

Urban waste for biomethane grid injection and transport in urban areas

Project No: IEE/10/251



Municipal waste management in the City of Zagreb/Croatia

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Authors: Bojan Ribić, Dinko Sinčić, Monika Kruhek
Zagreb City Holding - Waste Management Division, Croatia

Editors: All project partners

Contact: Bojan Ribić
phone: +385 1 6321 325
e-mail: bojan.ribic@zgh.hr
url: www.zgh.hr, www.cistoca.hr

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1 Introduction

City of Zagreb, largest city in the country and the capital, inhabits around 800.000 people. City is cultural, scientific, economic, political and administrative center of the Republic of Croatia with seat of Parliament, President and Government of the Republic of Croatia.

The work of Zagreb Holding is of vital importance to the City of Zagreb, which makes us especially responsible for the quality of life of the community in which we operate. We are aware that the quality of our services and choice of technology have a direct impact on the standard and quality of life of all the citizens of the city, and through socially responsible business, we endeavour to increase the standards of social development, protect the environment and respect human rights. At the same time, within the Company we promote social dialogue, and enable our workers to gain new, advanced knowledge and skills.

Alongside the high standards of business practice that we aim for, we also have a clear commitment to improve our attitude toward the environment. In line with the principles of sustainable development, in the area of the City of Zagreb, Zagreb Holding carries out and develops environmental management policies. The quality management system and management of the environment are founded on the demands of the international standards HRN EN ISO 9001:2000 and ISO 14001:2004.

Zagreb Holding (Zagrebački holding d.o.o.) was founded in 2007 and is in 100 percent ownership of the City of Zagreb. It consists of 18 branches which perform the work of the former city enterprises, with a total of about 12,000 employees. Zagreb Holding is also the owner of 6 companies and one institution.

The main activities of the Company can be grouped into three business areas:

- Municipal functions;
- Transport functions;
- Market functions.

Renewable Energy Directive encouraged City of Zagreb and whole Zagreb region to come forward with the program for realization of the obligation that by 2020, 20% of the energy needs to be covered by renewable energy sources. Also, 10% of fuel consumed in transport must come from renewable sources.

The relevant actions are also part of Covenant of Mayors treaty encompassing a large number of European cities. Therefore, certain divisions of Zagreb City Holding have already begun using renewable fuel such as biodiesel in their vehicles. Natural gas grid in Zagreb is City's owned and is interlaced thru the entire City. Almost 90% of the inhabitants in the City are connected to gas grid making natural gas a major energy source. City industry is also using a natural gas as primary energy for production.

2 Overview of municipal waste management

2.1 *Municipal waste generation in the Republic of Croatia*

Republic of Croatia will soon, in 2013, become a full member of European Union and therefore is obligated to fulfil certain EU directives regarding the waste management (Landfill directive¹ and Waste Framework directive²). One of the major challenges will be fulfilment of the biodegradable waste obligation which sets the goal of almost 400.000 t of biodegradable waste to be separately collected and not sent to the landfill by the end of 2013. By the 2020 that amount will be almost tripled. Also, Republic of Croatia commits to close all of its landfills by 2018.

