PROBIOPOL

Biogas Polygeneration for Romania

Screening the rise of fermentable wastes & market prices for energy and waste treatment in Romania

Research report carried out by SC Project Developer (ProDev), Romania

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1.1 Introduction

Biomass-produced energy accounts for about 11% of the total energy production in Romania. About 70% of the firewood resources are utilized. Also, the utilization of industrial biomass by-products is relatively high. Other type of biomass use is straw. The biomass supply is quite good. Statistical records group biomass in two categories: firewood and agricultural waste (accounts for 95% of the total) and wood waste from industrial processes (about 5%). Representing the target potential users of biogas polygeneration, the main sources of fermentable waste in Romania are represented by the following 5 components:

- Organic waste, sludge and by-products from agriculture
- Organic waste, sludge and by-products from the food industry
- Mixed sludge from municipal waste-water-treatment-plants
- Biodegradable fraction from municipal solid waste centres
- Other secondary sources: paper & pulp industry, biodiesel industry

We will not include in the current assessment the availability of energetic crops (like maize silage, algae, beet, etc.) which can supply successfully to biogas plants. Instead, we will focus on the available organic waste streams with sufficient quality, quantity and price features making them suitable for market application of biogas polygeneration. A good reason for this is the large availability of organic waste in Romania, partly due to the overall increase of production and consumption, partly due to the lack of good practices and modern technologies in treating this waste. Moreover, organic fraction in domestic waste is much higher than the European average, ranging from 50 – 65%.

Thus, this report will focus on the four main sources of fermentable waste in Romania – agriculture, food industry, municipal wastewater treatment plants and domestic waste collection. For the purpose of this study, we focused on estimating the amounts of organic waste from the various available sources (industry, agriculture, sewage sludge, municipal waste, etc.). To complete the biogas potential estimation, one needs also to consider the potential of energy crops (maize silage, grass silage, sugar beet, etc.). Our rough expectation is that the overall biogas potential given by organic wastes could and should be doubled with the amounts of substrates generated by energy crops.

1.2 Methodology

To gather the entry data for the assessment of fermentable waste types and amounts in Romania, we used a series of information sources, which we processed through desktop work. These information sources are detailed in the text and annexes, but the main ones were the 8 Regional Plans for Waste Management and the National Statistic Yearbook 2006.

Where we had access to direct data on specific fermentable waste we used them as such, after a cross-checking with at least another source. Where there was no such data found (e.g. most of the food industry), we used data about production and data about waste generation in report to production, to calculate the amounts of available waste.

Based on the identified or calculated amounts of fermentable waste, we used different sources from the literature or research projects (see *Optipolygen* in Information Sources) – to calculate the potential of biogas generation through anaerobic fermentation. The amounts of biogas have been then integrated into energy potential calculations, based on the general supposition that 1 m³ of biogas is equal to an average of 6 kWh of energy, which used in a CHP unit with an average efficiency of 40% net electric output and 40% net thermal output and having an average of 7.500 hours of functioning in a year, would give approx. 2.4 kWh el. and 2.4 kWh th.

1.3 Assessment of fermentable waste availability in agriculture

Although most of the Romania's agriculture land is used by individual small farms (in 2005 were 4,237,889 of them, with a 2.1 ha average surface used), an increasing number of large professional farms (often associations of small owners) are leading the development of today's agriculture in the country. In 2005 there were 18.263 farming companies, using an average of 263 ha. These are the most suitable for an integrated organic waste management and biogas production *[source 1]*.

Most of Romania's land is agricultural
About 62 % of Romania's total area of 23.8 million hectare - some 14.9 million Hectares - is agricultural (the EU average is 41 %). Arable land represents about 63 % of the agricultural area, permanent crops 3 % and permanent grassland 33 %. In addition, 28 % of Romania's land is forested *[source 1]*.

To estimate the biogas potential from agro-waste, we divided the search into two parts – one focused on **livestock manure** and the other on **crops residues**.

1.4 Livestock manure

Traditionally, the Romanian livestock sector comprises two very different types of farms: a household, family owned, small sized one, and another in medium and large professional farms, which during 1950 – 1990 were state owned, now mostly private.

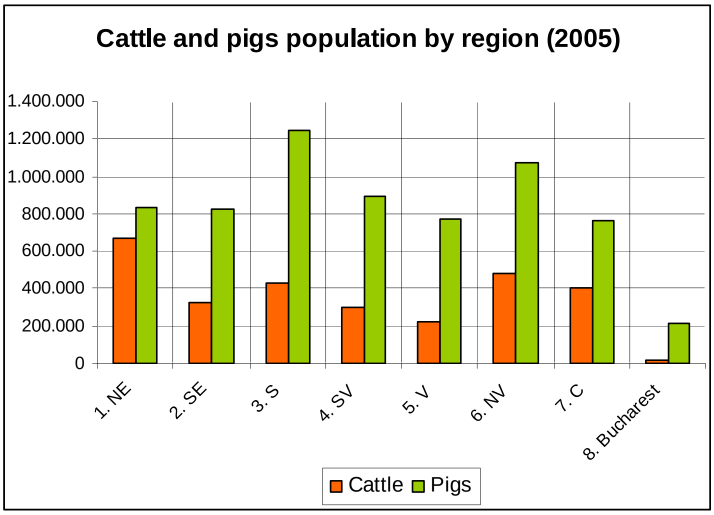
Usually – the large livestock farms in Romania are facing severe challenges to comply with the European standards in the fields of hygiene, environmental protection and animal welfare. This is why – energy recovery from animal manure is potentially a little "gold-mine" for the medium and large farms, even in investment partnerships with experienced companies.

The following table presents the 2005 situation of livestock in the 8 Romanian regions:

Livestock by regions in Romania (Dec. 2005)					
Development region	**Cattle**	**Pigs**	**Sheep & goats**	**Horses**	**Poultry**
Total - heads	2.861.671	6.622.302	8.297.723	833.952	86.552.203
1. North - East	668.434	836.143	1.323.153	207.270	15.822.313
2. South - East	328.955	823.557	1.457.329	137.162	13.257.090
3. South - Muntenia	430.520	1.245.153	862.155	132.259	18.965.189
4. South - West Oltenia	301.594	892.672	797.418	103.084	11.120.048
5. West	225.275	772.193	1.076.745	50.320	7.429.085
6. North - West	481.008	1.073.294	1.114.600	106.029	10.013.644
7. Center	404.638	763.443	1.631.538	92.246	8.525.281
8. Bucharest - Ilfov	21.247	215.847	34.785	5.582	1.419.553

Source: Romanian Statistical Yearbook (2006)

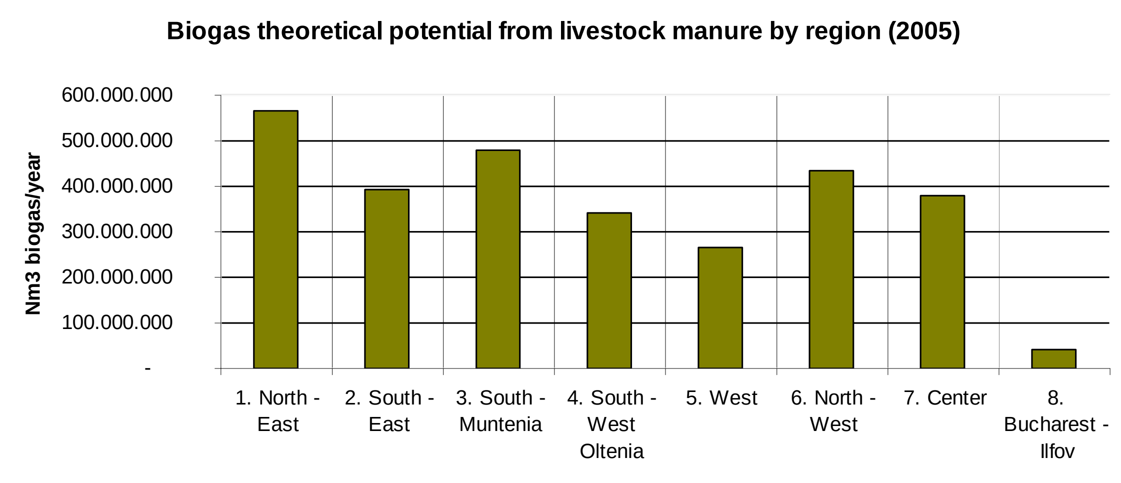
In 2005, the Romanian livestock was counting: 2.861 th. cattle, 6.622 th. pigs, 7.610 th. sheep, 686 th. goats, 833 th. horses and 49.724 th. poultry. Our estimations indicate that the organic waste generated by this livestock can supply around 10.000 MW installed electric power with biogas technology.



Based on this data, as well as on the specific parameters from literature, we built an estimation of biogas potential from livestock manure – as follows:

Estimation of biogas theoretical potential for livestock manure in Romania						
	cattle	**horses**	**sheep & goat**	**pigs**	**chicken**	**TOTAL livestock**
Nm3 biogas/1000 kg live animal/day	3,05	3,31	4,15	2,62	6,21	
no. of animals / Romania	2.861.671	833.952	8.297.723	6.622.302	86.552.203	
adult animal average weight (kg)	344	412	24	110	2	
total weight (t)	984.415	343.588	199.145	728.453	173.104	
Nm3 biogas/day	3.002.465	1.137.277	826.453	1.908.547	1.074.978	7.949.721
Nm3 biogas/year	1.095.899.803	415.106.113	301.655.422	696.619.814	392.367.102	2.901.648.254
MWh biogas energy / year	6.575.399	2.490.637	1.809.933	4.179.719	2.354.203	17.409.890
MW installed potential	350,69	132,83	96,53	222,92	125,56	929

It is, however, important to take into consideration the relative value of this estimation, due to the problem of animals' concentration. Biogas application is especially interesting for medium and large farms, concentrated on specific surfaces, where a proper manure collection can be organized. Because of this, we estimate that only half of the theoretical energy potential estimated above is technically usable by biogas investments.



The regional differences in biogas potential based on livestock manure is given by the general hierarchy of Romanian regions in terms of agricultural production, which makes the NE, the NW and the S regions to be the most developed. The total estimated installed CHP power for this substrate is >900 MW:

Biogas energy potential from livestock manure - 2005			
Development region	**Nm3 biogas/year**	**MWh biogas energy / year**	**MW installed potential**
Total - Romania	**2.901.648.254**	**17.409.890**	**929**
1. North - East	566.937.993	3.401.628	181
2. South - East	393.959.940	2.363.760	126
3. South - Muntenia	479.003.081	2.874.018	153
4. South - West Oltenia	340.111.393	2.040.668	109
5. West	265.369.593	1.592.218	85
6. North - West	435.800.660	2.614.804	139
7. Center	379.144.974	2.274.870	121
8. Bucharest - Ilfov	41.320.620	247.924	13

1.5 Crops residues

The second main source of substrate for biogas production in agricultural farms is represented by the vegetal waste generated from various crops cultivation. Almost any vegetal crop is producing a specific amount of waste and by-products, which in many cases, in Romania, have no market value or local utilization (e.g. straw from cereal crops, which are usually burnt on field, illegally). This means – a large quantity of organic waste is available each year (especially during summer – autumn) to be used as energy source – either through biomass combustion systems or biogas stations.

As a source for biomass combustion – agricultural waste is known for a high content of ash and sometimes high humidity content. Both – make them more appealing for biogas production, rather than for combustion.

The current situation of vegetal farms in Romania is very similar to the one in the livestock sector. The farms are usually very small (average of 3 ha), agricultural machines are old and not enough for a proper efficiency, and few farming cooperatives are working successfully as groups of producers. However, this situation is evolving fast, under the premises of Romanian and European policies for agriculture (C.A.P., etc.) and many large farms are now on the market. There are more than 40 large farms with >5000 ha each (max. 40.000 ha), mainly in the South and East part of the country, which are mainly cultivating cereals and oil-seeds crops.

The next table indicates the cultivated surface and productivity for the main crops in Romania:

Crops (2005)	**Ha (millions)**	**Yield (t)**	**Observations**
Wheat	>2,2	>7,6	There are 40 large farms with >5.000 ha in operation (average surface 10 ha).
Corn	>3,2	>14,2	
Barley	>0,5	>1,5	
Sun flower	>1,1	>1,8	
Sugar beet	>0,2	>0,5	5 large sugar factories using local sugar beet
Vegetables	>0,3	>3,6	6 large vegetable producers operating heated greenhouses – with a total of >420 ha. Heating represents 65% of their production costs.
Vineyards	>0,2	>1,1	110 vineyard farms each with >50 ha
Source: Minister of Agriculture			

To estimate the theoretical potential for biogas generation from crops residues, we used the 2005 statistic data for main crops production (cereals, maize, sugar beet, oilseed crops and vegetables) and a specific percentage of residues in report to the production itself. Each region was thus calculated with potential amount of biogas generated, amount of energy and installed power.

Main crops - production 2005	**Cereal (wheat, rye, barley, oats)**	**Maize grains**	**Sugar beet**	**Oilseed crops**	**Vegetables**
North - East	775.612	1.739.898	175.808	212.723	1.522.011
South - East	1.423.341	2.220.085	1.620	681.523	980.905
South - Muntenia	2.261.535	1.841.392	5.185	524.940	940.006

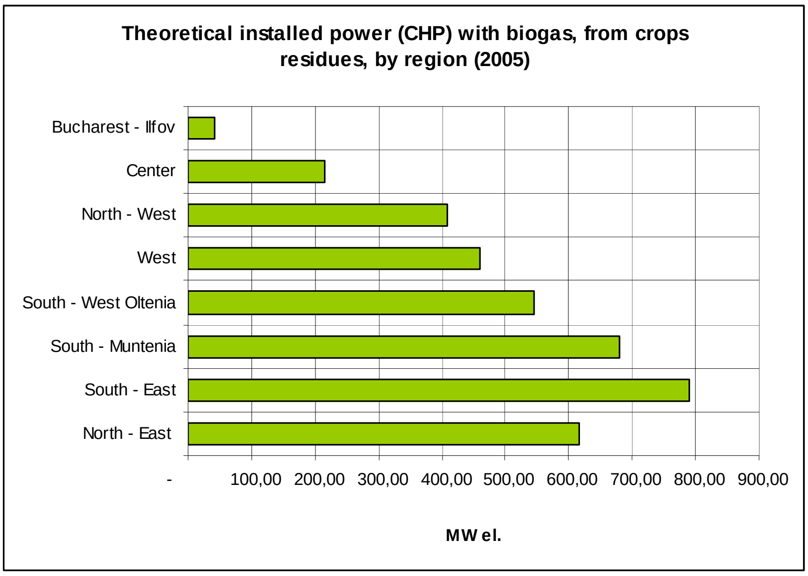
South - West Oltenia	1.709.476	1.518.862	24.180	119.841	681.693
West	1.114.782	1.286.170	80.659	128.366	793.628
North - West	847.319	1.116.378	215.723	112.141	1.207.442
Center	611.431	552.454	226.483	8.247	1.116.012
Bucharest - Ilfov	102.734	113.260	0	15.299	121.509
Total - production	**19.345.464**	**10.388.499**	**729.658**	**1.803.080**	**7.363.206**
Crops waste (% of production)	**25%**	**200%**	**20%**	**120%**	**35%**
Crops waste - t	4.836.366	20.776.998	145.932	2.163.696	2.577.122
dried matter (%)	85%	86%	18%	13%	25%
organic from d.m. (%)	90%	72%	81%	85%	80%
biogas (m3/t odm)	350	820	675	710	820
Total - Nm3 of biogas potential	**1.294.936.997**	**10.549.396.073**	**14.361.858**	**169.752.770**	**422.648.024**
North - East	51.917.528	1.766.845.540	3.460.429	20.027.020	87.363.431
South - East	95.274.888	2.254.469.676	31.886	64.162.664	56.303.947
South - Muntenia	151.381.499	1.869.911.479	102.056	49.421.001	53.956.344
South - West Oltenia	114.428.050	1.542.386.135	475.935	11.282.551	39.129.178
West	74.620.720	1.306.090.201	1.587.611	12.085.145	45.554.247
North - West	56.717.416	1.133.668.462	4.246.076	10.557.627	69.307.171
Center	40.927.663	561.010.408	4.457.865	776.422	64.059.089
Bucharest - Ilfov	6.876.757	115.014.171	-	1.440.340	6.974.617
MWh from biogas	**7.769.622**	**63.296.376**	**86.171**	**1.018.517**	**2.535.888**
North - East					

	311.505	10.601.073	20.763	120.162	524.181
South - East	571.649	13.526.818	191	384.976	337.824
South - Muntenia	908.289	11.219.469	612	296.526	323.738
South - West Oltenia	686.568	9.254.317	2.856	67.695	234.775
West	447.724	7.836.541	9.526	72.511	273.325
North - West	340.304	6.802.011	25.476	63.346	415.843
Center	245.566	3.366.062	26.747	4.659	384.355
Bucharest - Ilfov	41.261	690.085	-	8.642	41.848
MW installed (electric)	**414,38**	**3.375,81**	**4,60**	**54,32**	**135,25**
North - East	16,61	565,39	1,11	6,41	27,96
South - East	30,49	721,43	0,01	20,53	18,02
South - Muntenia	48,44	598,37	0,03	15,81	17,27
South - West Oltenia	36,62	493,56	0,15	3,61	12,52
West	23,88	417,95	0,51	3,87	14,58
North - West	18,15	362,77	1,36	3,38	22,18
Center	13,10	179,52	1,43	0,25	20,50
Bucharest - Ilfov	2,20	36,80	-	0,46	2,23
* *Source for crops production: Romanian Statistical Yearbook (2006)*					

From the calculations above, the main conclusions were:

- Theoretical biogas potential: 76,7 mil. MWh
- Main source of energy (85%) is maize crops residues (currently burnt, buried or used as a low quality fodder)
- Most important potential by region indicates a high potential in SE, followed by S and NE, which together totalize around 52% of the national potential.

