Energy Potential of Waste: Case Study of the Hungarian Waste Management System

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Abstract

The paper deals with the waste based energy potential of Hungary by analysing the change of the waste management practice and the waste statistics of the country. The paper presents detailed potential analysis for the Koppány Valley area of Hungary.

While the Circular Economy (CE) concept has become a flagship programme of the European Union, Hungary and other developing member states stay too far from the circular approach. Moreover, it is very complicated to calculate the CE indicators without good and detailed statistical database. In the Hungarian practice it is especially true at local/municipal level, although a lot of components of CE concept should be managed by the local governments (e.g. waste management, local economic development, local planning and legislation background etc.).

Due to the Europeanisation trends, the subsidies, the multinational companies and the good knowledge transfer in the waste sector, the Hungarian waste management system became “European” in the last few years. However, the change of the governance structure resulted in challenges for local governments and waste management companies, too. The main challenges of the Hungarian waste sector are the centralisation process of the Hungarian waste management and local governmental systems, the average environmental attitudes of stakeholders, and the lack of participative planning and cooperation practice at local and regional level.

However, waste is one of the renewable energy sources that are available to provide local energy/heating capacity and in doing so can reduce the level of greenhouse gas emissions. According to the global environmental sustainability concept, it is very important to reduce the waste, to change the consumer habits or to increase the selectively collected and recyclable proportion of waste. Also, the residual waste contains a considerable proportion of biomass and other burnable parts with a high energy potential.

The paper is an attempt to calculate the composition of the case study area’s municipal waste and the local/regional potential based on it.

Keywords: waste, waste management, energy potential, Hungary

1. Waste and waste management

While waste generation and accumulation is a global problem, what the different governmental levels try to manage together [1], the sustainability and circular economy principles, and the European requirements in municipal solid waste (MSW) management, involve improving the waste separation, recovery and valorisation [2]. According to Hoornweg and Bhada-Tata [1] the urbanised part of the world generated 1.2 kilogram of municipal solid waste per person per day and a total 1.3 billion tonnes per year, and by the forecasts this amount will rapidly increase in the near future. Moreover, one half of this mass is biodegradable contents, including food scraps and agricultural refuse [3].

The untreated, deposited waste is a huge challenge and problem area around the world with a lot of risks and negative effects (greenhouse gas emission, smell, unused resources, contaminated landscape, air and groundwater pollution etc.). But, from the other side the volume of this deposited municipal solid waste could be a kind of resource potential of these regions.

- When the organic materials of waste break down in landfills, various gases, landfill gas (LFG), are produced and either buildup within a landfill or discharge into the atmosphere. This gas is flammable, odorous, and a potent source of greenhouse gases (GHG). The utilisation of LFG with an appropriate investment project and good management systems for collection and either burning (flare) or converting these gases into energy can help mitigate these problems and contribute to the overall safe operation of a landfill [3]. Accordingly, older landfills could be interesting as biogas sources only if the age of the material deposited is not more than 15-20 years (but it could not be a well-paid investment) [4].
- It seems logical to use waste (and not only the gases buildup within landfills) as a source of energy creation, because the average heating value of municipal solid waste is approximately 10 MJ/kg [5]. Traditionally, waste-to-energy has been associated with incineration (which means all forms of controlled direct combustion of waste [5]), but nowadays the term is much broader, embracing various waste treatment processes generating energy (for instance, in the form of electricity and/or heat or producing a waste-derived fuel) [6].
- Various ways of composting could be the solution for the easily-degradable waste part of MSW [7]. There are different management models for the composting. The municipality structure (type of housing, urban and rural areas etc.) made it necessary to implement different composting systems, models [2]. The potential solutions could be: home composters, community composting islands, composting plants where could be transferred either the selectively collected (at households, at restaurants, at farms etc. or at community containers) or the directly delivered organic waste to the composting plant or the waste yards.
- Another opportunity is the waste mining. From the economic and environmental point of view there is a need to seek a range of new opportunities to minimise

society's materials losses, for example at the landfills. The more economy recycles and recovers useful metals and other materials from waste, the less mining will be needed and the less environmental damage will result from waste disposal [8]. In those landfills where the decomposition of organic fraction is finished, the only source for energy recovery is the plastic fraction, which could be higher where there were no mechanical-biological treatment plants and the recycling activity was low in the landfilling period [4].