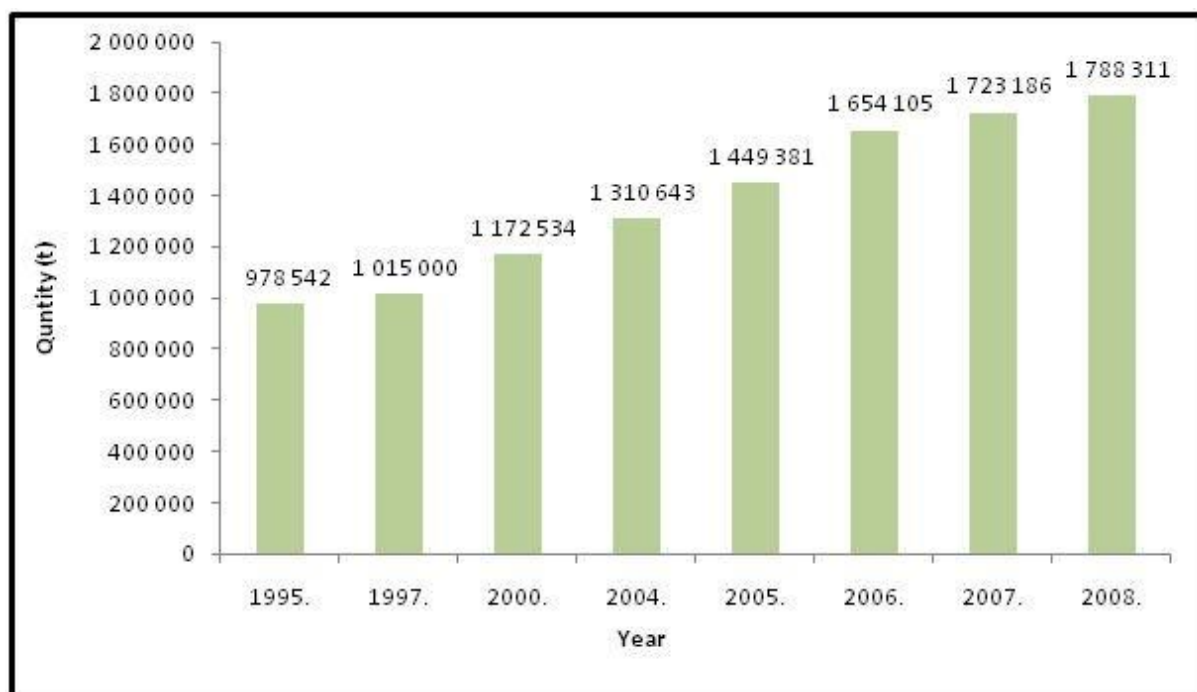


Figure 1. Amounts of municipal waste generated in Croatia, 1995–2008 (t)
(source: Croatian Environment Agency - AZO)

Republic of Croatia is facing the decrease of municipal solid waste in the last couple of years (from 2008 onwards). Total amount of produced municipal waste in 2010 is 1.629.915 t. Amount of produced municipal waste per capita in 2010 is 367 kg, as shown in the figure 2.

The amount of separately collected types of municipal waste is continually growing and in 2008 it accounted for 14% (247.252 tonnes). However, only part of this quantity ends up being recovered while the rest is still landfilled.

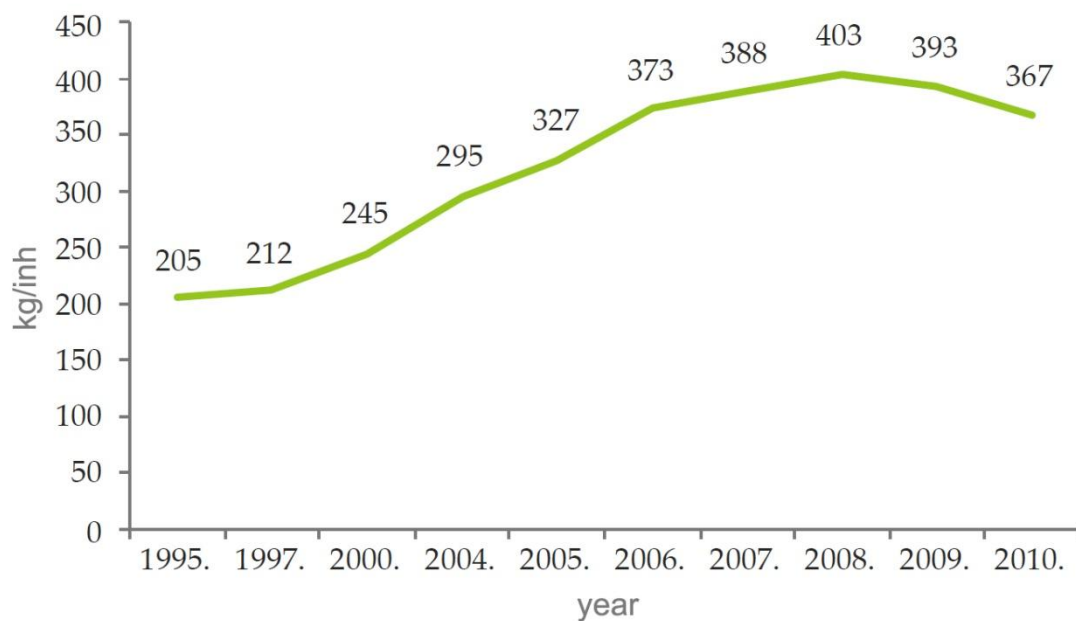


Figure 2. Amount of produced municipal waste per capita in the Republic of Croatia (source: Croatian Environment Agency - AZO)

