improve the integrated waste management system. As part of the creation of the Information Center, another opportunity will be to collaborate with the research and educational institutions to develop and test the advanced technologies.

Infrastructure Improvement Schedule

When drawing up the Polygon infrastructure improvement schedule, realization of the current projects is taken into account, to meet the operational needs of the landfill and to meet the objectives of the waste management. The priority activities to be implemented are as follows:

- ✓ Commissioning the semi-automatic and automatic sorting plants from 2022;
- ✓ Construction and commissioning of the IV Landfill cell since 2022, following the closure of the III cell of the Landfill;
- ✓ Conversion of landfill gases to heat and electric energy by the co-generation equipment and commissioning since 2023, after landfill gas collection and extraction systems have been put into operation;

- ✓ Commissioning the bioreactor cell for biodegradable municipal waste recycling from 2025 to achieve the mandatory waste recycling targets;
- ✓ Commissioning processing plant of the inert waste resulting from the construction and buildings demolition, since 2025 to achieve the mandatory waste recycling targets;
- ✓ Launch of anaerobic processing plant for biodegradable municipal waste recycling from 2030, to achieve the mandatory waste recycling targets;

The above mentioned task will be carried out by the working group of Geo-Consultants. The group is comprised from the local and foreign experts, who are highly qualified specialists in the field.

In preparation of this report were involved the the following experts:

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