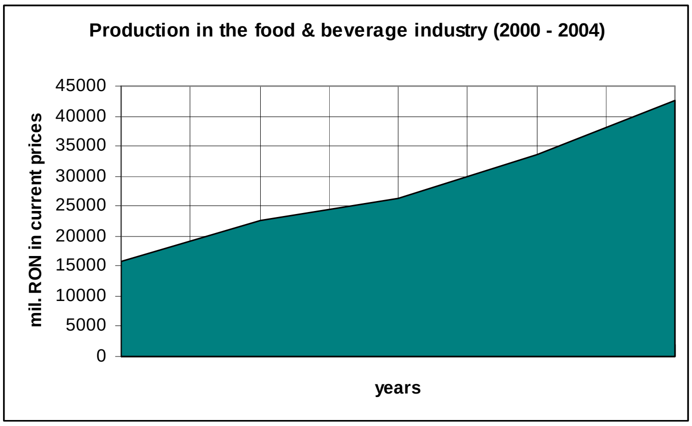
Whatsoever, these figures can only indicate a very general, theoretical dimension of the crops residues as biogas feedstock. In reality – there are several reasons why this potential will probably never be totally used. The main reason is given by the spread of the crops surfaces and the costs for collection, transport and storage, lack of proper machines. Comparing with the livestock manure, which is produced on a permanent basis, crops residues are generated mainly during summer and autumn, which is a serious obstacle for an effective use for biogas generation (need for storage, etc.).



1.6 Assessment of fermentable waste availability in food-industry

The food industry is an important sector in the Romanian economy, accounting for about 17 percent of the output of all manufacturing industries, 9 percent of total national production, and 7 percent of gross value-added in 2002.

The **food & beverages** industry now comprises 11.000 companies, 200.000 employees and has a cumulated turnover of approx. 10 billion EUR/year, with several very large stakeholders (cumulated turnover of the first 5 companies: 10%, first 20: 20%).



The continuous growth of this industry (based on both local and imported agro-products) and its significance in organic waste and by-products generation, make the energy recovery of its bio-degradable particularly attractive for the coming years.

One important aspect of this good potential is also the fact that many large food-companies in Romania are now part of the main European players in this industry, providing enough experience and financial support for biogas and polygeneration investments.

In general, almost all food processing requires both electric power as well as heat for some kind of thermal processing. Electric power is required for mechanical processing such as pumping, ventilating, mixing and conveying etc., but a great part is also used for cooling by mechanical compression coolers. The required thermal processing comprises both high temperatures processing such as pasteurization, cooking and evaporation as well as low temperature processing such as freezing and cooling.

Food products	Production (2005) in Romania (thousands tones)
Meat	220
Meat-based products	295
Vegetables cans	52
Oils	275
Milk + yoghurt	1600 + 2800 thousand hl
Other diary products	70
Wheat flower	1900
Alcohol (100%)	467 thousand hl

Source: Romanian Statistical Yearbook 2006

Many sectors of the food industry produce significant amounts of biodegradable waste or by-products that could be used for energy production. This utilization could either be directly as a solid biomass fuel or as a raw material for biogas production. The amount of bio-waste per food sector and ton product produced or processed depends on the raw material processed and the utilized cleaning technologies at the plant. Typical values for the amounts of waste produced were estimated for each food sectors and are listed below as either kg solid or amount of chemical oxygen demand (COD).

The following table presents the statistic estimation of food-industry production, for the main products interesting for biogas generation:

Industrial products - food, beverages and tobacco	units	2001	2002	2003	2004	2005
Meat	thou tonnes	202	167	204	210	265
Meat products	thou tonnes	168	169	204	254	290
Tinned meat	thou tonnes	16	17	21	22	27
Semi-tinned fish	tonnes	3.295	1.801	3.051	8.040	7.860
Tinned fish	tonnes	1.230	1.316	1.702	925	908
Tinned vegetables and fruit	thou tonnes	50	54	67	52	73
Edible oils	thou tonnes	296	228	243	258	264
Margarine	tonnes	45.617	60.017	68.173	60.933	65.805

Consumption milk	thou hl	1.168	1.281	1.442	1.577	1.600
Fresh milk products (3.5 % fat)	thou hl	1.306	1.665	1.740	2.708	3.171
Powder milk*	tonnes					10.718
Butter	thou tonnes	7	5	6	7	8
Cheese products	thou tonnes	36	43	49	53	61
Ice-cream*	tonnes					11.805
Wheat and rye flour (equivalent wheat)	thou tonnes	1.382	1.297	1.603	1.828	1.742
Sugar	thou tonnes	493	514	460	506	539
of which: of sugar beet	thou tonnes	74	66	59	50	64
Confectioneries and pastries	thou tonnes	101	109	115	145	166
Fermentation equivalent 100% alcohol	thou hl	444	539	565	467	366
Wine for consumption	thou hl	5.463	5.488	5.457	7.071	2.602
Beer	thou hl	12.663	11.627	13.292	14.406	15.295
Juice*	thou hl					12.999
Tobacco products	thou tonnes	39	35	36	35	33
*Source: Romanian Statistical Yearbook 2006 & *ROMALIMENTA statistics for 2005*						

In the following section, we used the specific waste generation characteristics estimated for the European food-industry (see www.optipolygen.org) to calculate the specific biogas potential for the Romanian food industries (corresponding to the 2005 statistic data on the food production):

Fish & meat industry

- This industry is producing fresh, frozen, cooked and tinned products from fish and meat, totalizing approx. 590.000 t/2005 *[source 2]*.
- The specific amounts of waste and by-products from this industry is between 100 - 450 kg/tons carcase (COD 40kg/tons carcase), as residues from fish and animal carcase *[source 3]*.
- Our estimation indicates a biogas potential of approx. 8.171.600 Nm3 biogas for meat industry and 633.500 from the fish industry summing up to 8.805.100 Nm3 (approx. 52.800 MWh – generated by approx. 2,8 MW el.).

Tinned and frozen vegetables

- This industry is producing cooked food and vegetables (including tinned and frozen products), totalizing approx. 73.000 t/2005 *[source 2]*.

- The specific amounts of waste and by-products from this industry are approx. 250 kg/tons product, as waste from fruits and vegetables; with 30% volatile solids (VS) *[source 3]*.
- Our estimation indicates a biogas potential of approx. 400 Nm3 biogas / t VS - summing up to 2,19 mil Nm3 (approx. 13.140 MWh – generated by approx. 700 kW el.).

Oils and fats

- This industry is producing mainly vegetal oil (from sunflower, rape, soybean, etc.), totalizing approx. 264.000 t oil/2005 and margarine – approx. 65.800 t/2005 *[source 2]*.
- The specific amounts of waste and by-products from this industry (as cake) is approx. 2.500 kg/tons oil, as cake (660.000 t/y) *[source 3]*.
- Our estimation indicates a biogas potential of approx. 700 Nm3 / t o.d.m. (o.d.m. = approx. 84,5% of the cake) which means 390 mil. Nm3 biogas summing up to 2,34 mil MWh (generated by approx. 124,8 MW el.).

Wastewater characteristics in vegetable oil processing

Process operation	Parameter	Level
Crude oil production	COD load	0,1-1 kg/ton seed processed
Neutralisation	Wastewater volume	1 – 1,5 m³/ton refined product
	COD load	≤ 5 kg/ton refined product
Deodorisation	Wastewater volume	10 - 30 m³/ton refined product
	COD load	≤ 7 kg/ton refined product

Source: OPTIPOLYGEN project – Work Package 2 Report

Beverages, breweries, wine and spirits

- This industry produced in 2005: 15,3 mil. hl beer, 2,6 mil. hl wine, 0,36 mil. hl alcohol and 12,99 mil. hl juice *[source 2]*.
- The specific amount of waste and by-products from this industry is approx. 23 kg for 1 hl beer *[source 3]*.
- Estimations indicate a biogas potential of approx. 3 Nm3 biogas / hl beer, 1,12 Nm3 biogas / hl juice and 0,3 Nm3 biogas / hl spirits, summing up to approx. 45,9 mil. Nm3 from beer industry, 14,5 mil. Nm3 from juice, and 0,1 mil. Nm3 biogas from spirits (approx. 60,5 mil. Nm3 biogas = 363.000 MWh, generated by approx. 19,4 MW).

Flour

- This industry produced in 2005 - 1.742.000 t of flour (equivalent wheat) *[source 2]*..
- The specific amounts of waste and by-products from this industry is approx. 250 kg for 1 t cereal processed *[source 3]*.
- Estimations indicate a biogas potential of approx. 21,8 Nm3 biogas / t cereals, summing up to approx. 38 mil. Nm3 (227.850 MWh, generated by approx. 12 MW).

Sugar

- The sugar industry produced in 2005 – 539.000 t of sugar, of which only 64.000 t were produced totally in Romania from sugar beet *[source 2]*. The production capacity for beet sugar is provided by 5 main sugar factories (Oradea, Ludus, Bod, Roman, Corabia). According to the EU-Romania negotiations, Romania has a sugar cotta of 500.000 t/y, of which approx. 109.164 t – from internal production of sugar beet. We expect that the internal sugar production will increase and stabilize in the next 10 years to this limit.
- For this study, due to the lack of data, we only used the data for the sugar from beet, which generates the main portion of organic waste in the sugar industry, compared to the imported raw sugar processing. The specific amounts of waste and by-products from this industry is approx. 890 kg for 1 t sugar beet totally processed *[source 3]* - approx. 398.720 t in 2005.
- Estimations indicate a biogas potential of approx. 0,065 Nm3 biogas/kg solid wastes, summing up to approx. 26 mil. Nm3 (155.500 MWh, generated by approx. 8,5 MW). Considering another method of estimation, we used 8000 kg waste/tons sugar, which means 512.000 t waste, potentially generating approx. 33 mil. Nm3 (199.680 MWh from 10,6 MW).

Diary

- This industry produced in 2005 – 1,6 mil. hl consumption milk, 3,17 mil. hl fresh milk products (like yoghurt), 10.718 t powder milk, 8.000 t butter, 61.000 t cheese and 11.805 t ice-cream *[source 2]*.
- The specific amounts of waste and biogas productivity is shown in the table below *[source 3]*.
- Our estimation indicates a biogas potential of approx. 872,27 mil. Nm3 (5,23 mil. MWh, generated by approx. 279 MW).

An overall view on the Romanian food-industry potential for biogas generation is shown in the table below:

Industry	Nm3 biogas potential	MWh/y energy potential	MW installed potential
Fish & meat industry	8,8 mil.	52.800	2,8
Tinned and frozen vegetables	2,19 mil.	13.140	0,7
Oils and fats	390 mil.	2.340.000	124,8
Beverages, breweries, wine and spirits	60,5 mil.	363.000	19,4
Flours	38 mil.	227.850	12
Sugar	26 mil.	155.500	8,5

Diary	872,27 mil.	5.230.000	279
TOTAL – food-industry	1397,76 mil.	8.382.290	447,2

1.7 Assessment of sludge availability in municipal wastewater treatment plants

In the field of **waste-water treatment plants** (WWTP), biogas potential is good both for municipal WWTP (many included in EC funded programs) and for industrial ones. There are several WWTPs producing some biogas for their own internal energy needs, but probably for less than 5% of the total sites.

In the **European Waste Codes – EWC** (HG no. 856/2002), WWTP sludge is identified with no. 190805

There are 732 sewage sludge treatment plants in Romania, out of which 416 municipal treatment plants and 316 industrial treatment plants (out of which 66 doesn't work or economic agents haven't treatment plants anymore). *[source 4]*

In 2003, according to the Report on state of Wastewater Sludge EC Directive implementation the quantities of **wet sewage sludge** are splitting: from the total of sludge treatment plants were collected 3.268.277 tons/year primary sludge, 714.855 tons/year secondary sludge, 81.919 tons/year chemical sludge and 1.877.628 tons/year mixed sludge.

In 2003, the same Report states that the quantities of **dry sewage sludge** are splitting: from the total of sludge treatment plants were collected 222.893 tons/year primary sludge, 34.225 tons/year secondary sludge, 26.052,23 tons/year chemical sludge, 377.918,9 tons/year mixed sludge.

Regarding **the use** of this kind of sludge from the total one part is disposed: 188.639,11 tons primary sludge, 178.127 tons secondary sludge, 50.947,81 tons chemical sludge and 308.656,78 tons mixed sludge. Another part from the total is incinerate to the cement kilns or another plays: 36.083,41 tons primary sludge, 10,8 tons secondary sludge, 15,1 tons chemical sludge and 16.631,32 tons mixed sludge. Another part is temporary storage on the own platforms: 108.186,02 tons primary sludge, 29.812,74 tons secondary sludge, 3.612,16 tons chemical sludge, 165.713,71 tons mixed sludge. Another part is used or dispose in different way: 13.802,93 tons primary sludge, 109,5 tons secondary sludge, 9.257,3 tons chemical sludge and 25.375,95 tons mixed sludge.

There are used in agriculture about 28,62% from primary sludge means 63.802,48 tons, 27,61% from secondary sludge means 9.449,35 tons and 27,61% mixed sludge means 46.342,11 tons. *[source 4]*.

Industrial treatment plants

At this category, wet sludge **are collected:** 1.859.283,3 tons/year primary sludge, 357.330,9 tons/year secondary sludge, 81.919,1 tons chemical sludge and 562.871,67 tons/year mixed sludge. Dry sludge is collected: 138.181,61 tons/year primary sludge, 20.465,75 tons/year secondary sludge, 26.052,21 tons chemical sludge, 263.339,13 tons mixed sludge.

Regarding the use of sludge from industrial treatment plants one part is dispose: 39.492,27 tons primary sludge, 176.358,5 tons secondary sludge, 50.947,57 tons chemical sludge and 192.665,54 tonss mixed sludge. Another part is incinerate to the cement kilns: 36.083,41 tons primary sludge, 15,1 tons chemical sludge and 16.631,32 tons mixed sludge. Another part is temporary storage on the own platforms: 19.126,07 tons primary sludge, 27.805,3 tons secondary sludge, 3.612,16 tons chemical sludge and 115.972,74 tons mixed sludge.

Another part is used or dispose in different way: 13.394,43 tons primary sludge, 82 tons secondary sludge, 9.257,3 tons chemical sludge and 144,25 tons mixed sludge.

In agriculture are used about 40,46% means 55.901,54 tons primary sludge, 27,01% means 5.527,05 tons secondary sludge and 13,86% means 36.497,9 tons mixed sludge.

Municipal Treatment Plants

At this category, wet sludge are collected: 1.408.990 tons/year primary sludge, 357.524,55 tons/year secondary sludge, 0,24 tons/year chemical sludge and 1.314.756,79 tons/year mixed sludge. Dry sludge are collected: 84.711,51 tons/year primary sludge, 13.759,33 tons/year secondary sludge, 0,02 tons/year chemical sludge, 114.579,77 tons/year mixed sludge.

Generated sludge quantities in 2003, from municipal WWTP (tones/year)				
	Primary sludge	**Secondary sludge**	**Mixed sludge**	**Total**
Wet sludge	1.408.990	357.524	1.314.757	3.081.271
Dry sludge	84.712	13.759	114.580	213.051
TOTAL	1.493.702	371.283	1.429.337	**3.294.322**

Source: Report on state of Wastewater Sludge EC Directive implementation

sewage sludge in Romania	**tonss of d.m. in 2006**
TOTAL	**225.630**
landfilled	69.230
used in agriculture	380
composted	3.870
disposed on platforms	145.440
incinerated	0
treated through other methods	6.710
Source: *Source: Romanian Statistical Yearbook 2006*	

Considering the 225.630 t d.m. produced in 2006, we estimate that the biogas generation potential is 225.630 x 90% (organic) x 1000 m3/o.d.m. = approx. 203 mil. m3 biogas, with 60% CH4 content. This ends with 121 mil. m3 CH4, which means 1.218.000 MWh/y, produced by an installed capacity of approx. 65 MW.