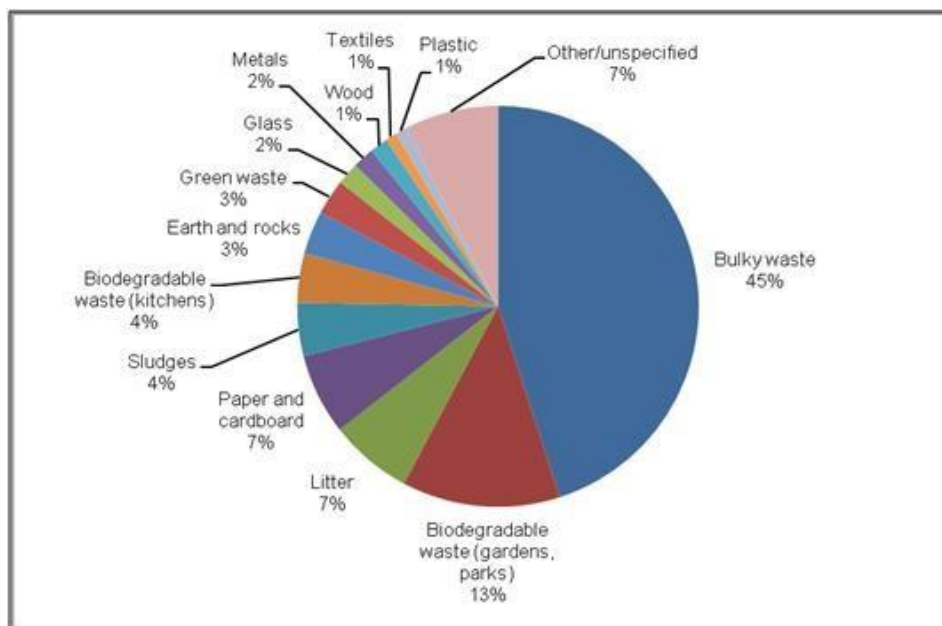


Figure 3. Separately collected types of municipal waste as reported by municipal operators in the EPR (Environmental Pollution Register), 2008

2.2 *Municipal waste management system in the Republic of Croatia*

Waste management in Croatia is considered to be one of the primary issues affecting all the components of the environment. The Waste Management Strategy³ for the Republic of Croatia and the Waste Management Plan⁴ as its implementation document are elements of a continuous waste management planning process which reflects on all the levels, from local to national, and appears as a segment in other sectors (e.g. water resources management, mining, veterinary medicine, health care, land-use planning, building, etc.).

The Waste Act⁵ and the Waste Management Plan have set up a concept that focuses on for waste avoidance, increase in waste recovery and use in power generation, reduction in quantity of material for final disposal and consequently lowering risks for the environment, climate and human health. It is planned to establish an integrated waste management system with planned completion of remediation and closure of official landfills and illegal dump sites, to carry out remediation of the highly waste-loaded sites in the environment, and to establish maximum 21 regional/county waste management centres. Largest share of produced waste is being landfilled at the almost 300 landfills in the country.

Waste separation and sorting is lagging behind due to insufficient funds allocated in the past to the implementation of modern separate waste collection system. Lack of

education and awareness among citizens contributed to the inadequate results in achieving set up goals for recycling of valuable materials such as paper, plastic, metals, glass etc. The actions taken in last couple of years are changing and improving the situation in that regard.

In order to remove and prevent certain detrimental environmental impacts caused by inappropriate waste management practices, particularly on the dump sites which are not environmentally sound, numerous activities have been initiated and completed and significant results accomplished. Setting up of a strategic/planning and legislative framework, capacity building of relevant authorities and development of the information system resulted in improvement of the existing system of separate waste collection and waste recycling/recovery. New systems have been developed for management of special types of waste (including construction of recycling/recovery facilities).

Such developments enabled remediation and closure of landfills and illegal dump sites, remediation of sites contaminated by hazardous waste, all in line with the EU regulations applicable to the waste management. Intensive preparations for construction of a certain number of waste management centres are under way. Coverage of population and municipalities/towns by organised municipal waste collection increased from 86% in 2004 to 93% in 2008, which fulfilled the quantitative target for 2015 set by the Waste Management Strategy of the Republic of Croatia.

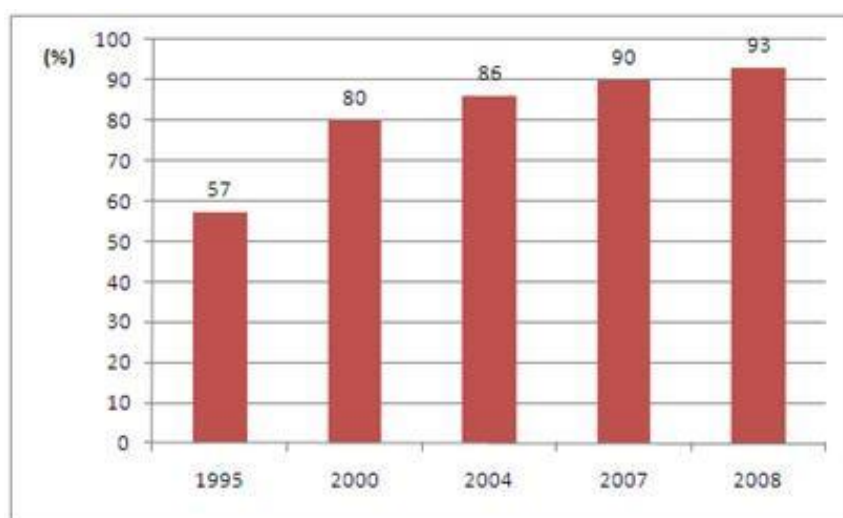


Figure 4. Coverage of population by organised municipal waste collection, 1995-2008 (%) (source: Croatian Environment Agency - AZO)