The economically-viable and environmentally-acceptable disposal of municipal solid waste is a major concern in many industrialised countries [9], while the less developed ones just try to collect and treat the solid waste as they can (with a limited financial, governmental tools and weak social background). The main problem facing the policy makers and waste management is how to predict the amount and the composition of MSW that is likely to be generated in the near future in order to devise the most appropriate treatment/disposal strategy and model for a region [9]. For the utilisation of waste potential a very good, professional waste management is needed in the regions/countries, but this potential is strongly determined by the national governmental and public administrational systems, and the level of relevant EU-standards.

The rural specialities of waste generation and management are:

- The typical rural areas are less populated areas with low population density, where different mixture (less, availability problems) of public services is provided. The municipal waste management is one of the public services which all of the local or regional governments have to provide for their residents.
- There is a different composition and amount (per capita) of waste (own composting solutions of households, less urbanised lifestyle, organic farms etc.) in a rural area, and it could be much more expensive to collect this waste within a centralised waste management system (very long transport routes).
- The waste management development projects usually reach the rural areas later than the agglomeration centres, so the sanitary landfills, the composting plants, the mechanical-biological treatments and other modern waste management infrastructure are many times missing from these areas.
- Compared with urban spaces the rural areas usually are characterised by inhabitants with more natural lifestyle and more cohesive communities, where the pro-environmental behaviour, the quality of life factors (e.g. waste treatment) can be closer to the perception of the people.
- Due to the smaller built-up areas the average rural settlement has more natural landscape. Other characteristics are the higher environmental quality (because of the smaller urbanisation pressure).
- Usually there is a decisive proportion of agriculture within the local economy in the rural areas, which resulted in the composition of rural waste (higher organic proportion).

2. The Hungarian solid waste management system

In Hungary since the acceptance of the new Environment Protection Law [10] the local governments have had the task of collecting and treating the local municipal waste. From the point of view the so fragmented and centralised Hungarian governmental system the main problem was the lack of any obligatory territorial integration principle for the local governments. It means that every average settlement (with an average 3,105 inhabitants [11]) has to provide almost the same collection of public services at a determined level of minimum quality. In the area of waste management all this has resulted in a very fragmented waste management system [12]. Since the country's EU-accession the optimal territorial scale for the waste management has been supported by European Cohesion and Structural Fund's sectoral investment projects (with requirements of local governmental partnerships for the application and implementation of these projects).

After 2010 the Hungarian local governmental system turned into a recentralisation process [13]. The new Local Governmental Law (Act CLXXXIX of 2011 on the Local Self-Governments of Hungary [14]) contains a list of the main local government tasks including the waste management even now, but the municipalities have lost most of their classical local services provision functions. With the centralisation pressure the central government tried to reduce the fragmentation of the public service system both in waste management and other public services (schools, healthcare system etc.).

Based on the new Act on Waste (Act CLXXXV of 2012 on the Waste [15]) and the new National Waste Management Plan for 2014-2020 [16] the total Hungarian waste management system has been changed after 2012. The local municipalities still have the right to make contracts with the waste management public service providers, but since 2013 they have limited contractual freedom, because from this time they can make just one, integrated contract (waste management contract) for the waste collection and the waste treatment.

The new "innovation" of the Act on Waste [15] was the introduction of the landfill taxes which could divert waste from the landfills, namely it was the interest of the public service providers (less landfilling, less taxes). The waste tariff-setting opportunities of local authorities were transferred to the Hungarian Energy and Public Utility Regulatory Authority (MEKH) after 2012. The Authority calculates the price of service for the service provider companies (before this regulation it was the part of local contracting and bargaining process between the local government and the service provider, and it resulted in very different prices and services among the settlements (rural-urban, small-large, developed-underdeveloped)).