Regarding the use of sludge from municipal treatment plants one part is dispose: 149.146,84 tons primary sludge, 1.768,5 tons secondary sludge, 0,24 tons chemical sludge and 115.991,24 tons mixed sludge. Another part is incinerate to the cement kilns: 10,8 tons secondary sludge. Another part is temporary storage on the own platforms: 89.538,15 tons primary sludge, 2.011,24 tons secondary sludge and 49.740,96 tons mixed sludge.

Another part is used or dispose in different way: 408,5 tons primary sludge, 27,5 tons secondary sludge, 25.231,7 tons mixed sludge.

In agriculture are used about 9,33% means 7.900,94 tons primary sludge, 28,51% means 3.922,3 tons secondary sludge and 8,59% means 9.844,52 tons mixed sludge.

1.8 Assessment of organic waste availability from municipal waste collection

The waste management in Romania and the fact that a great proportion (50 – 65%) of the domestic waste is biodegradable, make the organic waste management a problem but also a great opportunity for energy re-using / recovering. Each urban inhabitant in Romania produces annually approx. 420 kg of mix waste, of which approx. 50% - is biodegradable. This means that the total amount of biodegradable waste collected in Romania is approx. 2,2 million tonss / year (considering 10,5 ml. urban inhabitants).

The opportunity given by the municipal organic waste is also given by the large current investments in the upgrading of collection (towards a better coverage and a separate collection) and treatment (mostly sorting and landfilling in regional landfills) systems in Romania. These investments are also supported by the EC and will offer a double perspective for future biogas production from this type of waste. The large majority will probably be the capture, purification and utilization of landfill-gas (LFG), but it is also expected that several centralized biogas-production plants will use separated municipal organic waste (especially using the dry fermentation technology). However, biogas production from municipal organic waste is still limited, due to lack of separate collection of organic waste. Only landfill gas capture and utilization is under development.

Directive 1999/31/EC and HG 349/2005 on landfilling of waste has the following provisions for biodegradable municipal waste:

In the **European Waste Codes – EWC** (HG no. 856/2002), biodegradable waste is identified with no. 200108

(a) not later than five years after 16th July 2001 biodegradable municipal waste going to landfills must be reduced to 75 % of the total amount (by weight) of biodegradable municipal waste produced in 1995;

(b) not later than eight years after 16th July 2001 biodegradable municipal waste going to landfills must be reduced to 50 % of the total amount (by weight) of biodegradable municipal waste produced in 1995;

(c) not later than 15 years after 16th July 2001 biodegradable municipal waste going to landfills must be reduced to 35 % of the total amount (by weight) of biodegradable municipal waste produced in 1995.

Directive 1999/31/EC on landfilling of waste provides for member states in which in 1995 or a previous year for which standardized EUROSTAT data is available, more than 80% of collected municipal waste has gone to landfills, to postpone the fulfillment of the targets set out in paragraphs (a), (b) and (c) for a period which cannot exceed four years.

In the Implementation Plan for Directive 1999/31/EC on landfilling of wastes is mentioned that Romania does not request a transition period for the fulfilment of the target regarding the diversion of quantities of biodegradable waste. In order to meet the targets set out in art. 5(2) (a) and (b) of the Directive Romania will apply the provisions of paragraph 3 of art. 5(2) regarding the option to postpone the fulfilment of the targets by conceding a grace period of 4 years, until 16th July 2010 and respectively until 16th July 2013. The third target will be attained at the date set out in the Directive, i.e. 16th July 2016.

In order to estimate the regional differences and select the most attractive regions for biogas polygeneration investments, we synthesized the available data from the 8 Regional Plans for Waste Management, elaborated in 2006.

The main data presented below, together with the estimated biogas potential:

Regions	**Biodegradable waste - urban & rural collected (tonnes)**	**Amounts collected (t)**		**Biogas potential (m3)**		**Biogas potential (MWh)**	
		2008	**2013**	**2008**	**2013**	**2008**	**2013**
Region 1 - North East	Food and garden waste from households	360.670	493.149	120 m3 / t biodegradable municipal solid waste		6 kWh / m3 biogas	
	Organic waste from institutions, commerce	93.387	97.178				
	Public gardens and parks waste	18.900	19.667				
	Markets waste	12.155	12.647				
	Street waste	9.303	9.682				
	TOTAL	**494.415**	**632.323**	**59.329.800**	**75.878.760**	**355.979**	**455.273**
Region 2 - South East	Food and garden waste from households	395.000	411.000	120 m3 / t biodegradable municipal solid waste		6 kWh / m3 biogas	
	Organic waste from institutions, commerce	89.000	93.000				
	Public gardens and parks waste	19.000	20.000				
	Markets waste	17.000	18.000				
	Street waste	5.000	5.000				
	TOTAL	**525.000**	**547.000**	**63.000.000**	**65.640.000**	**378.000**	**393.840**
Region 3 - South Muntenia	Food and garden waste from households	387.494	464.183	120 m3 / t biodegradable municipal solid waste		6 kWh / m3 biogas	
	Organic waste from institutions, commerce	97.884	101.862				
	Public gardens and parks waste	29.700	30.907				

	Markets waste	7.645	7.956				
	Street waste	6.770	7.046				
	TOTAL	**529.493**	**611.954**	**63.539.160**	**73.434.480**	**381.235**	**440.607**
Region 4 - South West Oltenia	Food and garden waste from households	332.000	335.000	120 m3 / t biodegradable municipal solid waste		6 kWh / m3 biogas	
	Organic waste from institutions, commerce	105.000	109.000				
	Public gardens and parks waste	17.000	17.000				
	Markets waste	15.000	16.000				
	Street waste	7.000	7.000				
	TOTAL	**476.000**	**484.000**	**57.120.000**	**58.080.000**	**342.720**	**348.480**
Region 5 - West	Food and garden waste from households	286.153	292.565	120 m3 / t biodegradable municipal solid waste		6 kWh / m3 biogas	
	Organic waste from institutions, commerce	99.393	103.420				
	Public gardens and parks waste	23.433	24.382				
	Markets waste	15.081	15.692				
	Street waste	7.785	8.100				
	TOTAL	**431.845**	**444.159**	**51.821.400**	**53.299.080**	**310.928**	**319.794**
Region 6 - North West	Food and garden waste from households	371.908	406.967	120 m3 / t biodegradable municipal solid waste		6 kWh / m3 biogas	
	Organic waste from institutions, commerce	91.285	94.996				
	Public gardens and parks waste	10.021	10.429				
	Markets waste	7.992	8.317				
	Street waste	20.696	21.538				
	TOTAL	**501.902**	**542.247**	**60.228.240**	**65.069.640**	**361.369**	**390.418**
Region 7 - Centre	Food and garden waste from households	618.236	674.782	120 m3 / t biodegradable municipal solid waste		6 kWh / m3 biogas	
	Organic waste from institutions, commerce	173.091	180.126				

	Public gardens and parks waste	13.528	14.078				
	Markets waste	12.280	12.779				
	Street waste	36.942	38.444				
	TOTAL	**854.077**	**920.209**	**102.489.240**	**110.425.080**	**614.935**	**662.550**
Region 8 - Bucharest Ilfov	Food and garden waste from households	375.117	394.890	120 m3 / t biodegradable municipal solid waste		6 kWh / m3 biogas	
	Organic waste from institutions, commerce	92.796	96.540				
	Public gardens and parks waste	11.414	11.873				
	Markets waste	9.235	9.606				
	Street waste	2.654	2.760				
	TOTAL	**491.216**	**515.669**	**58.945.920**	**61.880.280**	**353.676**	**371.282**
ROMANIA		**4.303.948**	**4.697.561**	**516.473.760**	**563.707.320**	**3.098.843**	**3.382.244**

Considering the 2008 amounts of biodegradable municipal waste, the estimated potential for installed power (CHP) is 165 MW.

1.9 Other sources for biogas substrates

To complete the inventory of potential biogas substrates (fermentable wastes), we do not intend to make an exhaustive list of sources. Instead, this chapter will include specific industries with significant amounts of organic wastes generated.

1.10 By-products from biodiesel industry

In the last 3 years, there were several very important projects prepared and implemented for the construction of biodiesel factories in Romania. Currently, at least 12 large factories are under construction, with capacities ranging from 30.000 – 200.000 t/year, mainly located in Southern and Eastern regions of the country.

The total production of biodiesel from 2009 - 2010 onwards, is estimated to >850.000 tons /year *[Source: various Romanian business newspapers and magazines]*. This production will generate an impressive amount of rape and soybean cake, as well as glycerine water.

Estimation:

850.000 t/y biodiesel needs 850.000 t oil; 850.000 t oil is produced with 2,5 mil. t rape or soybean seeds, generating approx. 1,7 mil. t cake.	
to produce biodiesel from oil, there will be	approx. 100.000 t glycerin water (60%)

generated	
biogas generation potential from cake	91% d.m., 93% organic from d.m., 700 Nm3 biogas/t o.d.m.
biogas generation potential from glycerin	11% d.m., 60% organic from d.m., 900 Nm3 biogas/t o.d.m.
theoretical biogas potential	1,03 bl. Nm3 from cake and 5,9 mil. Nm3 from glycerin.
energy potential	6,2 mil. MWh
necessary installed power	331 MW el.

1.11 Sludge from pulp & paper industry

The pulp & paper industry is considered to be one of the highly polluting industries and consumes large amount of energy and water in various unit operations. The wastewater discharged by this industry is highly heterogeneous as it contains compounds from wood or other raw materials, processed chemicals as well as compound formed during processing.

Estimation:

in 2005, Romania produced 134.000 t pulp and semipulp and 411.000 t paper and cardboard *[source 2]*	
average level of waste production	50 kg sludge / t paper-pulp
1 t of this type of sludge generates theoretically approx. 220 m3 biogas	
total theoretical biogas potential	approx. 6 mil. Nm3 biogas
total energy potential	36.000 MWh, produced with 2 installed MW

1.12 Existing and prospective treatment methods for biodegradable waste in Romania

Agricultural use

The precondition to use sludge as fertilizer in agriculture is that its components do not affect the soil in a negative way. This is a continuously control of sludge and soil. The sludge from water treatment plants has a water content of 97%. By centrifugal action or filtration the water content can be diminished to 70-80%. The dehydration process is a pre-condition for an economical transport and a possible landfilling / elimination. Requirements for agricultural reuse suppose a dryness level of at least 90%, to ensure the fact that the sludge does not ferment and can be stored in silos until reuse.

Energy recovery

All kinds of energetic recovery like: co-incineration in cement factories, fuel combustion or incineration on fluid beds requires a sufficient caloric power of the sludge. This means the installation of a drying process separately or in combination with an incinerator. Co-incineration in a cement factory requires a sufficient caloric power.

	Biological method		Thermal method		
	Compost	**Anaerobic digestion**	**Incineration**	**Pyrolysis**	**Gasification**
Proven technology, track record	Yes; Very common	Yes; common	Yes; Very common	Partly; few	Partly; few
Basic principle	Degradation by aerobic microorganisms	Degradation by anaerobic microorganisms	Combustion	Anaerobic thermochemical conversion	Thermochemical conversion
Cost of treatment	Low to high	Medium to high	Medium to high	Medium to high	High to very high
Suitability	Good	Good	Good	Medium	Depending on Technology
Waste acceptance	Source separated waste only since matter and nutrients is to be recovered as pure as possible	Source separated wet waste only since matter and nutrients is to be recovered as pure as possible	All waste since air cleaning technology is good and residual solids are minimised by volume reduction	In particular suitable for contaminated, well defined dry waste fractions	Source separated dry waste only unless combined with better cleaning technology
Acceptance of wet household Waste	Yes	Yes	Yes	Possible but normally no	Possible but normally no
Acceptance of dry household Waste	Yes	Yes	Yes	Yes	Possible

Acceptance of garden and park waste	Yes	Yes	Yes	Yes	Possible
Acceptance of waste from hotels and restaurants	Yes	Yes	Yes	Yes	Possible but normally no
Acceptance of paper and board	Small amounts of paper possible	No	Yes	Yes	Possible
Excluded waste Fractions	Metal, plastic, glass, plants without high degree of sanitary treatment: no waste of animal origin)	Metal, plastic glass, garden waste, (plants without high degree of sanitary treatment: no waste of animal origin)	None	Wet household Waste	Wet household Waste
Environmental impact:					
Solids	High	Medium — high	Medium — high	Medium	Medium
Air	Low	Medium	Medium — high	Medium	Medium — high
Water	Medium — high	High	High	Medium — high	Medium — high
Control of odour	Bad — good	Bad — good	good	Medium — good	good
Working environment	Bad — good	Medium — good	good	good	good
Energy recovery	No	Yes; 3.200 MJ/ tonne	Yes; 2.700 MJ/tonnes	Yes; approx. 70 % of	Yes; as incineration

		waste	waste	incineration + energy contained in the by-product char	
Carbon cycle (% of weight)	50 % in compost 50 % to air	75 % in fibres/liquids 25 % as biogas	1 % in solids 99 % to air	20–30 % in solids 70–80 % to air	2 % in solids 98 % to air
Nutrient recovery (kg nutrient / tonne waste input)	Yes; 2.5–10 kg N 0.5–1 kg P 1–2 kg K	Yes; 4.0–4.5 kg N 0.5–1 kg P 2.5–3 kg K	No	No	No
Products for recycling or recovery, (weight- % of waste input)	40-50 % compost	30 % fibres, 50–65 % fluids	15–25 % bottom ash (incl. clinker grit, glass), 3 % metal	30–50 % char (incl. bottom ash, clinker, grit, glass), 3 % metal	15–25 % vitrified bottom ash (incl. clinker grit, glass). 3 % metal
Residuals for other waste treatment or for land filling (weight- % of waste input)	2–20 % overflow sieving (plastic, metal, glass, stonss)	2–20 % overflow sieving (plastic, metal, glass, stonss)	3 % fly ash (incl. flue gas residues)	2–3 % flue gas residues	2 % gas cleaning residues

Source: Biodegradable municipal waste management in Europe, January 2002

1.13

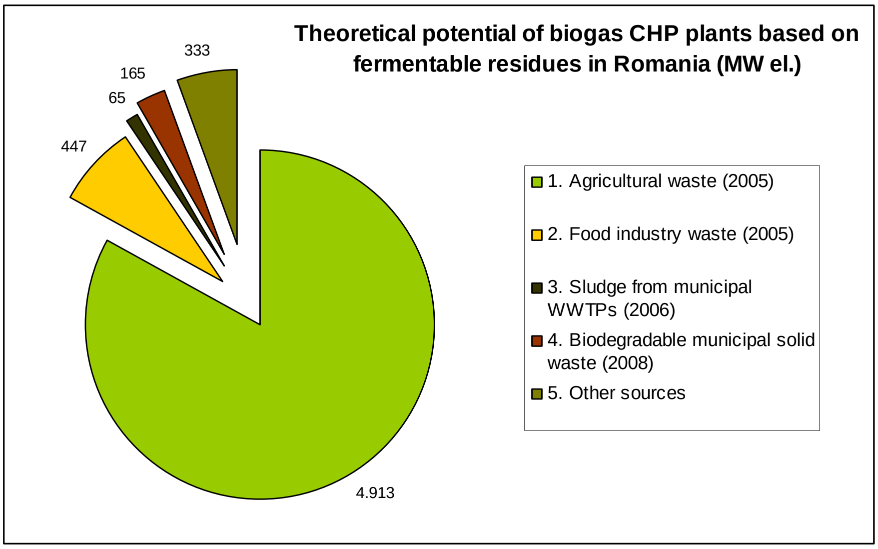
1.14 Conclusions

To have a comparative and synthetic image on the biogas potential analyzed before, the main sources of fermentable waste were put together in the table below:

Sources of fermentable waste	Estimated biogas potential (mil. Nm3/year)	Estimated biogas energy (MWh) (2 x 6000)	Potential of installed power (MW el.) (3 x 40% / 7500)	Potential electricity production MWh el. (3 x 40%)	Potential heat production MWh th. (3 x 40%)
1	2	3	4	5	6
1. Agricultural waste (data from 2005)	**15.353**	**92.118.000**	**4.913**	**36.847.200**	**36.847.200**
1.1 Livestock manure	2.902	17.412.000	929	**6.964.800**	**6.964.800**
1.2 Crops residues	12.451	74.706.000	3.984	**29.882.400**	**29.882.400**
2. Food industry waste (data from 2005)	**1.397**	**8.384.940**	**447**	**3.353.976**	**3.353.976**
2.1 Fish & meat industry	9	52.800	3	**21.120**	**21.120**
2.2 Tinned and frozen vegetables	2	13.140	1	**5.256**	**5.256**
2.3 Oils and fats	390	2.340.000	125	**936.000**	**936.000**
2.4 Beverages, breweries, wine and spirits	61	363.000	19	**145.200**	**145.200**
2.5 Flours	38	228.000	12	**91.200**	**91.200**
2.6 Sugar	26	156.000	9	**62.400**	**62.400**
2.7 Diary	872	5.232.000	279	**2.092.800**	**2.092.800**
3. Sludge from municipal WWTPs (data from 2006)	**203**	**1.218.000**	**65**	**487.200**	**487.200**
4. Biodegradable municipal solid waste (data for 2008)	**516**	**3.096.000**	**165**	**1.238.400**	**1.238.400**

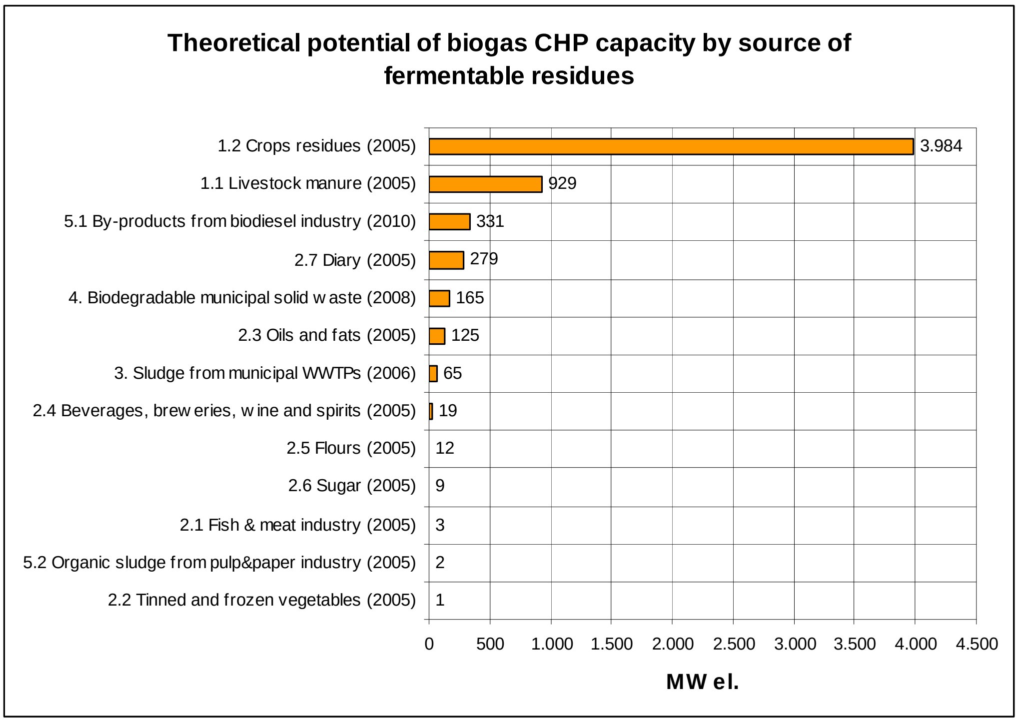
5. Other sources	**1.042**	**6.252.000**	**333**	**2.500.800**	**2.500.800**
5.1 By-products from biodiesel industry (predicted for 2010)	1.036	6.216.000	331	**2.486.400**	**2.486.400**
5.2 Organic sludge from pulp & paper industry (data from 2005)	6	36.000	2	**14.400**	**14.400**
TOTAL - from known fermentable waste sources	**18.511**	**111.068.940**	**5.923**	**44.427.576**	**44.427.576**
Estimated potential from energy crops	**18.511**	**111.068.940**	**5.923**	**44.427.576**	**44.427.576**

The total estimated potential for biogas production from fermentable waste in Romania is estimated to be of: 18.511 mil. Nm3/year of biogas, with 111 TW energy content, which can supply 5923 MW el. installed power, producing 44 TWh el. and other 44 TWh th. net energy.



One important aspect of this estimation is that it represents only the **theoretical available potential** (not always economically feasible). Technical and economical potential will have to be further investigated.

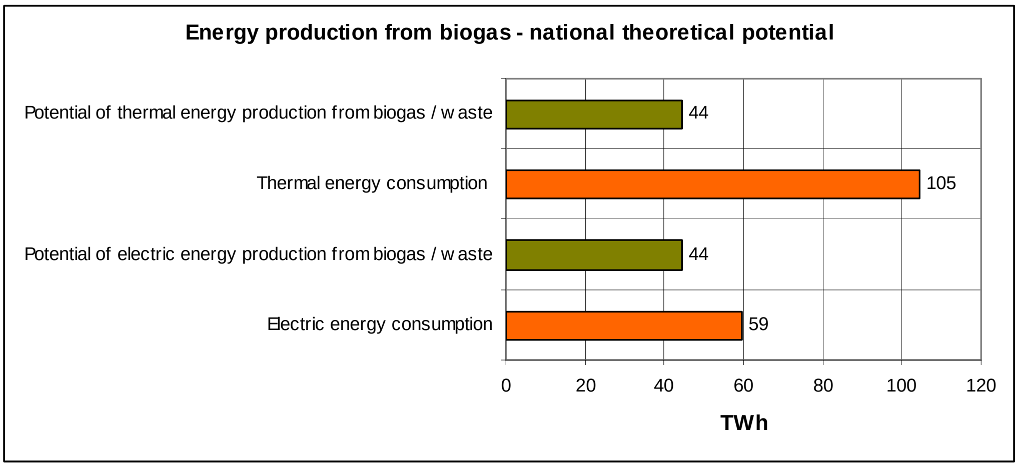
On the other hand, to support the production of biogas from such sources, it is envisaged to use a mixture of different fermentable wastes (as the ones analyzed), as well as various energy crops (like maize silage) – which themselves will add a significant energy value to the existing waste substrates, which we estimate to be as high as the above estimations.



To have a better image on this opportunity – one can take into consideration, as an example – that to add another 5.923 MW of energy crops – maize silage, an arable surface of approx. 2,4 mil. ha. Romania is currently registering approx. 9,5 mil. ha of arable land, but a large proportion of it is poorly utilized or not utilized at all. This makes the opportunity for energy crops – an attractive future investigation for businessmen and scientists.

To have a better image on the significance of the above-estimated figures on the biogas potential in Romania from fermentable residues, we compared the potential CHP installed capacity and energy production on biogas with the existing installed capacity and energy production in Romania. The outcomes are presented below:

	TWh	Percentage of total
Electric energy consumption	59	100%
Potential of electric energy production from biogas / waste	44	75%
Thermal energy consumption	105	100%
Potential of thermal energy production from biogas / waste	44	42%



To have a more realistic image on the significance of the biogas potential based on existing fermentable waste in Romania – we propose below a step-by-step target development, which means – percentage of the theoretical biogas potential used in concrete projects in the future.

How much this potential can contribute to the Romania's renewable energy targets? To answer this question, we used the existing national level targets for renewable energy, detailed in the National Strategy on Energy:

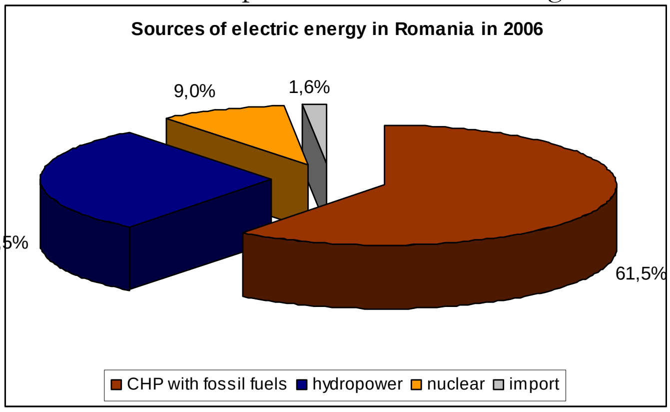
Years	Power consumption	National targets on RES in power consumption		Biogas potential contribution			
	MWh	%	MWh	% of the 2010theoretical biogas potential used in concrete projects	installed MW el. in CHP units	MWh	% of national targets
2010	59.400.000	33%	19.602.000	0,5%	29,6	222.120	1,13
2015	66.900.000	35%	23.415.000	3,0%	177,7	1.332.720	5,69
2020	74.400.000	38%	28.272.000	7,0%	414,6	3.109.680	11,00

The above elaborated calculations are not taking into account the thermal energy contribution of future biogas projects. But as a general indicator – the power production of the biogas based CHPs – indicates a very attractive contribution to the national RES targets, especially considering that this would be based on fermentable waste, in general having a very low cost, compared to fuels or crops.

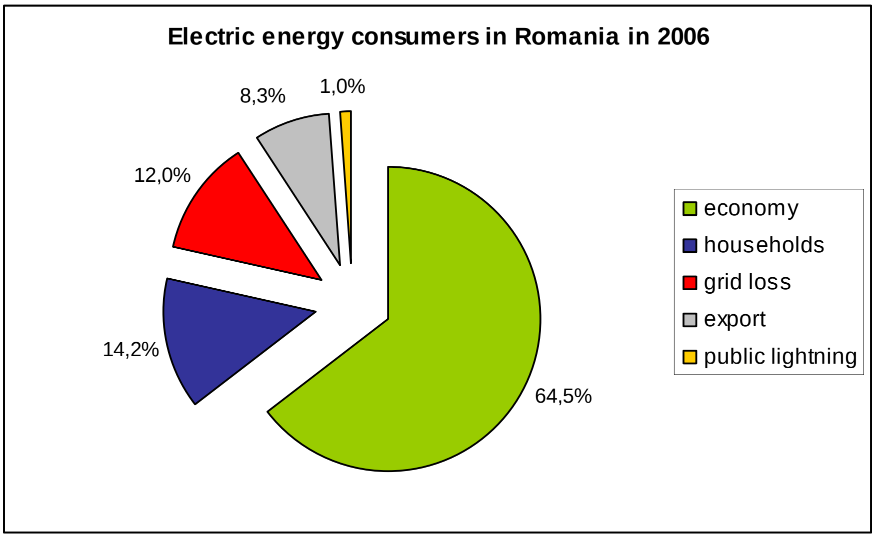
2 Market prices for energy and waste treatment costs

2.1 Introduction

Romania has an important exploitable potential of RES (biomass, micro hydro, solar, wind, geothermal, bio fuels and other resources). The valorisation of RES may offer a long-term competitive advantage, while substantially contributing to sustainable development. While the EU target for 2020 is to achieve 20% of the total Community energy consumption from RES, Romania sets out an even more ambitious goal of 33% as share of electricity produced from renewable energy resources in the national gross electricity consumption until 2010 (35% until 2015 and 38% until 2020). In this view, Romania has to intensify its efforts to use renewable energy resources. Furthermore, the valorisation of renewable energy resources is needed for introducing into the economic system some isolated areas by using the technical potential of the country and to reduce the environmental impact by producing green energy.



The renewable energy resources will be used both in the sector of electricity production and in the heating sector; in the latter both building of new power plants for high efficiency cogeneration (especially based on biomass use) and building of new power plants based on solar and geothermal energy are envisaged, thus leading to an increase of RES-based heat production. The production of bio fuels used in electricity/heat generation will also help to comply with the environmental standards. Moreover, the various locations of renewable energy resources in Romania may lead to a diversification of the energy production capacities/sites and to increasing employment opportunities in less economically developed areas. In this context, new job opportunities can be created locally for the production, installation and maintenance of RES capacities. The valorisation of RES will also significantly contribute to the national technological progress. Producing energy from RES can reduce the burden on existing production capacities using fossil fuels or can be more advantageous than the conventional solution in some punctual situations. Indicative operation investments in upgrading and building new power and heating production capacities by valorisation of



renewable energy sources: biomass, micro hydro, solar, wind, geothermal, bio fuels and other renewable resources.

Improving energy efficiency contributes to the three core objectives of the EU energy policy: security of supply, competitiveness and sustainable development. Actions on energy efficiency will reduce waste of energy resources and will strengthen the security of supply. It is also a cost effective manner to mitigate climate change as energy efficiency improvement/energy saving ultimately leads to the reduction of fossil greenhouse gases emissions. Improving energy efficiency at the end-users envisages specific types of investments in installations/equipments (such as compressed air, pumps, ventilation, process heating and cooling plants, boilers, burners, heat exchangers) of industrial operators in order to achieve energy savings (leading to reduction of the energy bill), based on energy balance.

Investments in installations for their energy consumption reduction at industrial users (switching, adjustment and control automatic systems, and frequency converters, electrical motors with high efficiency, power factor mitigation, and integrated energy consumption management systems) are also envisaged. The main target sectors of these measures are large energy consumers, which have also good premises for development in the near future: metallurgy, construction materials, glass industry, chemical products, food industry, cellulose and paper products, etc. The high share of the energy cost in total production cost justifies the intervention in the above industrial sub-sectors (i.e. about 20% in metallurgy, about 45% in lime and cement industry, about 22% in ceramics industry, 23% in glass industry). Priority will be given to projects coming from these fields.

Where there is an important demand for heat and electricity, high-efficiency co-generation can have considerable benefits for industrial users of power. Benefits include reductions in energy cost, improved security of supply and reduced environmental impact. Co-generation is a key method identified to improve energy efficiency at industrial users. The modernization and expansion of the electricity, natural gas and oil transport grids and of electricity and natural gas distribution grids will lead to a decrease in energy losses, to an increased security of supply by avoiding crisis situations and to meeting the economic performance and quality standards required by electricity consumers. At the same time it will contribute to the development of the standard infrastructure for new economic activities leading, in the future, to increasing Romanian products and services access on the EU market and to fostering the development of cross-border energy interconnections.

Although the focus shall be on the upgrading of the distribution grids, their extension may also be envisaged in order to improve the accessibility of RES – based production capacity, and of all types of energy end-users to the grids. Supporting investments in modernization and expansion of the electricity transmission, natural gas and oil transport and electricity/natural gas distribution grids in the areas most vulnerable to black-outs may contribute to their economic development and to ensuring security of supply.

Priority will be given to projects implemented in these areas. Due to the high contribution of the LCPs under central public authorities' coordination in the total installed capacity of National Power System, as well as to the total electricity production, closing down these power plants because of non-compliance with the environmental standards would have important negative effects: it would induce a power deficit, the energy sector would become less competitive through phasing out these economic operators. Most of those LCPs are either located in mono industrial areas and thus with high unemployment risks, or providing energy for a large number of population in important cities. On top of that, diminishing the production capacity would require a reshaping of transport and distribution networks thus incurring high additional costs.

In accordance with the principle of preventing or reducing pollution at source, it is necessary to introduce best available technologies for the reduction of flue gas emissions, to endow power and heating plants with flue gas desulphurization installations, to install electro filters for reducing powder emissions and to replace existing burners with new ones that will reduce the NOx emissions (NOx being an indirect GHG). At the same time, new investments concerning environmental compliance of some existing power plants are not economically and technically justified without previous refurbishment /upgrading.

An efficient, flexible, safe and clean energy infrastructure is a necessary precondition for economic development as it boosts productivity, and thus competitiveness. More efficient energy production, transport and distribution, and end use, entail the reduction of both primary and final energy. As a direct result, final consumers would benefit from both a better quality and security of supply, implicitly leading to increased productivity. Within its national strategies for energy efficiency and valorisation of renewable energy, Romania's targets are to improve energy efficiency and to increase the share of electricity produced from renewable resources in the national gross electricity consumption. Promoting these targets by using less energy or using more environmental friendly energy, contributes to the reduction of pollutant emissions (especially greenhouse gas emissions) at the level of Romanian economy, in compliance with the recommendations of the Spring 2007 European Council.

The share of electricity produced from renewable energy resources in the national gross electricity consumption was about 29% in 2004, close to the target of 33%, by 2010, but almost entirely in large hydropower plants. Therefore, the gap should be bridged primarily by other renewable sources, in order to avoid a heavy reliance on hydro energy produced in large capacities. To reach the renewable energy targets – it is foreseen a minimum investment amount of 1800 million € before 2015 *(source 9)*.

As indicated in the economic situation analysis, energy intensity is the indicator where Romania has the biggest gap compared to EU average (the final and primary intensity were 3 times higher in 2004 compared to the EU average). Such a gap, if not properly addressed, could be an important impediment for the competitiveness of the national economy on the Single Market and on the South-East Regional Market, taking into account the gradual increase of energy prices, towards the European levels.