As mentioned, according to Treaty of accession⁶ between the Croatia and EU, the requirement to reduce the amount of biodegradable municipal waste going to landfills to respectively 75 %, 50 % and 35 % of the total amount (by weight) of biodegradable municipal waste produced in 1997 shall apply in accordance with the deadlines specified below:

- (i) by 31 December 2013, the share of biodegradable municipal waste deposited on landfills shall be reduced to 75 % of the total amount (by weight) of biodegradable municipal waste produced in 1997;
- (ii) by 31 December 2016, the share of biodegradable municipal waste deposited on landfills shall be reduced to 50 % of the total amount (by weight) of biodegradable municipal waste produced in 1997;
- (iii) by 31 December 2020, the share of biodegradable municipal waste deposited on landfills shall be reduced to 35 % of the total amount (by weight) of biodegradable municipal waste produced in 1997.

Also, Croatia shall ensure a gradual reduction of waste landfilled in existing non-compliant landfills in accordance with the following annual maximum quantities:

- by 31 December 2013: 1 710 000 tonnes,
- by 31 December 2014: 1 410 000 tonnes,
- by 31 December 2015: 1 210 000 tonnes,
- by 31 December 2016: 1 010 000 tonnes,
- by 31 December 2017: 800 000 tonnes.

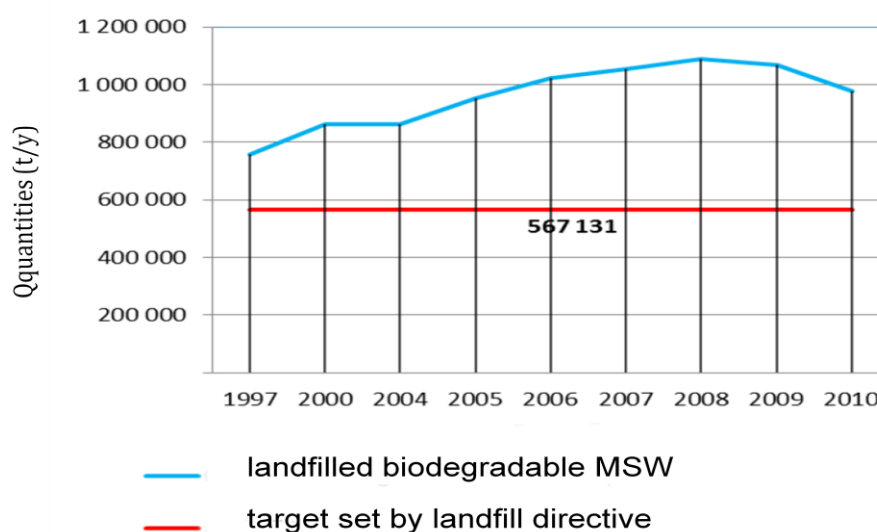


Figure 5. Reduction for landfilling of biodegradable waste

2.3 *Municipal waste management system in the City of Zagreb*

City of Zagreb is annually producing around 250.000 tonnes of municipal solid waste which is mostly being landfilled. Zagreb Holding - branch Čistoća is in charge of waste management in the city area. Currently, the main portion of municipal solid waste is disposed at the landfill site Jakuševac - Prudinec. Most of the municipal solid waste is biodegradable (paper, cardboard, kitchen and green waste) with a significant portion of plastics which is illustrated in Figure 7.

Table 1. Total amount of waste being landfilled, 2007-2011

Year	Čistoća	Others	Total, t
2007.	237.124	34.180	271.304
2008.	248.243	31.847	280.090
2009.	239.672	18.230	257.902
2010.	233.407	22.496	255.903
2011.	225.021	20.934	245.955