Since 2016 the Hungarian government has established a new central state waste management organisation, the National Coordination of Waste Management and Asset Management Plc. (NHKV) for the coordination of the waste sector. The most important effects came from this new organisation that is the top-down regionalisation of the public service providers in Hungary. There were 170 public service provider organisations in 2010, 114 in 2016, while the real number is 25 units [17].

Although the competency of making a contract with a certified public service provider remained at local governmental level, the NHKV reduced the number of certified potential service providers. As after 2016 fewer licenses were issued, the local municipalities' contractual freedom has decreased. Since 2017 the ownership of separately collected secondary raw material and residue derived fuel (RDF) has been monopolised by the state. It can be a barrier of circular economy concept in Hungary, since these materials could not be place-based resources in local/regional circular flows any more. However, taking into consideration from the other side, some of the local major companies which use these materials as resources can buy large amount from them [18]. It is good that they do not depend on the limits of the regional waste market any more, and there is a quality "guarantee" of materials transferred to the secondary raw material market by the NHKV (via public procurement procedure).

3. The case study area

A rural development association was established for the further development of Koppány Valley area. The Koppány Valley Nature Park association aims to develop natural-based innovative, sustainable tourism, active recreational facilities, strengthen local economy with a diversified agriculture and to create the social, economic and environmental sustainability of agricultural production [19]. 10 settlements are members of the Nature Park association (Table 1). All settlements have own local governments, but the smaller ones have not got own local administration (own governmental office).

The waste management service provider of the Koppány Valley Nature Park's 9 settlements within the South Balaton Waste Region is the DBR Dél-Balatoni Régió Nonprofit Kft. The PELSO-KOM Nonprofit Kft. as a subcontractor is responsible for the collection of waste for these 9 settlements. At the same time Koppányszántó belongs to another public service network (another waste region (Middle-Duna), another public service provider (Vertikál Nonprofit Zrt. and a subcontractor called Alisca Terra Nonprofit Kft.), but the same, South-Balaton Regional Waste Management Local Governmental Association) (Figure 1).

There is a centralised waste management system, where an average kg of waste "travels" at least 40 km (to the central waste handling facility (in Som). The paper, the glass, the metal and the plastic waste are collected separately in 240 l waste bins at households. The service provider transmits this secondary raw material to the regional material recovery facility (in Som), but the owner of these resources is the state.

The collection of the biowaste is organised at collection points in every settlement. The service provider collects the gathered amount of biowaste once in a month. Major problem of the region is that there is not an available composting plant with appropriate capacity. For many years the biowaste was delivered to the composting plant in Keszthely (90 km) or to the Kaposmérő landfill (50 km). Currently the collected amount is delivered to Balatonlelle (40 km) where a co-composting with sewage sludge operates. This composting facility is owned by a private company, which tries to sell the product on the market. The communal waste bins are owned by the households, institutions, companies

(which generate communal waste). They are collected weekly, and transferred to the Som waste management plant (where mechanical waste treatment with optical sorting operates). The RDF and the paper and plastics that come from the municipal waste are owned also by the national waste company. The NHKV sells it through the public procurement procedures. The rest of the waste goes to the landfill in Som.