For the 2005-2012 period, the estimations show a reduction of energy intensity both as a result of GDP increase and as a result of energy efficiency measures and efficiency improvement by natural trend. At present, the internal electricity production is sufficient for meeting internal demand. It should also be able to meet forecasted demand, on condition that the existing production capacity is maintained at the forecasted levels. The forecasted increase in energy production is generated mainly by the forthcoming entry into service of the nuclear power unit no. 2 at Cernavoda, also by the valorisation of renewable energy sources and, if the case, by refurbishment/ upgrading/rehabilitation of the existing power plants or building new ones on fossil fuels (these last two ones, financed from national funds and/or loans like the program "District Heating2006-2009 - quality and efficiency"34 financed from the state budget and loans, or the follow-up of the "National program for reducing the energy costs for population, by increasing the energy efficiency and use of renewable energy in 2006").

Romanian energy market

Primary Energy consumption in 2004		
Source	Amount (PJ)	Share (%)
Solid fuels	388,4	23,5
Crude oil and petroleum products	432	26,1
Natural gas	583,5	35,3
Nuclear energy	59,9	3,6
Renewables	194	11,7
Electricity balance (import-export)	-4,3	-0,3
Total	1.653,6	100

Energy consumed from RES is mainly represented by small scale hydro-energy (1/3 from total) and by biomass (account for 2/3 of the total). A very small share is represented by geothermal and wind and their share are immeasurable for the moment.

Electricity in 2004 – net installed power and gross production				
Power Plant (PP)	Installed Capacity		Production	
	MW	%	GWh	%
Conventional CHP plants	12.638	64,4	34.421	60,9
Nuclear PP	707	3,6	5.548	9,8
Large hydro PP	5.960	30,4	15.5855	28,1
Small hydro PP (up to 10 MW)	319	1,6	658	1,2
Other RES	~0	~0	~0	~0
Total	19.624	100	56.482	100

(source 2)

The total potential of RES is stated to be 385 PJ for heat (82 % from biomass, 16% from solar energy, 2% from geothermal) and 109 PJ for electricity (75% from wind, 20 % small hydro plants, 5% photovoltaic) *(source 9)*.

Targets for primary RES energy consumption is laid out as 11 % in 2010 and 11,2 % in 2015. The target for electricity from RES production is set at 33 % by 2010 *(source 9)*. Both targets may be regarded as un-ambitious because they were already achieved without any real efforts through contribution of large hydro plants as RES.

Biogas may be used in a gas-engine or boiler at the biogas plant. Biogas can be added to the natural gas network after expensive and comprehensive gas treatment to meet natural gas quality standards. Another option is to supply an isolated network with biogas using a controlled mixture of natural gas and air as back-up. Biogas can also be compressed and used as fuel for public transport (buses).

Raw product gas from pyrolysis and gasification is not suitable for distribution. A consumer of pyrolysis or raw product gas from gasification of waste must therefore be located adjacent to the plant in order to avoid condensation of tarry substances in the pipes. The gas can be used on site, for example in a steam boiler for incineration under controlled conditions. Contrary to pyrolysis gas, cleaned product or synthesis gas can — as for biogas — be distributed several kilometers in separate pipes and used to power an engine or even a gas turbine, but clean-up demands are very strict. Gas clean-up normally results in contaminated wastewater as a by-product, which also needs cleaning or may be returned to the process.

Strict safety measures must be taken if product gas is distributed, due to the high content of carbon monoxide in the product gas. In some cases emissions of nitrogen oxides NOx and unburned hydrocarbons may be a limiting factor depending on local legislation.

Energy in production costs are varying very much, especially thermal energy, less electrical and fuels. Waste treatment costs are very much depending on the market value of the waste, given the fact that some types of organic waste (ex. grain waste fro breweries) are sold as feedstock for farms. The majority of the organic waste in food industry is treated as wastewater and organic sludge. Some companies are treating it inside, in their own WWTP, some others are paying other providers of this type of services to treat (ex. Protan SA).

2.2 Methodology

To gather the entry data for the evaluation of energy and organic waste costs, we used a range of information sources, including:

- other documents and studies (listed in the annex – sources of information)
- a questionnaire – sent to several companies
- telephone and face-to-face interviews with specific companies
- our own experience

The questionnaire has been sent to over 50 companies, mainly from the food industry sector, throughout Romania. Different reasons made that the rate of feedback to be not so high (7 companies answered until the date of this report). These reasons may be: fear of public bad-advertising through issues related to waste management; total lack of interest for biogas; fear for industrial spying activities; etc.

However, the information gathering for the verification / completion of this data – will be continued throughout the PROBIOPOL project.

Answers to the questionnaire:

During November 2007 – March 2008, we have sent over 50 questionnaires to different companies in the agro-food industry in Romania. Different reasons made that the feedback to be quite small, so that only 4 companies replied. The conclusions are found below:

Conclusions	Covalact - Covasna	Danone - Bucuresti	Lujerul - Bucuresti	Agricola - Bacau	Avicola Bucuresti	United Romanian Breweries Bereprod (Tuborg) Bucuresti	Apa Grup Botosani
Industry	Milk and milk products	Milk products	Flour & bakery	Meat & meat products	Egs and chicken	Beer and juice	Municipal wastewater treatment
Consumption of electric energy (MWh el./year)	2.690 MWh el.	10.000 MWh el.	2.500 MWh el.	44.638 MWh el.	1.800 MWh el.	18.455 MWh el.	7.400 MWh el.
Cost of electric energy (eur/MWh el. and total)	98 eur/MWh el.	69 eur/MWh el.	?	88 eur/MWh el.	125 eur / MWh el.	?	91 eur / MWh el.
Consumption of thermal energy (MWh th./year)	20.611 MWh th.	16.000 MWh th.	2.900 MWh th.	80.853 MWh th.	2.552 MWh th.	47.138 MWh th.	910 MWh th.
Cost of thermal energy (eur/MWh th. and total)	25 eur/MWh th.	26 eur/MWh th.	?	35 eur/MWh th.	36 eur / MWh th.	?	26 eur / MWh th.
Consumption of cooling energy (MWh/year)	535 MWh	?	?	8.829 MWh	-	?	-
Cost of cooling energy (eur/MWh and total)	133 eur/MWh; 0,07 mil. eur/year	?	?	64 eur/MWh; 0,56 mil. eur/year	-	?	-
Amount of solid waste and sludge (per year)	376 m³ sludge and 41.395 hl whey	1100 t/year sludge; 800 t/year grease	?	9.135 t from slaughter house; 10.400 m³ sludge and grease from pre-WWTP; 61.000 t poultry and pig manure	720 t solid waste; egs shells; 22 t dead chicken; 21 t waste from incubation	28.134 t/year fermentation grains from beer production	50 m³ sludge/day; 18.250 m³ sludge/year
Cost of solid waste and sludge (eur/m³ and total)	33 eur/m³ sludge; 12.400 eur/year	25 eur/t sludge; 220 eur/t grease; together = 0,45 mil. eur/year	?	-	?	?	-
Amount of wastewater (m³/year)	104.000 m³/year	200.000 m³/year	18.000 m³/year	801.202 m³/year	5.840 m³/year	600.000 m³/year	-

Cost of wastewater (eur/m³ and total)	0,3 eur/ m³; 31.200 eur/year	0,97 eur/ m³; 0,19 mil. eur/year	0,64 eur/ m³; 11.500 eur/year	-	?	?	-
Attitude towards biogas technology	They do not know much about it	Interested but affraid of odour problems	Affraid of odour problems	Very positive; they already started to evaluate this opportunity	Feasible for covering part of their energy needs	They know about it; in 2008 they will install a small generator using the biogas from the wastewater treatment plant	Positive; they already use biogas from fermentation of primary sludge to heat the officies and fermentation tanks; in the future – they want to get a CHP unit

- The fuel for thermal energy consumption is predominantly natural gas. The use of thermal energy is for production steam, for warmwater and for heating of production halls and offices; predominantly is the production of thermal energy through their own plants (no cogeneration).

- The cooling systems are predominantly based on electric solutions.

- The electric consumption is relatively uniform during the seasons, while the thermal consumption is much higher during trimesters I and IV.

- The organic waste is predominantly sent for treatment to specialized companies.

- A major part of organic by-products (e.g. fermentation grains from beer production) has a good market value as fedstock for animals.

- The wastewaters with high organic content have, predominantly, a neutral pH.

2.3 Costs and revenues for electrical energy

It is possible to produce electricity from biogas and thermal waste treatment processes but reliable consumers with a known demand are required. Power generation can have a large impact on plant economics but this depends on tariff structures, possible subsidies, contracts for the supply of electricity to a consumer or the public power utility/ distribution company/power procurer. Electric power production can normally be sold to the public grid, but the price, which can be obtained, depends largely on political criteria.

The power procurer is responsible for ensuring a power production meeting the power needs of a geographic area. Any contract for the supply of electricity will be arranged through negotiations with this body meaning that a competitive electricity market will exist. The price for electricity under this regime will tend towards the lowest possible price, thus encouraging only the most modern and efficient generation methods. The pool price for electricity is presently often in the range of **EUR 25–35/MWh**. This price will serve as a benchmark for the negotiations. If power can be sold directly to a consumer or in countries, where non-fossil fuel utilization (e.g. biogas) is subsidized, a payment of around EUR 50/MWh may be achieved.

The potential revenue from sales of electricity from a treatment plant ranges typically from EUR 15 to 25 per tons of waste, based on a net electric efficiency of 20 % and a lower calorific value of 10 MJ/kg. Compared with a gate fee of say EUR 40 per tons for a modern WTE facility, the significance of this revenue source to the facility is apparent. The grid connection costs depend largely on the actual site location and whether the size of the plant fits the conditions and capacity of the present grid.

Costs are varying from region to region, from consumer to consumer (large consumers are negotiating their prices), depending on electricity characteristics (night tariffs, different voltage tariffs, etc.). But – in general – these costs are much easier to know and analyze than for thermal energy. Revenues from electricity production are based on the market prices established freely by the energy bourse (Opcom SA).

According to EUROSTAT, Romania has registered in 2007 one of the lowest price levels for electric energy and natural gas in the European Union.

The reference price for the natural gas supplied to industrial users in Romania was 7,31 eur/GJ (10th place in Europe). The lowest prices were in Estonia - 3,69 eur, followed by Bulgaria - 5,21 eur, Latvia - 5,29 eur, Denmark - 5,76 eur and Lithuania - 6,02 euro/GJ. The highest prices were in Germany - 12,15 eur, Sweden - 11,05 eur, UK - 10,55 eur, Luxemburg - 9,85 eur and Hungary - 9,47 eur/GJ.

For electricity supplied to industrial consumers, Romania has registered in 2007 a reference level of 0,0842 eur/kWh. The lowest prices were in Latvia - 0,0443 eur, Bulgaria - 0,0465 eur, Estonia - 0,0534 eur, France - 0,0541 eur, Lithuania - 0,0548 eur, Denmark - 0,0638 eur, Greece - 0,0698 eur/kWh, while the highest – in Ireland - 0,1125 eur, Italy - 0,1027 eur, Cyprus - 0,1048 eur and Luxemburg - 0,0963 eur/kWh.

This data makes plausible a future increase of the energy prices in Romania, due to European market average price levels and the inter-connectivity of this market.

2.4 The green electricity supporting system in Romania

A **mandatory quota system** combined with the **system of trade with Green Certificates (GC)** has been adopted. The legislation in this field was updated in November 2008, through Law 220/2008 regarding *The Establishment of a System to Promote the Production of Renewably Generated Electricity.*

Generally, electricity suppliers must demonstrate a proportion (5,26% in 2008, increasing each year and reaching 16,8% by 2020) of renewable electricity in their portfolio of supplied electricity through the ownership of Green Certificates bought from RES producers together with renewable electricity.

Green Certificates are issued only for units operated or refurbished from 2004 onwards and which produce electricity from renewable energy sources (hydropower plants only >10 MW installed capacity).

Any electricity supplier that fails to cover the annual share of renewable electricity on its total domestic supply must pay a penalty (calculated as the value of the missing share of renewable electricity). If at the end of the year the RES Electricity producer didn't sell the GC, the OPCOM is obliged to acquire it with the minimum price established for that year. The final destination of the collected penalty money is designated to RES producers for investments necessary to promote the use of RES. The system is defined until 2020.

According to the new legal framework, the number of Green Certificates (GC) to subsidies the renewable electricity production from biogas is of 3 GC/MWh, issued for a period of 15 years, as long as the investment is done with new equipments.

The price for one GC on the Romanian market will be in a range of 27 – 55 eur / GC for the period 2008 – 2014, while the minimum price after 2014 will be at least the minimum one in 2014.

Law 220/2008 also supports specific grid access measures for renewable projects, through investment subsidies and fiscal subsidies. The exact rules will be published around February – March 2009. Such supporting measures will be:

- Co-participation with 50% of Transelectrica 50% to the grid connection costs
- Governmental guaranty for 50% of the loans required by the investment
- Public funds involved in access roads improvement
- Reduction of fiscal taxes on profit for the first 3 years
- Fiscal incentives for jobs created

The amount of electricity that entered the **GC trading scheme** in 2005 was 7,608 MWh (0.012 % of gross production) so the required RES share of 0.7 % on supplied electricity was not achieved. This situation is foreseen to continue many years ahead, which will engender most of the time – a maximum level for the Green Certificates prices (55 eur).

Production of renewable energy from biogas is one issue which might rely on three public funding sources:

- The Sector Operational Program – Increasing Economic Competitiveness, measure 4.2: "*Use of renewable sources for the production of green energy*" (see more on http://oie.minind.ro/)

- The Rural Development Program – measure 1.2.1: "*Modernization of Farms*" (see more on www.apdrp.ro)

- The National Environmental Fund – see more on www.afm.ro

Support in the form of **grants, loans** and a mix of these two is accessible also for businesses. Unfortunately disbursement is done after the expenditure have occurred, which may make it difficult for some beneficiaries such as local public authorities and SMEs to secure project cash flow.

Another relevant aspect to be discussed is the policy promoting the utilization of transport biofuels (including bio-methane) and fuels from other renewable sources (such as biogas). **Specific objectives have been established for their utilization through Law 1844/2005**: thus for 2005-level a 2% of the content of all transport fuels shall be represented by biofuels. This share shall increase to 5,75%.

Main stakeholders

- **ANRE –** National Authority for Regulation of Electricity
- **OPCOM –** Operator of Centralized Electricity Market and Green Certificates Market
- **TRANSELECTRICA –** Operator of Transportation Grid
- **ELECTRICA (Romania), EON (Germany), CEZ (Czech Republic), ENEL (Italy) –** Operators of Regional Distribution Grids

In Romania the legal framework established that operators of the networks (transportation and distribution grids) must guarantee the connection transport and distribution of electricity from RES. Since almost all electricity from RES is supplied by large companies owning large hydro power plants, and because small private RES electricity producers are very few, there have not been many examples of application of this principle. Yet examples of some private ventures (wind and photovoltaic) have shown that there were no problems with the connection to the electrical grid and distribution towards clients.

In what concerns the national electricity market, this is composed of two different trading schemes:

a. Centralized Day Ahead Market – managed by OPCOM, which establishes a Daily Reference Tariff for transactions. Usually, en-gross quantities are bargaining.

b. Free Electricity Market – based on bilateral contracts. The energy is bargained under en-gross or en-detail forms.

The policy of central authorities is to reduce the share of Centralized Electricity Market, contributing thus to the development of Free Electricity Market.

The average tariff for trading the electricity on the Day-Ahead-Market was in 2008 around 160 RON/MWh**.**

Large industrial consumers) are negotiating their electricity tariffs with the local distributors. In this way, they could pay 70 EUR/MWh if they have a 110 kV connection, with their own transformer internal station, (e.g. European Drinks and Foods, Bihor County, or Danone Bucharest), or 88,5 EUR/MWh for a direct 20 KV connection (e.g. Agricola International, Bacau County).

Main aspects regarding the transportation/distribution grids

The **transport grid** is managed by TRANSELECTRICA, a state-owned operator. The main transportation lines are of 220 KV and 400 KV and are in general of good conditions. The degree of covering is a good one.

The **distribution grid** is more important for the electricity produced through biogas projects; this is handled by several regional companies:
1. **Electrica:** the state owned operator (going to be privatized) covering the following regions – Transilvania Sud, Transilvania Nord, Muntenia Nord
2. **EON Romania:** German Operator covering the Moldova Region
3. **ENEL Romania:** Italian operator covering Dobrogea, Banat and Muntenia Sud regions
4. **CEZ Romania:** Czech operator covering Oltenia region.
Generally the distribution grid is in a good shape. Locally, there are cases of unsuitable location (damaged lines, obsolete transformators, etc.). This kind of situation can be avoided through a consistent preliminary study.

B. Green Certificates (GC) Market

a. Centralized/Regulated GC Market – managed by OPCOM and TRANSELECTRICA

b. Free GC Market – based on bilateral contracts.

Currently, the Centralized GC Market is highly developed comparing with the Free GC Market, but the trend is to change this situation.