Figure 6. Photo of the Landfill Prudinec in the City of Zagreb

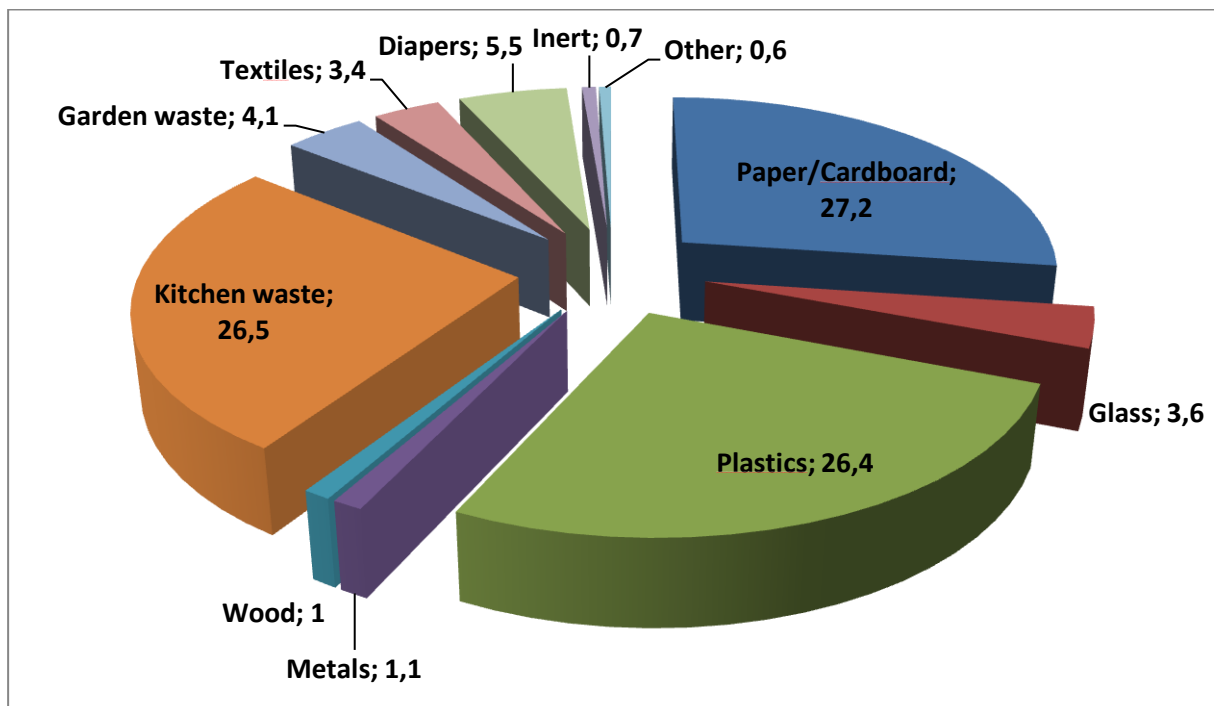


Figure 7. Waste composition in the City of Zagreb (source: IPZ 2010.)

Developing waste separation system, along with the increased number of recycling yards (17 in total) will significantly increase the quantity of separately collected waste and biowaste as well, which is suitable for biogas production. This will also decrease the amount of biodegradable waste currently landfilled in accordance with the EU Landfill Directive.

At the moment there is an insufficient number of recycling yards, containers, vehicles and other equipment which are necessary for efficient waste separation systems. The lack of education and awareness among citizens and inadequate penalties for polluters, contributed to the unsatisfactory results in achieving goals defined by the above mentioned directives regarding the recycling of high-value materials such as biowaste, paper, plastic, metals, glass etc.

In the last couple of years systematic action has been undertaken to increase the quantity of separately collected biowaste. The part of the currently collected biowaste is used in a composting plant. The actions taken in the last couple of years are changing and improving the situation: systematic approach for source separated biowaste collection from restaurants, schools and kindergarten canteens, market places, shopping centers and green waste from households. In order to more

precisely determine the possibilities and costs of citywide source separated waste collection, the two pilot projects are currently underway encompassing 10,000 households.

In and outside of the city of Zagreb (Zagreb region), there is a large number of shopping centres, restaurants, spas and similar objects where food waste collection and treatment is not standard practice. The assessment of current practices, recommendation and establishment of the practice which would go along with the ideas and goals of this project should be an important contribution to the biowaste management in the whole region. At the same time the connection with the City of Zagreb plans in this area should be established and possibly joint projects undertaken.

Table 2. Total amount of collected biodegradable waste processed at composting plants

Year	Markuševac	Jankomir	Jakuševac	Total
2007	4.399	1.839	7.153	13.391
2008	4.596	0	9.995	14.591
2009	4.194	0	10.591	14.785
20010	4.517	81	10.457	15.055
2011	7.483	0	10.489	17.972



Figure 8. Composting plant Jakuševac

3 Technical requirements for biowaste management system implementation

3.1 *Biowaste collection systems / approaches*

The analysis of the MSW in the city of Zagreb performed recently (figure 7), showed that about 30% of total municipal waste may be classified as kitchen and garden waste. That amount is collected mostly from private households, while lesser part originates from small enterprises which do not have separate collection of biowaste for various reasons. Certain amount of the kitchen type of waste is collected from a number of restaurants and hotels and is currently delivered to the composting plant where it is mixed with the garden waste collected from public areas.