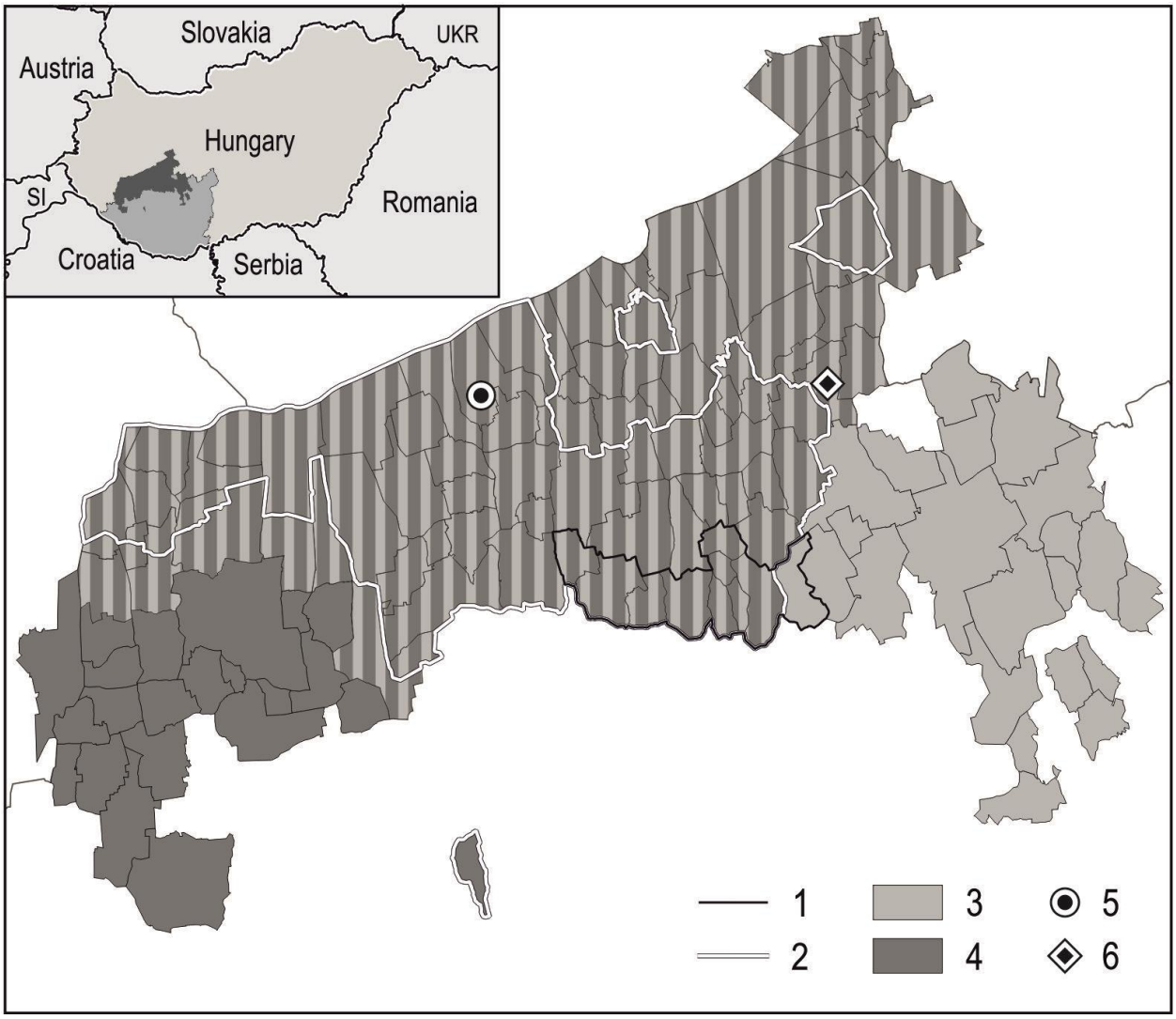

Figure 1: The waste management system of case study area

Key: 1) Koppány Valley Nature Park; 2) Public service area of PELSO-KOM; 3) South-Balaton Regional Waste Management Local Governmental Association 4) South-Balaton Waste Region 5) Composting plant in Balatonlelle 6) Complex waste treatment plant and landfill in Som.

Source: Made by Tamás Szabó based on [20] and [21].

4. Measuring the potential of waste

For the potential calculations and comparisons (Table 1) we use the EU LEADER categorisation of rural areas (less than 10,000 inhabitants and less than 120 person/km^2 population density). According to this classification, from the 3,155 Hungarian settlements 2,762 are rural.

These rural areas have a lot of specialities according to the waste data (Table 1). The generated MSW is less than the national average, but the selectively collected part of MSW is better in the urbanised areas of country, due to the advanced infrastructure (closer yards, containers) and the higher ratio of direct waste collection from the households. All the settlements from the case study area have worse selective collection practice compared to the urban areas, but no selective bins have been introduced at households for the bio-waste (collected at the streets with communal containers), only for the packaging waste (operating in a two-week period). Koppányszántó has started the selective collection after 2015 at their administrative area.