Regarding the permits required for biogas investments, even if there are not concrete administrative barriers, it cannot be said that the necessary permitting procedures are simple and rapid. Nevertheless, there have been two positive steps made in Romania, which are about to contribute to the development of RES electricity investments:

- the establishment of unique permitting bureau (CAT) within the City Halls, and
- cutting half of the period needed to execute authorization or licenses for RES.

The main authorization/permits probably required for biogas projects:

- Land Planning Certificate
- Fire protection permit
- Health protection permit
- Gas handling permit
- Environmental Permit
- Construction Permit
- Electricity Production Location Permit
- Grid Connection Permit
- Power Producer Operation Authorization
- E-RES Producer License

2.5 Costs and revenues for thermal energy

Heat energy is used in industrial applications both for heating production halls and offices, and for producing steam for production. The proportion between heating and steam is very much depending on each company; large steam consumptions are registered by companies in the food industry and beverage.

Variability along the year is especially the case of breweries and beverage companies, due to the steam production costs. Little variance (3-5%) between seasons is registered in diary and meat products industries, except the space heating requirements.

Thermal energy costs are very much depending on the type of fuel used (heavy oil, natural gas, wood, etc.) and the heating system (with/without hot water from the central network, efficiency of the boiler, etc.). An indicative range for industrial consumers is **25 – 35 EUR/MWh** (or 20 – 30 EUR/Gcal) for the thermal energy.

District heating

The market for heat is dependent on housing and/or industries, which can be connected to a district heating system. The economic viability of a district heating project is dependent on the location, the distance from the incinerator to the consumers, tariff structures and the heat prices of the actual market. Depending on location, housing for 20 000 people and office complexes and shops with 15–18 000 employees could represent a heat market of more than 100.000 MWh per year.

District heating may be a main product, provided that there is a sufficient heat market and an existing district-heating scheme. For new plants it is necessary to establish a district heating network, central peak load and back-up boilers. Existing supply with natural gas may inhibit the development of a district-heating scheme. If a new district-heating network has to be established the income from selling heat to the network is normally very low due to the capital cost for the network.

District heating temperatures are normally 90/45°C flow and return temperature in winter and 70/50°C during summer. District heating can also drive absorption chilling machines for cooling purposes during summer months or for industrial use and cold stores (not freezing). Waste heat in excess of demand, for example, in the summer, must be discharged using a nearby water stream or air-cooled coils. Waste heat may to some extend also be used to dry incoming waste, for example, sewage sludge, in cases where the moisture content is high.

Steam for process heating

Dry saturated steam can be supplied to a nearby industry as process heating provided that there is a market. Steam is normally needed at 6–10 bar and cannot be transported over longer distances due to pressure loss in the piping system. If condensate is not returned it implies a cost for water treatment for the make-up water. Returned condensate may contain harmful impurities for the steam cycle. It should be noted that steam supply to an external user results in a reduction of the electricity output from the turbine, especially in the case of condensing turbines. The potential outputs should therefore be balanced carefully in order to maximize the plant's revenue from sales of energy. The value of steam for process heating is typically negotiated with each customer and is therefore less quantifiable than the value of, for example, electricity.

Cooling technologies are utilized on large scale in the food industries, as well as for offices and homes air conditioning. The large majority of energy consumption for cooling in Romania is electrical power, while the absorption cooling (tri-generation) is only used occasionally by some companies in food industry.

2.6 Waste treatment costs and revenues

Waste Management system improvements will have tariff implications for end-users. The precise impacts upon user tariffs throughout the region must be determined through feasibility studies for specific projects and investment programs (with due consideration for characteristics of specific sites of treatment/landfill facilities and transfer stations where applicable).

Specific future user tariffs to be applied throughout the region are a function of a number of factors, including but not limited to the following:

- existing cost structures of service providers;
- level of existing tariffs applied throughout the region and adequacy of existing tariffs to fully cover costs (both O&M and investments);
- waste characteristics within specific service areas and distribution of waste generated/collected between households and non-households;
- depreciation costs of all existing assets and proposed investments;
- annual asset replacement needs (i.e. useful remaining lives of existing assets);
- financing structure for new assets and level of existing debt service costs within the systems;
- user payment performance (bad debt levels, and timeliness of user payments);
- detailed investment plans (accurate costing of all investment components, based on specific sites of facilities and fully cost considering foreign/local split, contingencies, inflation etc);
- detailed operating costs taking as a point of reference the existing cost structure and adjusting for impacts from proposed investments and operational/procedural changes;

It can be expected that a degree of variation in tariffs will be seen throughout the region as service providers face varying cost structures (particularly with regard to local collection activities for which costs will vary depending on collection methods used, density of population, frequency of collection, transport distances to landfill etc).

According to waste management industry standards, the acceptable affordability threshold for waste management services is approximately 1,5% of average household income levels – i.e. monthly waste management costs for an average household should not exceed 1,5% of household monthly income levels (where costs should cover the entire cycle of waste services – collection, transport, sorting, treatment and disposal).

For companies, in Region 1, the prices for waste collection and treatment are between 20 – 43 RON/m^3. For population – average of 2,8 RON/person/month.

Unit costs in Urban and Rural areas, for waste management (€/ton)

Waste Management Unit	Urban	
	Investment (€/ton year)	**O&M (€/ton)**

Landfill	9,30	3,00
Composting facility	33,63	28,11
Incinerator	60,00	50,00
Sorting facility	20,48	30,72
Bio-mechanical treatment unit with Refuse-Derived Fuel (RDF)	22,31	32,02
Transfer station	0,16	2,53
Bulk haulage from transfer - Biodegradable	1,05	1,63
Collection of biodegradable waste from households	0,74	3,00

Although send questionnaires were requested such data and unit measures, the responses doesn't reflect totally the reality but we hope the next situation will be better. This is the first questionnaire and taking account of this we consider that it's necessary economic agents accustom to this kind of job to collaborate better with the stakeholders for filling these questionnaires. In this way the future questionnaires and the future data base will be more complete.

As sludge management cost are mainly supported by water consumers through the water bill, we estimated the maximum weight of sludge management costs compared to overall water management costs (water treatment, production and delivering).

To calculate the maximum relative weight of sludge management cost, we made the following assumptions:

(1) Sludge management costs include all internal costs after dehydration

(2) The maximum internal cost of sludge management corresponds to a situation where all sludge production is incinerated

(3) 1 tDM corresponds to a water consumption of 2.700 m3 (based on an average water consumption of 150 l/PE/day and an average sludge production of 55 gDM/PE/day)

(4) Overall water management costs are equal to the total water service price (full cost recovery principle).

Following previous assumptions, the relative weight of sludge management is as follows:

Part of water cost	**Costs**	**Relative weight (% of total water management costs)**
Sludge management	0,12 (0,10 … 0,13) Euro/m3	7% (3% … 14%)
	318 (262 … 344) Euro/t d.m.	

Water treatment	0,87 Euro/m3	40%
Total water service cost	2,2 (0,8 … 3,0) Euro/m3	100%
Comparison of maximum sludge management costs with overall water management cost (average EU 15, Source: OECD, The Price of Water; Trends in OECD Countries; 1999)		

This table shows that even if sludge management can involve high costs (particularly when all sludge is incinerated) these costs represent an average proportion of only 6% of the total cost water service (including water production, and treatment).

The use of natural fertilizers in agriculture in Romania is a general characteristic (around 17 ml. tonss are used annually for fertilization). In comparison, only 450.000 tonss of chemical fertilizers are used annually. This makes the utilization of biogas slurry in agriculture particularly feasible.

2.7 Conclusions

It was a premiere for Romania (for the last 50 years) that in 2006 - 2007 the GDP growth was decoupled from the raw energy consumption growth, mainly due to the increase of services but also to the increase of energy efficiency within the economy.

The costs for electrical and thermal energy, as well as for production steam and cooling – have continuously raised in the past 20 years (and especially in the last 2 years), as result of the international price increase to fossil fuels (natural gas and oil in particular).

The Romanian industry has been affected by this cost increase as result of the extensive use of fossil fuels. Although there are some cases where industrial companies have started to use biomass (especially sawdust or other wood waste for boilers) or other sources of renewable energy, the vast majority of the industry is based on fossil fuels.

Regarding the source of energy production, the Romanian industry is relying predominantly on the public power grid for supplying with electricity. For the thermal energy – most medium and large companies are using their own plant, operated with natural gas and/or fossil oil.

Regarding co(poly)generation, there is a very little experience within the Romanian industrial companies, excepting the large power plants, owned by municipalities or large energy service operators.

The cost range for energy can be considered to be pretty uniform for electricity (an average of **90 – 95 Euro/MWh el**.), with lower unitary tariffs for large consumers. The costs of thermal energy is much more variable, given the diversity of thermal plants used, types of fuels, efficiency, amount of gas/oil purchased, etc. An average cost for thermal energy could be considered as approx. **30 Euro/MWh th**.

As regarding the waste treatment costs – these are also depending on very many variables, given the types of waste, degree of mixture with other types, amounts, humidity, content of hazardous substances, etc. The usual case for industrial companies producing fermentable waste, is the use of an internal pre-treatment plant for wastewater and the contracting of a specialized company for the sludge treatment (with costs of 25 – 35 eur/t). Agricultural companies (large farms) usually have their internal system for sludge use, as direct fertilizer on the fields. As for solid wastes, these are usually taken by specialized contracted companies, with costs ranging from 20 – 250 eur/t (depending on the degree of hazardousness).

There are many cases, however, when the organic waste is actually a by-product, which is marketed as raw material or feedstock for animals, and is not bringing additional costs, but additional income. This case is valid for example – for breweries.

- Law No. 13/2007 – law of electricity
- ANRE Order No. 3/2007 – approving the Methodology for establishment of electricity distribution tariff, others than the main distribution operators
- Governmental Decision No. 1535/2003 – approving the Strategy for Capitalization of RES
- Governmental Decision No. 540/2004 – approving the Regulation for attune licenses and permits in electricity sector
- Governmental Decision No. 1844/2005 – promoting utilization of bio-fuels and other fuels from renewable sources.

3 Annex

3.1 Relevant information sources and legislation

1. ECSSD Environmentally and Socially Sustainable Development Working Paper No. 39 - ROMANIAN FOOD AND AGRICULTURE FROM A EUROPEAN PERSPECTIVE (June 2005) - Csaba Csaki, Holger Kray

2. National Institute of Statistics - Romanian Statistical Yearbook (2006)

3. IEE Programme funded project – OPTIPOLYGEN – Technical Potential for polygeneration in the Food Industry (Work Package 2 Report)

4. IEE Programme funded project – OPTIPOLYGEN - Technical issues on the Polygeneration application (Work Package 3 Report)

5. Report on state of Wastewater Sludge EC Directive implementation

6. Regional Waste Management Plans (the 8 of them).

7. European IPPC Bureau – BAT and BREF documents

8. EUROSTAT statistical data-base

9. Romanian Energy Strategy 2007 – 2020 (draft version from July 2007)

10. Romanian Strategy on Energy Efficiency (2003)

Romania has adopted a comprehensive legislation that supports renewable energy:

- **Law 220/2008 - Establishing a System to Promote the Production of Renewably Generated Electricity**
- Governmental Decision No. 443/2003 – promoting of RES electricity production

- Governmental Decision No. 867/2003 – approving the Regulation on connection of users to public electricity networks
- Governmental Decision No. 1429/2004 – approving the Regulation for certification of RES electricity sources
- Governmental Decision No. 1892/2004 – establishing the system of promoting the RES electricity
- ANRE Order No. 43/2004 – approving the Framework-Contract for electricity distribution
- Governmental Decision No. 958/2005 – modifying Governmental Decision No. 443/2003
- ANRE Order No. 22/2006 – approving the Regulation regarding organizing and functioning of Green Certificates Market
- ANRE Order No. 38/2006 – approving the Regulation regarding monitoring of Green Certificates Market
- ANRE Order No. 39/2006 – approving the Regulation regarding certification of priority production of RES electricity
- ANRE Order No. 45/2006 - approving the Regulation regarding establishment of connection solution for public electricity networks users

3.2 Compost and sludge use in agriculture

Directive 86/278/CCE regarding environment protection and in particular soils when sewage sludge is used in agriculture was transposed through Ministerial Order no. 344/2004 regarding environment protection and in particular soils when sewage sludge is used in agriculture.

The objectives of Directive are:

* regulating the use of sewage sludge in agriculture in such a way as to prevent harmful effects on soil, vegetation, animals and man, thereby encouraging the correct use of such sewage sludge.

* establish the values for concentration of heavy metal (cadmium, cooper, nickel, lead, zinc, mercury) in sludge and soil. The use of sludge is prohibit where the concentration of one or more heavy metals in the soil exceeds the limit values.

* encourage use of sewage sludge in agriculture in conditions of right utilization taking account of quality of soils and agriculture production to be not affected.

* limit the quantities of heavy metals in crop soil regulating of maximum quantities of sludge per year or taking account of limit values for quantities of heavy metals from used sludge do not exceed limit values for quantities of heavy metals which may be added annually into soil, based on a ten year average value.

* establish obligation that sludge must be treated before being used in agriculture. It may be authorizing, under conditions to be laid down by them, the use of untreated sludge if it is injected or worked into the soil;

* the used of sludge must be done guarantying the protection of soil, surface and ground waters.

* the need of control of sludge and soil qualities for making the analyzing them.

The purpose of Minister Order no 344/2004 are to use the agrochemicals potential of the sewage sludge, prevention and decrease the harmful effects on soil, waters, vegetation, animals and people, encouraging in this way the correct use of such sewage sludge.

This Order establishes:

* the values for concentration of heavy metal (cadmium, cooper, nickel, lead, zinc, mercury) in soil when the sludge are used, the values for concentrations of heavy metals in sludge and the annual maximum quantities of heavy metal used in agriculture soils.

* the use of sludge is prohibit where the concentration of one or more heavy metals in the soil exceeds the limit values and measures for assurance that these limit are not exceed.

* regulating the use of sludge in such way that the accumulation of heavy metals in soils do not exceed the limit values of heavy metals in soils. In this way are established: the maximum quantities of sludge expressed in tonss of dry matter which may be applied to the soil per unit of area per year while observing the limit values for heavy metal concentration in sludge. It's necessary to respect limit values for the quantities of metals introduced into the soil per unit of area and unit of time.

* sludge must be treated before being used in agriculture.

* sludge generators of sewage sludge must provide to the users all information.

* prohibit the use of sludge or the supply of sludge for use on:

- grassland or forage crops in certain
- soil in which fruit and vegetable crops are growing
- ground intended for the cultivation of fruit and vegetable crops which are normally in direct contact with the soil

* sewage sludge users must used in such a way that account is taken of the nutrient needs of the plants and that the quality of the soil and of the surface and ground water is not impaired,

* up-to-date records are kept, which register the quantities of sludge produced, composition and properties of the sludge, the type of treatment carried out, and the names and addresses of the recipients of the sludge and the place where the sludge is to be used.

* cooperation between stakeholders, sewage sludge producers and users regarding treatment of residual water, waste management and agriculture for purpose of this order.

Regarding Ministerial Order no 344/2004 *the responsibilities of sludge generators and users are:*

1) inform the local environmental authority and sludge users about the potential harmful elements present in the sludge.

2) identify the sludge user and the land (including the sensitive lands) which meet the requirements necessary for sludge spreading, according to the pedological studies carried out at the producer's request by OSPA (the Territorial Offices for pedological and agrochemical studies).

3) contact the sludge users and evaluate the possibilities for the sludge to be used

4) assure the transport and the spreading of sludge

5) inform the local environmental authority when the conditions initially stipulated in the spreading authorization are not complied with, when the land has been changed or the sludge has been refused by the user

6) choose the optimal method of sludge disposal when the sludge is not proper for spreading or there are not lands fit for spreading

7) keep up-to-date records, which register:

- a) quantities of sludge produced and quantities of sludge used in agriculture
- b) composition and characteristics of sludge
- c) type of sludge treatment applied
- d) the names and locations of sludge users and the places for sludge spreading

8) release data kept in the records at the request of the authorities

9) carry out the specific agrochemical study for the control and monitoring of the soil after spreading.

In order to obtain the permit for sludge spread, the sludge generators must transmit to the local authority at least one month before spreading data about:

- a) quantities of generated sludge and sludge delivered for agricultural use
- b) sludge composition and characteristics in accordance with data in the present order.
- c) the type of sludge treatment applied
- d) sludge users identification data
- e) data regarding the location of the land where the sludge is going to be spread
- f) the probable time when the sludge is going to be spread
- g) the type of crops

The quality, quantity, transport, spreading on the land is the responsibility of the sludge producer, including its effects on the environment and human health after spreading.