Therefore waste management system should concern itself with following subjects' structure:

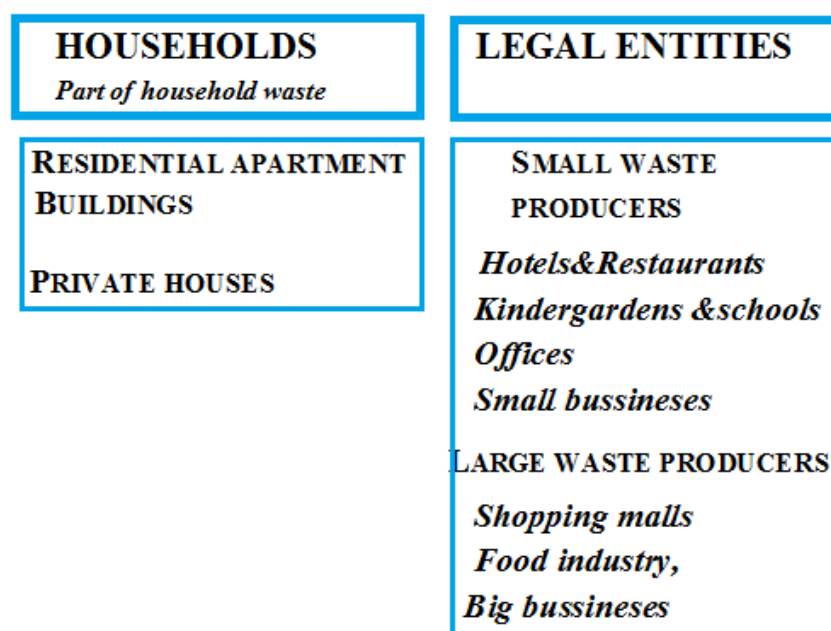


Figure 9. Biodegradable waste producers

Implementation of the biowaste management must be defined for each specific source. There are two tasks which should be defined and realized in that context. First one, the analysis of the existing activities and the second is establishment of the new procedures and assignments related to the new subjects as described above and new collection system.

Current biowaste collection is concentrated on the group of streets (Voćarska, Petrova, Domjanićeva) encompassing 2.000 households where biowaste collection is going on for number of years. The quantities of the biowaste collected in that area and from recycling yards re given in Table 3.

Table 3. Total amount of collected biodegradable from private households and recycling yards

Year	2007.	2008.	2009.	2010.	2011.
20 02 01	130,4	156,5	114,8	362,1	156,2
20 02 01 RY	61,4	78,4	102,9	59,4	64,5
Total	191, 8	234,9	217,6	421,5	220,7

The calculation of the recycling degree shows to be about 17% which may be considered satisfying. It shows though that the longer the practice is carried out naturally the success is greater.

The second part is the area of recently introduced pilot project for a large apartment complex called Mamutica (meaning mammoth-size building) with 1.400 apartments. After a year of execution the results show that the rate of biowaste separation was about 13 %. We consider this to be significant result since it is known that it takes time for public to accept and participates in this type of action.

The state of current practice regarding the biowaste collection from the legal entities is presented on the Table 4.

Table 4. Total amount of collected biodegradable from legal entities in the City of Zagreb

Year	2007.	2008.	2009.	2010.	2011.
20 02 01	35,1	0,0	4,4	632,2	1.478,9
20 01 08	30,2	31,1	48,5	47,9	64,1
02 01 03	30,7	69,1	70,3	46,6	46,0
02 03 01	0,0	61,2	212,3	196,4	8,3
02 03 04	25,6	13,8	11,0	16,7	7,8
02 07 01	0,0	0,0	0,0	4,5	4,0
15 01 03	0	0	0	0	7,8
Total, t	121,6	175,3	346,4	944,2	1.616,9

The significant portion of these quantities is from Zagreb green Markets. The action of improving that system is underway for about a year now and the results are obvious. We do expect significant improvement in the future.

We point out that in 2010., we have conducted the pilot project on “green waste” collection which showed a success to certain degree but it was terminated due to financing problem.

We have just prepared the project of improvement city waste management in which particular attention has been paid to the biowaste collection improvement in connection (in particular) with the obligations Croatia has regarding biodegradable waste landfilling. The system should run along the following lines:

Household waste:

Apartment buildings: The main component is the kitchen waste. It is planned to distribute the containers of 120 or 240 l, eventually 1100 l. Because of liquid content the deposition should be in the (plastic) bags, and collection once a week (more frequently during the summer). The containers would be located in the “*eco-points*” in the neighbourhoods or, where available, building storage spaces.