Table 1. The main characteristics of the case study area, 2015

Settlement/feature	Number of inhabitants (capita)	Population density (capita/km^2)	Generated municipal waste (kg/capita)	Selectively collected waste proportion (%)
National average	3,176.75	73.01	192.78	3.97
Rural average	1,160.52	43.92	188.00	3.32
Urban average	17,346.86	277.48	226.38	8.54
Bonnya	281	19.22	113.88	3.13
Fiad	155	10.40	109.68	5.88
Kára	69	12.85	188.41	7.69
Kisbárapáti	404	14.07	136.14	1.82
Koppányszántó	346	15.34	130.06	0
Miklósi	229	21.87	165.94	5.26
Somogyacsa	199	8.14	175.88	2.86
Somogydöröcske	160	14.77	168.75	7.41
Szorosad	102	15.74	137.25	7.14
Törökkoppány	388	15.04	121.13	6.38

Source: Own calculation based on HCSO 2018 database.

For the calculation of waste potential (Table 2) within the case study area we have formed two major categories of waste, the already deposited waste (accumulated during the last 20 years and landfilled) and the just generated waste (during the given year).
The energy potential of yearly generated waste is calculated from the 10% of selectively collected packaging waste and the total amount of composite waste. From this fraction an estimated 45% goes to the landfill as a compost-like organic fraction, which has about 6MJ/kg energy potential. The selectively collected organic fraction of MSW (between 1 and 10%) and the compost coming from it is very low. The better the separation practice of organic waste, the higher the alternative use of this fraction, so there is a huge potential within this region.
For the calculation of old landfills' energy potential we have projected back for 20 years (this is an average lifetime of a landfill) the generated total municipal solid waste amount from last year (2017). This was the basis for the capacity estimation of the generated

MSW within a given settlement. Although there is neither closed nor operative landfill in the Koppány Valley, we calculated with the generated waste as a potential. Due to the old landfills' specialities [4], we calculated with only 15% of these capacities (tonnes), as an estimated plastic fraction of the waste (the rest, organic fractions generate the LFG potential of closed landfills). This part has 14MJ/kg potential in our table.
The landfill gas potential estimation is based on the capacities (tonnes) of the above mentioned 20 years old closed landfill calculation, where the energy potential is 17 MJ/m^3 [22] and the compacted waste weight is 750kg/m^3 [23].

Table 2. The main potential of waste within the case study area, 2017

Settlement/feature	Energy potential of yearly generated waste (MJ/year)	Selectively collected organic proportion of MSW (%)	Compostable organic waste (T/year)	Energy potential of old landfills, MJ	LFG potential, MJ
Bonnya	113,499	2.29	1.16	2,122,711	22,912
Fiad	63,587	1.28	0.34	1,105,942	11,937
Kára	36,480	9.90	1.58	669,441	7,226
Kisbárapáti	189,088	1.48	1.16	3,295,369	35,569
Koppányszántó	151,885	…	1.15	2,719,833	29,357
Miklósi	112,684	3.22	1.51	1,966,100	21,221
Somogyacsa	86,588	4.23	1.69	1,678,012	18,112
Somogydöröcske	68,597	4.61	1.38	1,256,397	13,561
Szorosad	55,126	5.11	1.19	980,972	10,588
Törökkoppány	199,830	1.23	1.01	3,452,301	37,263

Source: Own calculation based on the public service provider's data release, except for Koppányszántó where the data source is HCSO 2018.

5. Conclusions

All the calculations of the case study area show *usable energy potential*. There are a *lot of alternative recovery modes against the landfilling of the biodegradable waste fraction*, but the closed, old landfills also have energy potential (although outside the researched area).
As an average rural area, the centralised waste management system results *in longer transport routes* in the Koppány Valley, and the scope of *waste services is also narrower than in an average urban place* (collection at households, more frequent shipping, etc.).
The special problem of the Koppány Valley is the *lack of composting capacities* near the area. The just introduced separate collection of biowaste within the area (with containers) results in 12 tonnes of compostable biowaste in the region, but is too "far" from the organic waste potential of the area. The further change of social behaviour (selective collection) and a new investment in the composting capacities would help the region a lot.

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