The required quality of sludge – as fertilizer in agriculture:

Characteristics - sludge composition	Minimal	Maximal
Dry Matter– organic composition	1	730
Calorific values	4	12
Agronomic parameters	4	4

Heavy metals	2	12
Organic components	No data	No data
Pathogen agents	2	2
PH	5,62	7,5
Humidity %	30	96
Ash	No data	No data
Organic substances	42	4.500
Inorganic substances	47	5.500
Organic matter mg/kg dry matter	10,35	5.500
Inorganic matter mg/kg dry matter	10	4.500
Total sulphur mg/kg dry matter	No data	No data
Total Nitrogen mg/kg dry matter	2,09	19,700
Phosphorus mg/kg dry matter	0,266	19.213
Aluminum mg/kg dry matter	No data	No data
Silicon mg/kg dry matter	No data	No data
Calcium g/kg dry matter	5,7	36.507
Iron mg/kg dry matter	No data	No data
Manganese mg/kg dry matter	6,3	340
Magnesium mg/kg dry matter	0,3	63.153
Cadmium mg/kg dry matter 10	1,96	3,8
Lead mg/kg dry matter 300	0,12	413,56
Cooper mg/kg dry matter 500	0,35	494,55
Arsenic mg/kg dry matter	No data	No data
Chromium mg/kg dry matter 500	0,47	349
Mercury mg/kg dry matter 5	No data	No data
Nickel mg/kg dry matter 100	22,61	97,97
Zinc mg/kg dry matter 2000	6,8	648,01
Fluorine mg/kg dry matter	No data	No data
Chlorine mg/kg dry matter	No data	No data
Silicon mg/kg dry matter	No data	No data
Minimal Calorific power kcal/kg	No data	No data
Maximal calorific power kcal/k	No data	No data
AOX 500	No data	No data
PAH 5	No data	No data

PCB 0.8	No data	No data
Dioxins mg/kg dry matter	No data	No data

The EU Directive no. 86/278/EEC on environment protection and in particular of the soil, when sewage sludge from the waste water treatment plants is used in agriculture has been adopted through a Common Ministerial Order of the Ministry of Environment and Water Management and Ministry of the Agriculture, Forests and Rural Development no. 344/708/2004 on approving the technical norms for environment protection and in particular of the soil, when sewage sludge is used in agriculture *(Official Journal no.959 of 19.10.2004).*

Compost from anaerobic digestion

Compost quality

Compost of high quality can be produced by simple technology whereas good process management eliminates problems with malodour, handling properties, weeds or pathogens. A consistently good source separation of BMW and the use of paper bags, and/or buckets eliminate problems with visible impurities, heavy metals or organic pollutants (e.g., the plastic softener DEHP).

Choice of composting plant type is mainly governed by the need to avoid potential odour and vector problems, the limitations in the size of the available area, and the desire to treat an expanding range of waste types in the future. The most efficient/quickest elimination of pathogens is normally achieved with forced aeration treatment.

Compost has to be used in the right amount at the right time of year depending upon the type of compost and application area. Characteristics such as degree of stability and electrical conductivity are very important in determining possible areas of application.

Future estimates of waste quantities and the area needed for compost storage are very often underestimated. Good process management is very difficult under these conditions and most often result in low quality compost and loss of market share. A single batch of bad compost can have a long-lasting devastating effect on the reputation of a plant and should be disposed of.

Compost marketing

The vast majority of composting plants are not actively marketing their products compared with, for example, companies marketing phosphorous fertilisers or peat. Marketing towards the agricultural and horticultural sectors (including private gardens) requires knowledge of plant growing requirements as well as an understanding of the needs of the different sectors.

Quality declarations must be comparable with those of competing products. Additional information regarding application etc., is necessary and the specific advantages of compost over other products should be pointed out such as:

- a high content of beneficial micro-organisms (for improved top soil structure, inhibition of plant diseases, furthering of mycorrhiza);
- a source of stable humus;
- no weeds;
- a liming effect and a slow release nitrogen fertiliser effect.

The fibres produced by many anaerobic digestion processes differ from compost in three ways:

- the content of ammonia-nitrogen is high;
- the degree of stability is low;
- only a few species of micro-organisms are present.

The fibres are best suited for agricultural usage, while a post-treatment composting stage is needed for general marketing in other sectors. Knowledge concerning the seasons for compost application and focusing on possible terms of delivery is important for the timing of campaigns. A marketing plan must include some degree of personal contact between the composting plant's agronomist and the compost users. The agricultural market is very important in regions where there is a large and rapidly expanding production of compost. The highest possible nutrient content of the compost is normative for its value within this market. Compost low in nutrients, e.g., pure garden waste compost, is very well suited for the landscaping sector and for all sectors using compost as mulch. The demand for garden waste compost is substantial within metropolitan areas and for infrastructure constructions (e.g. vegetated areas, road verges).

Agriculture and forestry

The agricultural sector is a very large market paying low prices. The sector may be willing to pay for the nutrients available in compost if there is no surplus animal manure available in the neighboring area. Organic agriculture often pays more for compost products as compared with high-input agriculture. The nutrient content of composted BMW can be high thus paying for transportation to and application on farmland up to 20–40 km away. Farmers only apply the compost for a short period during both spring and autumn, which is a key consideration when developing a production and marketing plan for a plant.

Organic farming is dependent upon supplementary phosphorous and potassium nutrients from external sources, especially when growing vegetables or if the farm is non (animal) husbandry. Within the agricultural sector, organic farming will pay the highest price for compost (assuming that local supplies of manure are insufficient). The agricultural market is sensitive towards public media discussions, and vegetable growers are often not allowed to use composted BMW due to the food producer's fear of negative consumer reactions. The establishment and maintenance of good connections with the farmers associations and the food producers is therefore recommended. The importance of continuously documenting low heavy metal content and pathogen inactivation cannot be underestimated.

A declaration targeted at the agricultural sector should comprise information about N-total, ammonia-N, nitrate-N, N-available 1. yr. (Spring, Autumn-application), P-total, K-total, Mg-total, S-total, liming effect (as $CaCO_3$ or CaO), pH, organic matter, dry matter, volume weight, visible impurities, heavy metals, possible organic pollutants, sanitary treatment and compliance with the content of possible indicator micro-organisms. Nutrient content should be stated in kg/tonne fresh weight compost. For most uses within agriculture a fairly fresh compost is preferable to a very stable compost, since the latter has a lower content of available nitrogen. the user guidelines, i.e. directions for application, should deal with the permitted amounts according to present fertilisation legislation (e.g., max 170 kg N-total per hectare per year). They should also deal with application methods and crops on the area with respect to sanitary treatment/level of indicator micro-organisms. It should be noted that the fibres produced by many anaerobic digestion processes are best applied before sowing and should be lightly worked into the topsoil. If left on the surface, a substantial part of the plant available nitrogen will evaporate due to a high content of ammonia and a high pH-value.

Forestry is defined as the commercial growing of trees, other than fruit trees, for timber exploitation purposes and coppicing. Regulations for compost application in silviculture are comparable to those for agricultural application though lower levels of nitrogen are needed.

Application of compost is most beneficial in areas with topsoils low in organic matter (< 2 %).

The establishment of forest in previous agricultural land, where high rate agricultural production took place within the last few years, does not benefit from any form of fertilisation, nor from organic fertilisers if the organic matter of the soil is sufficient.

Landscaping

The landscaping sector is a very important market for compost products, especially in metropolitan areas. The sector demands stable or very stable composts free of weeds, with a low level of visible impurities and with good handling properties. High prices are paid for refined compost products, e.g., topsoil mixtures/substitutes, mulches for shrubbery, topdressing for lawns and ball playing pitches. Urban topsoil is often of poor quality (low in organic matter, compacted, damaged by usage of all-purpose pesticides) therefore additional sources of humus and beneficial micro-organisms are desirable. The extended use of woody plants within this sector makes the slow release of fertiliser properties of compost an advantage. Generally, the sector prefers composts low in nutrients for most uses. Some plant species used in landscaping are sensitive to chloride and prefer low pH.

A general compost declaration for the landscaping sector should comprise the same information as for agriculture, except for nutrient content being stated in kg/m3 and not kg/tonne. Information about electrical conductivity, content of weeds and degree of stability must be added. Mulches should have a content below 10 % (w/w) of particles < 5 mm. Terms of delivery (delivery within one or a few days) are very important when dealing with the landscaping market.

Detailed guidelines are very important when marketing compost for the landscape sector. Recommended use for establishment tasks as well as for maintenance tasks must be stated, including possible need for supplementary nitrogen.

The reclamation of former landfills and mines, or soil sanitation of leftovers/debris from mining, can consume large amounts of, mostly, locally produced compost within a short period of time. Recommendations for soil improvement and the production of topsoil mixes with compost also apply for reclamation purposes. The landscaping market is dependent upon the level of construction activity in the region.

Private gardens and homes

Compost with a high content of nutrients is best suited for vegetable growing, while pure garden waste compost is well suited for perennials, bushes and trees. Many municipality owned composting plants consider that returning compost made from the collected waste back to the households that supplied the waste is important because it encourages people to continue their participation in source separation and separate collection schemes.

Pricing of compost marketed towards the private garden sector is mostly politically controlled.

Regional campaigns in spring with low (subsidised) product/transportation prices or 'pick up a trailer full of compost for free' are very successful and can result in outlets of amounts greater than during the rest of the year. Compost for private collection is often distributed to local locations ('recycling depots', 'Waste centres') to avoid any disturbance of the production including possible accidents as well as a way to lower the overall energy consumption for transportation.

Compost for the private garden sector must be of high visual quality and without malodours. Finely screened compost is more easily marketed than coarsely screened compost. A short guide with simple application hints is very important. Nutrient contents should be stated in kg/m3. To ensure maximum environmental benefit it should be mentioned, that the use of compost renders any fertilisation with phosphorous and potassium (including NPK-fertilisers) superfluous. However, for low nutrient composts like garden compost, the application of additional nitrogen is still needed for the growing of vegetables and a few other plant types such as roses.

Fruit and wine growing

In wine growing, mulching is fairly common for soil improvement, for reduction of water evaporation and to suppress annual weeds. Composts with a very low nutrient content and a very low content of particles (< 5 mm) are best suited for mulching. The continuous but slow degradation of the mulch will supply the wine with most of the needed nutrients. The growing of apples, pears and most stons fruits requires large quantities of potassium. The maintenance of a topsoil with a high pH is desirable. Using compost can fulfill both needs.

The ground below the tree rows are kept free of weeds by the use of herbicides in high input horticulture, and by weeding or mulching with, for example, garden compost in organic horticulture. Berries have very different needs regarding nutrient levels and pH from fruit trees such as apples and pears and are often very sensitive to chloride. For berry growing, only a very small yearly supply of compost can be recommended. The declarations on composts to be used in fruit and wine growing should contain the same information as for similar use in the landscape sector. Suggestions and information about machinery needed for the application of mulches are valuable, and a possibility to sub-let the needed machinery from the composting plant will be a competitive advantage in the marketing of compost.

Nurseries and greenhouses

The nursery sector can be divided into plants growing in fields and plants growing in containers/pots, and both ways of plant growing can benefit from the use of compost. Field nurseries need a supply of nutrients and of humus. They are experiencing increasing soil structural problems due to the continuing removal of both plant tops and most of the plant root system. The type of declaration needed and user directions are the same as for the agricultural sector.

Container nurseries are interested in improved growth media and it can be a well paying niche for compost producers. The compost must be of uniform high quality, stable with good structural qualities, and guaranteed free of phytotoxic elements, pathogens, weeds and visible impurities. The slow release nutrient properties of compost are valued. The declaration must include all traditional analyses of growth media, including a number of soluble/plant available nutrients. The total and available content of chloride Cl- must be sufficiently low not to cause problems.

A few ready-made blends comparable to the traditionally used growth media are best marketed for the container-nursery niche. Physical parameters like air-filled porosity and water retention must be checked for short-term and long-term compliance with the standards and growth performance trials before marketing is recommended. Container nurseries are often specialised in growing very few plant species and know the exact needs of these species.

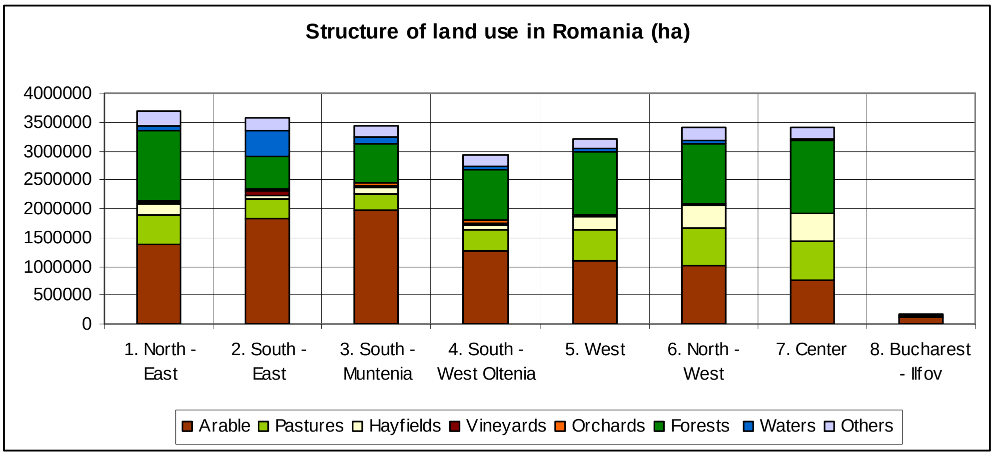
The growth media producer must account for this. Nurseries are experiencing increasing problems with root pathogens which cannot be eliminated by use of fungicides. Disease suppressing properties are inherent in several types of compost, which can be useful to the nursery sector.

The professional greenhouse sector is probably the most difficult sector for compost products to enter with its very high demands for uniformity, quality and documentation. The greenhouse sector pays high prices for the right product, but the costs of product development and marketing are also high. The type of declarations needed for this sector are the same as those needed for the nursery sector, though often only one plant species is grown.

The quality requirements for growth media to be used in hobby greenhouses or for potted indoor plants in private houses are lower, but this is counterbalanced by high packing costs and low-paying middlemen.

Slurry from anaerobic digestion is used in agriculture only. Due to a low content of nutrients per tons, the slurry should be used on farms situated within a radius of 5–10 km from the anaerobic digestion facility. If the fibre fraction of the slurry is separated, the remaining thin slurry must be used on neighboring farms; some facilities choose to discharge such slurry. A very large part of the nitrogen in digested slurry is ammonia and the pH of slurry is high. The use of the right application equipment and avoiding windy and sunny weather, when applying the slurry is therefore very important to avoid high losses of ammonia-nitrogen. Slurry from anaerobic digestion is declared for content of N-total, ammonia-N, P-total, K-total, Mg-total, Stotal, liming effect (as $CaCO_3$ or CaO) pH, dry matter, organic matter, visible impurities, heavy metals, possible organic pollutants, sanitary treatment and compliance with the content of possible indicator micro-organisms. Nutrient content is stated in kg/tons. For general considerations, see the section on marketing of compost for agriculture. The fibres are best suited for agricultural usage, while a post-treatment composting stage is needed for general marketing into other sectors.

The agricultural land in Romania is predominantly arable. Differences between regions and counties can make a difference in the future rates of development in the biogas field. Data from 2005 are presented below *(source 2)*:



3.3 Alternatives technologies for biodegradable waste treatment

Centralized composting

Biodegradable waste is composted with the objective of returning the waste to the plant production cycle as fertilizer and soil improver. The variety of composting technologies is extensive as composting can be carried out in private gardens as well as in advanced, highly technological centralized plants. The control of compost processing is based on the homogenization and mixing of the waste followed by aeration and often irrigation. This leads to a stabilized dark media, rich in humic substances and nutrients.

Central solutions are exemplified by low cost composting without forced aeration and technologically more advanced systems with forced aeration and temperature feedback.

Central composting plants are capable of handling more than 100.000 tonnes of biodegradable waste per year, but typically the plant size is about 10.000 to 30.000 tonnes per year. Biodegradable wastes must be separated prior to composting: only pure food waste, garden waste, wood chips and, to some extent paper, are suitable for producing good quality compost.

The composting plants consist of some or all of the following technical units: bag openers, magnetic and/or ballistic separators, screeners (sieves), shredders, mixing and homogenization equipment, turning equipment, irrigation systems, aeration systems, draining systems, bio-filters, scrubbers, control- and steering systems.

The composting process occurs when biodegradable waste is piled together with a structure allowing oxygen-diffusion and with a dry matter content suiting microbial growth. The temperature of the biomass increases due to the microbial activity and the insulation properties of the piled material. The temperature often reaches 65–75°C within a few days and then declines slowly. This high temperature furthers the elimination of pathogens and weed seeds.