Private houses mostly produce “green waste”, to lesser extent kitchen waste. The 120/240 containers or green bags of adequate volume, would be offered to the owners. Collection would take place once week or more often if necessary.

The small waste producer in the meaning used here are the small businesses, schools & kinder gardens, hotels and restaurants. These producers would also dispose of the waste into containers of 120/240/1100 volume in the plastic bags due to the variable content of the liquid in the waste. The collection would take place once a week, min or more frequently if necessary.

The large waste producers (figure 9. need special attention according to the nature of the waste. That is particularly important for shopping centers.

Total estimated quantities of biowaste which in reasonable time might be collected in Zagreb and directed toward biogas production are presented in the table 5.

Table 5. Total estimated quantities of biowaste in the City of Zagreb

Input	Dry matter,%	Amount, t/year
Biowaste from shopping centers and households	20	5.000
Biowaste from kitchens and restaurants	20	10.000
Market biowaste	20	3.000
Industrial biodegradable waste (brewery, dairy, food processing)	20	1.500
Expired milk & eggs	17	500
Total		20.000

At this moment we are leading the Project team appointed by the ZCH management to define the further procedures regarding the treatment of biowaste and biodegradable waste as well. Therefore, we might expect that all the details of the system we have outlined above shall be elaborated and proposed for implementation by our Team.

3.2 Biowaste treatment technologies / solutions

Despite the actions we have undertaken and will undertake, the amount of biowaste in the remaining municipal waste shall be considerable. Landfill directive forces waste management in the cities to fulfil the obligations of diminishing the quantity of land filled waste. The calculations we have performed led us to the conclusion that along with the separate collection system, the separation of biowaste from the mixed municipal waste must also be implemented. To that end, we have also proposed the automatic waste separation system with particular emphasis on the biowaste. The biowaste quantity which shall be separated in this way we estimate to be approx. 60.000t.

The above discussion shows that there will be two biowaste streams in the biowaste management system in Zagreb. One ensuing from separate waste collection and second originating from the plant separated material stream. The treatments of these streams are quite different. Namely, the composition of the first stream is known (or may be controlled better) to the high degree. Therefore the digestate after fermentation may be used for the compost without restrictions. The physical nature of that stream requires pretreatment. For instance, the expired food may be packed in glass bottles or tetra pack type of packing which need to be crushed and removed from the stream entering the fermentors.

The biowaste originating from the automatic waste separation stream should be submitted to the somewhat different procedure. The fermentation technology may be of high solid type in order to avoid large amount of process water. The quality of the digestate might make it unsuitable for the agricultural land application. In that case post aerobic treatment results in biological stabilization meaning it becomes suitable for the landfill cover or non agricultural soil remediation.

The scheme of biogas production with source separated material is presented in the figure 10.

As may be seen, the digestate may be used as the liquid suspension as well as after liquids separation as the standard compost.

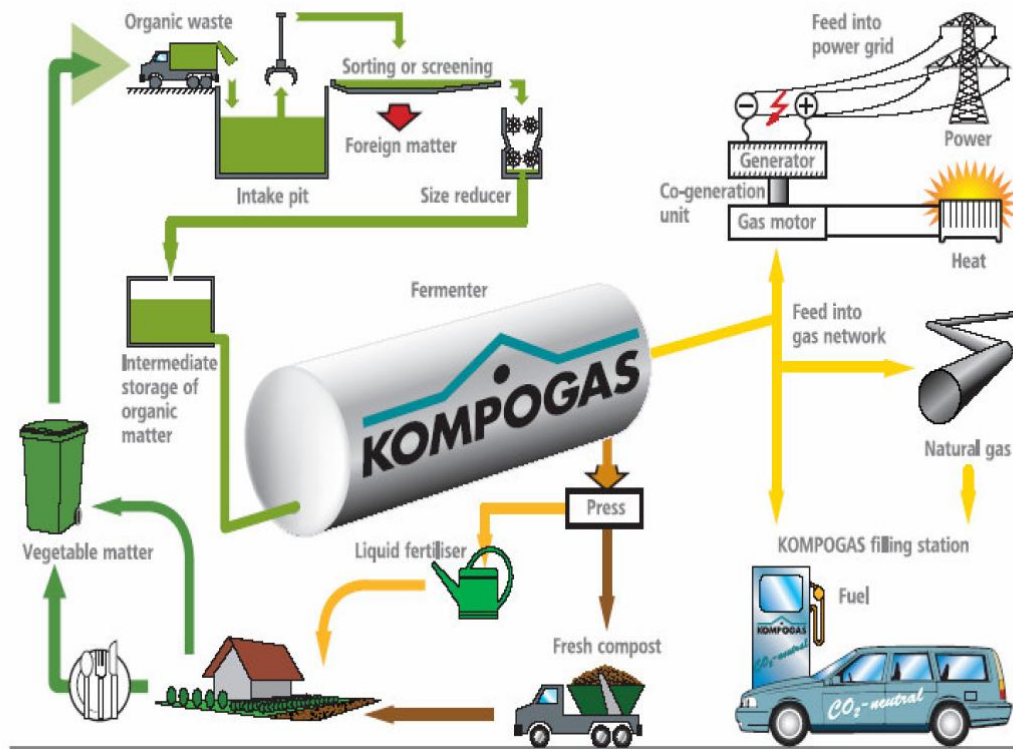


Figure 10. Biodegradable waste streams

The treatment of separation plant for biowaste stream runs somewhat differently where the first separation takes place in the screen drums. There, larger pieces are removed and the fraction, usually <math><60\text{ mm}</math>, which contains mostly biowaste is taken to the fermentation tanks. The further procedure is already discussed.

4 Economic and organisational considerations

There are two points which may be considered as the basis of legal requirements. First one is the obligation originating from Landfill Directive regarding the biodegradable waste landfilling and the second one is not legally binding but is related to the use of biowaste for energy production. The first one is strengthened by the Croatian Accession Treaty to the EU with the basis of 1997. landfilled quantity. For the city of Zagreb that would mean approx. 60.000t of biodegradable waste to be separated from mixed municipal waste the end of 2013 and diverted from the landfill. That is obviously not achievable so that consequences for the country may be only conjectured. However, we think that the threat of being punished may help us in successful pushing forward our initiatives for proper biowaste management system in the City of Zagreb.

At the moment, like in the almost all of the new EU members, landfilling is still the most common and the cheapest option for the waste management, but this is no longer environmentally acceptable.

The waste management division of Zagreb City Holding expects to be formally nominated to perform all the tasks which come out of the described policies. Therefore, Čistoća is continuing to give significant effort in order to increase the amounts of separately collected biowaste.

In regard to the infrastructure (containers, collecting trucks) for the support of the new waste management, large investments can be expected where also biogas plant and separation plant for biodegradable fraction contributes considerably. Based on the investment costs of similar plants around Europe, these costs may run as high as 100.000 mil EUR.

We are convinced that these two projects are suitable for the financing by the European structural funds which will be available for Croatia.

5 Involved parties in the biowaste management chain in the City of Zagreb

The main parties involved in the biowaste management chain are Zagreb City Holding, Waste Management Division Čistoća and City of Zagreb.

Namely, the general waste management plan should bring about the City authority, to be more precise the *City Office for Energy, Environmental Protection and Sustainable Development*. That document unfortunately has not seen the light yet and it is not clear when, if at all, it will. The Čistoća Company is responsible for proper waste management on a daily basis and shall therefore with the support of Zagreb City Holding management continue to work on realization of the plans described above.

Naturally, the most important participants in this chain are our partners: the citizens and all other subjects who must make the plans and proposals come true. For that reason our action will be supplemented by wide educational campaign in order to raise the subjects' awareness on the importance of proper biowaste handling.

We must state that for instance shopping centers have taken significant steps toward biowaste management so that realization of the plans with those subjects stands a good chance for success.

6 Strategy proposal for a biowaste use in production of biomethane in the City of Zagreb

Various activities concerning biogas production have started in Čistoća some four years ago so that Urban Biogas project came as natural extension of those activities. The initiative was part of our endeavours to introduce biofuels for our vehicle fleet. This initiative requires first to make all the stakeholders aware of the importance of replacing fossil fuels.

Another EU project we participated in helped initial awareness raising so that biogas was just continuation of those activities.

At this moment we may succinctly formulate our strategy in following manner:

1. Make the Waste Management Plan which includes above described activities accepted by the ZCH Management;
2. Prepare detailed basis for Feasibility study for the Biogas Production Plant
3. Prepare detailed basis for Feasibility study for MMW Separation plant with Biogas production
4. Coordinate with City Authorities the activities toward inclusion of these projects into Ministry of Environmental Protection lists of the project which shall be submitted for EU financing
5. Define the activities, ways and means for the improved source separation at all levels,
6. Assure appropriation of the adequate financial means in the next year plan for carrying out all the activities envisioned.

7 References

[1] Directive 1999/31/EC on the landfill of waste

[2] Directive 2008/98/EC on waste (Waste Framework Directive)

[3] Strategy of waste management in the Republic of Croatia (Official Gazette No.130/05)

[4] Waste management plan in the Republic of Croatia for the period from 2007 to 2015

(Official Gazette No. 85/07)

[5] Waste Act Law (Official Gazette No. 178/04)

[6] Treaty of Accession between the member states of the European Union and Croatia