Anaerobic digestion

Anaerobic digestion is a biological treatment method that can be used to recover both nutrients and energy contained in biodegradable municipal waste. In addition, the solid residues generated during the process are stabilized. The process generates gases with a high content of methane (55–70 %), a liquid fraction with a high nutrient content (not in all cases) and a fiber fraction. Waste can be separated into liquid and fiber fractions prior to digestion, with the liquid fraction directed to an anaerobic filter with shorter retention time than that required for treating raw waste. Separation can also be conducted following digestion of the raw waste so that the fiber fraction can be recovered for use, for example as a soil conditioner. The fiber fraction tends to be small in volume but rich in phosphorus, which is a valuable and scarce resource at global level.

Separate digestion, dry method

With separate digestion, dry method, the organic waste is first tipped into a shredder to reduce the particle size. The waste is sieved and mixed with water before entering the digester tanks (35 % dry matter content). The digestion process is carried out at temperatures of 25–55 °C resulting in the production of biogas and a biomass. The gas is purified and used in a gas engine. The biomass is de-watered and hereby separated into 40 % water and 60 % fiber and reject (having 60 % dry matter). The reject fraction which is disposed at, for example, a landfill. The wastewater produced is recycled to the mixing tank ahead of the digester.

Separate digestion, wet method

With separate digestion, wet method, the organic waste is tipped into a tank, where it is transformed into a pulp (12 % dry matter). The pulp is first exposed to a hygienic Regional Waste Management Plan process (70 °C, pH 10) before being de-watered. The de-watered pulp is then hydrolyzed at 40 °C before being de-watered once again. The liquid from the second de-watering step is directed to a bio-filter where the digestion is carried out resulting in biogas and wastewater. This water is reused in the pulp or, for example, may be used as a liquid fertilizer. The fiber fraction from the second de-watering is separated into compost and reject fractions to be disposed of at, for instance, landfill. The compost usually requires further processing prior to sale. The biogas is purified and utilized in a gas engine resulting in the production of electricity, heat and flue gas. Some of the heat can be used to ensure stable temperatures during the hydrolysis and the bio-filter processes. In this process, one ton of household waste will generate 160 kg biogas (150 Nm3), 340 kg liquid, 300 kg compost fraction and 200 kg residuals (including 100 kg inert waste). According to analyses it is found that 10–30 % of the nutrient content (tot-N, tot-P and tot-K) remains in the compost fraction.

Co-digestion, wet method

With co-digestion, wet method, organic waste is shredded and screened before further treatment. The shredded waste is then mixed with either sewage sludge or manure from farms, at a ratio of 1:3–4. The mixed biomass is first exposed to a hygienic process (70°C) before being fed to the digestion phase, which is conducted at temperatures of 35-55 °C. The process generates biogas and a liquid biomass, which is stored before being used as a liquid soil fertilizer. The biogas is purified and utilized in a gas engine resulting in the production of electricity, heat and flue gas. Some of the heat can be used to ensure stable temperatures during the hygienic and the digestion phases.

One ton of household waste will generate 160 kg biogas (150 Nm3), 640 kg liquid fertilizer, 0 kg compost fraction and 200 kg residuals (including 100 kg inert waste). According to analyses it is found that 70–90 % of the nutrient content (tot-N, tot-P and tot-K) remains in the liquid fertilizer fraction. Thus it is possible to achieve very high recovery and utilization of the nutrients. However it should be emphasized that liquid fertilizers, produced from sewage sludge, are much more difficult to sell than liquid fertilizers produced from manure.

Typical costs for anaerobic digestion

Separate digestion, dry method (100% waste)

Capacity Note 1 (tonss per annum)	Typical capital costs Note 2 (EUR)*	Typical operating costs Note 3 (EUR)**
5.000	2,9–3,1 million	120.000 p.a.

10.000	5,3–5,6 million	220.000 p.a.
20.000	9,5–10,0 million	400.000 p.a.

* Plant cost excluding energy conversion gas engine, tax, planning and design fee. (Hjellnes Cowi AS and Cowi AS, 1993).

** Operating costs excluding the costs of transport, residue disposal, staff costs, income from sales of residue/by products and incomes from net sales of energy. Operating costs includes yearly maintenance costs estimated to 4 % of the initial capital cost. (Hjellnes Cowi AS and Cowi AS, 1997).

Co-digestion, wet method (80% water)

Capacity Note 1 (tonss per annum)	Typical capital costs Note 2 (EUR)*	Typical operating costs Note 3 (EUR)**
5.000	3,7 – 4,5 million	130.000 p.a.
10.000	4,6 – 5,5 million	150.000 p.a.
20.000	10,5 – 12,5 million	350.000 p.a.

*Plant cost excluding energy conversion gas engine, tax, planning and design fee. (Danish Energy Agency, 1995).

** Operating costs excluding the costs of transport, residue disposal, staff costs, income from sales of residue/by products and incomes from net sales of energy. Operating costs includes yearly maintenance costs estimated to 3 % of the initial capital cost. (Danish Energy Agency, 1995; Claus D. Thomsen, pers. comm., Reto M. Hummelshøj, pers. comm.).

Staff costs may vary from plant to plant i.e. 5–15 persons for 100.000 tonnes per annum per plant. Total operating costs excluding transport may reach EUR 6 per tonne. Electric consumption at a plant is typically about 0,2 kWh/m3 biogas, and process heat consumption about 3 MJ/m3 biogas.

Incineration

Incineration reduces the amount of organic waste in municipal waste to about 5 % of its original volume and sterilizes the hazardous components, while at the same time generating thermal energy that can be recovered as heat (hot water/steam) or electric power or combinations of these. The incineration process also results in residual products, as well as products from cleaning of the flue gas, which has to be deposited at a controlled disposal site such as a landfill or a mine. Sometimes wastewater is produced. Nutrients and organic matter are not recovered.

Pyrolysis

Pyrolysis is a thermal pre-treatment method, which can be applied in order to transform organic waste to a medium calorific gas, liquid and a char fraction aimed at separating or binding chemical compounds in order to reduce emissions and leaching to the environment. Pyrolysis can be a self-standing treatment, but is mostly followed by a combustion step and, in some cases, extraction of pyrolytic oil (liquefaction). Waste is tipped into a silo where a crane mixes the incoming material and moves the material to a shredder and from here to another silo. The mixed waste is then fed into a gas tight hopper arrangement, screw- or piston feeder. The coarsely shredded waste now enters a reactor normally an external heated rotary drum operated under atmospheric pressure. In the absence of oxygen the waste is dried and hereafter transformed at 500–700 °C by thermochemical conversion i.e., destructive distillation, thermo-cracking and condensation into hydrocarbons (gas and oils/tar) and solid residue (char/pyrolysis coke) containing carbon, ash, glass and non-oxidised metals.

If the process temperature is 500 °C or below, the process is sometimes called thermolysis. The retention time of the waste in the reactor is typically 0.5-1 hour. The >300 °C hot product gas is normally led to a boiler plant, where the energy content is utilised for steam or hot water production. The raw product gas is **not** suitable for operation of an internal combustion engine due to the high content of tar in the gas phase, which will condense when the gas is cooled before entering the gas engine. Thermo-cracking of the tars in the gas followed by gas cleaning may solve the cleaning need.

Gasification

Gasification is a thermal treatment method, which can be applied to transform organic waste to a low calorific gas, recyclable products and residues. Gasification is normally followed by combustion of the produced gasses in a furnace and in internal combustion engines or in single gas turbines after comprehensive cleaning of the product gas. Coarsely-shredded, sometimes pyrolysed waste enters a gasifier, where the carbonaceous material reacts with a gasifying agent, which may be air, O2, H2O in the form of steam, or CO2. The process takes place typically at 800–1.100 °C (oxygen blown entrained flow gasification may reach 1.400–2.000 °C) depending on the calorific value and includes a number of chemical reactions to form combustible gas with traces of tar. Ash is often vitrified and separated as solid residue.

The main difference between the pyrolysis and gasification is that by gasification the fixed carbon is also gasified. Gasification plants may be designed as 1- or 2-step processes. The gasifier itself may be either up flow, down flow and entrained flow fixed bed type or for big plants also bubbling or circulating fluid bed types, atmospheric or pressurised when combined with gas-turbines. Sometimes the first step is a drying unit, in other cases a pyrolysis unit. Both pyrolysis and gasification units may be installed in front of coal fired boilers of power plants, which enable co-firing with a very high power-to-heat ratio.

Bio-Mechanical Treatment

Together with waste incineration, bio-mechanical treatment represents an important technique in municipal waste management. In bio-mechanical treatment facilities non-sorted municipal waste are treated, through a combination of mechanical and biological processes. In this process the wastes that are material and energy recovered are mechanically separated and, in the end, the other wastes are treated biologically, making them inert. These biologically inert wastes, that represent about 40% of the total input, are disposed of.

Landfilling

Building up, location and technical requirements for the construction of sanitary landfills are technically described in the Directive regarding waste landfilling. Essentially, a sanitary landfill represent a location that ensure an adequate environmental and health protection for disposing of solid municipal wastes.

3.4 Structure of agricultural land in Romania

Development region County (hectares)	Total area	Agricultural area	Arable	Pastures	Hayfields	Vineyards and nurseries	Orchards and nurseries	Forests and other forest vegetation lands	Waters and ponds	Other areas
Total	**23.839.071**	**14.741.214**	**9.420.205**	**3.364.041**	**1.514.645**	**224.082**	**218.241**	**6742.825**	**841.394**	**1.513.638**
1. North - East	**3.684.983**	**2.130.767**	**1381.306**	**495.964**	**197.119**	**34.340**	**22.038**	**1.231.175**	**71.532**	**251.509**
Bacău	662.052	320.601	186.128	85.126	39.060	7.241	3.046	281.754	14.777	44.920
Botoşani	498.569	393.468	298.917	75.411	14.712	1.773	2.655	57.232	13.795	34.074
Iaşi	547.558	381.396	253.243	88.110	19.608	12.293	8.142	98.193	12.367	55.602
Neamţ	589.614	284.033	170.939	69.776	40.107	786	2.425	260.885	10.228	34.468
Suceava	855.350	349.762	180.771	90.250	75.711	-	3.030	453.566	12.114	39.908
Vaslui	531.840	401.507	291.308	87.291	7.921	12.247	2.740	79.545	8.251	42.537
2. South - East	**3.576.170**	**2.332.847**	**1.827.024**	**331.256**	**62.307**	**89.183**	**23.077**	**573.190**	**458.882**	**211.251**
Brăila	476.576	388.428	349.515	33.304	74	4.805	730	27.806	32.196	28.146
Buzău	610.255	402.168	257.673	89.241	28.739	15.406	11.109	163.905	11.362	32.820
Constanţa	707.129	563.944	486.245	61.255	-	12.415	4.029	40.217	45.565	57.403
Galaţi	446.632	358.645	293.285	43.672	656	19.316	1.716	43.824	13.412	30.751
Tulcea	849.875	364.015	292.222	60.043	61	10.032	1.657	104.147	342.417	39.296
Vrancea	485.703	255.647	148.084	43.741	32.777	27.209	3.836	193.291	13.930	22.835
3. South - Muntenia	**3.445.299**	**2.448.500**	**1.975.561**	**288.804**	**103.902**	**33.227**	**47.006**	**676.637**	**101.978**	**218.184**
Argeş	682.631	344.879	172.295	102.689	45.783	1.255	22.857	289.947	9.354	38.451
Călăraşi	508.785	426.696	416.030	5.235	134	5.120	177	22.001	29.906	30.182
Dâmboviţa	405.427	249.234	174.921	44.154	20.362	333	9.464	120.909	10.969	24.315
Giurgiu	352.602	277.965	261.082	11.776	82	4.194	831	38.068	13.999	22.570
Ialomiţa	445.289	374.401	351.508	18.031	-	4.477	385	26.161	13.147	31.580
Prahova	471.587	275.481	145.338	71.777	36.780	8.830	12.756	150.399	9.061	36.646
Teleorman	578.978	499.844	454.387	35.142	761	9.018	536	29.152	15.542	34.440

4. South - West Oltenia	**2.921.169**	**1.806.606**	**1.255.049**	**377.572**	**88.002**	**39.625**	**46.358**	**858.740**	**72.955**	**182.868**
Dolj	741.401	585.699	488.677	68.435	2.952	17.538	8.097	85.041	20.757	49.904
Gorj	560.174	243.740	99.149	88.654	42.542	4.434	8.961	274.106	4.611	37.717
Mehedinți	493.289	294.082	188.692	80.740	10.687	5.997	7.966	149.840	17.002	32.365
Olt	549.828	437.165	390.569	31.022	637	7.630	7.307	58.873	18.041	35.749
Vâlcea	576.477	245.920	87.962	108.721	31.184	4.026	14.027	290.880	12.544	27.133
5. West	**3.203.317**	**1.891.126**	**1.088.809**	**553.383**	**212.659**	**8.736**	**27.539**	**1.098.354**	**45.442**	**168.395**
Arad	775.409	511.475	349.330	127.319	25.661	3.603	5.562	212.002	13.678	38.254
Caraș-Severin	851.976	398.083	127.313	183.466	74.796	766	11.742	411.276	10.169	32.448
Hunedoara	706.267	280.343	79.660	116.972	82.704	13	994	366.019	5.818	54.087
Timiș	869.665	701.225	532.506	125.626	29.498	4.354	9.241	109.057	15.777	43.606
6. North - West	**3.416.046**	**2.087.480**	**1.016.132**	**648.812**	**378.211**	**9.076**	**35.249**	**1.036.566**	**50.992**	**241.008**
Bihor	754.427	497.167	309.084	136.370	44.752	2.109	4.852	197.235	13.545	46.480
Bistrița-Năsăud	535.520	296.567	101.977	114.901	70.467	404	8.818	192.027	7.500	3.9426
Cluj	667.440	424.453	177.844	162.477	79.623	340	4.169	170.588	8.917	63.482
Maramureș	630.436	311.155	83.998	101.017	119.756	230	6.154	289.179	5.650	24.452
Satu Mare	441.785	317.477	221.734	55.470	29.689	3.425	7.159	80.892	9.594	33.822
Sălaj	386.438	240.661	121.495	78.577	33.924	2.568	4.097	106.645	5.786	33.346
7. Center	**3.409.972**	**1.929.240**	**767.146**	**666.037**	**472.361**	**8.196**	**15.500**	**1.241.988**	**33.239**	**205.505**
Alba	624.157	330.771	135.367	118.244	71.923	3.545	1.692	225.719	7.038	60.629
Brașov	536.309	297.213	118.021	119.877	56.566	188	2.561	199.314	6.645	33.137
Covasna	370.980	186.289	83.787	60.727	40.731	-	1.044	165.161	3.055	16.475
Harghita	663.890	394.324	91.755	145.479	156.293	35	762	238.959	4.252	26.355
Mureș	671.388	414.451	222.342	114.824	71.068	1.669	4.548	208.711	6.226	42.000
Sibiu	543.248	306.192	115.874	106.886	75.780	2.759	4.893	204.124	6.023	26.909
8. Bucharest - Ilfov	**182.115**	**114.648**	**109.178**	**2.213**	**84**	**1.699**	**1.474**	**26.175**	**6.374**	**34.918**
Ilfov	158.328	110.184	105.556	1.707	84	1.633	1.204	25.564	5.466	17.114
Bucharest Municipality	23.787	4.464	3.622	506	-	66	270	611	908	17.804

3.5 The questionnaire

Basic Data			
Company Name:			
Address:			
Tel.:			
E-Mail:			
Region:			
Industry:			
Produced goods (kind, quantity):			
Business size (e.g. number of employees):			
Energy			
Electricity			
	How high is your electricity consumption?		
	How high is your electricity consumption distributed over the year?		
	What do you pay for current? Cost of electricity?		
	Electricity consumption of the last years?		
	Possible private use for produced electricity?		
Heat			
	How high is the heat requirement of your enterprise?		
	How is the heat requirement distributed over the year?		
	Heat consumption of the last years?		
	What do you pay for heat/process heat?		
	Possible use of warmth (for what?)		
Cooling energy			
	How high is the cooling need of the enterprise?		
	How is the cooling need distributed over the year?		
	Cooling need of the last years?		
	Possible use for cooling (for what)?		
Substrate / waste (solid wastes and slurries)			

Solid wastes and slurries are for example: Animal waste of food preparation and products (e.g. animal tissue waste, sludge from washing and cleaning; fleshing and lime split waste; liming waste; organic matter from natural products like grease, wax) Vegetal waste of food preparation and products (e.g. sludge's from washing and cleaning, plant tissue waste. sludge's from washing, cleaning, peeling, centrifuging and separation, materials unsuitable for consumption or processing, wastes not otherwise specified, wastes from washing, cleaning and mechanical reduction of the raw material, sludge's from on-site effluent treatment) Mixed waste of food preparation and products (materials unsuitable for consumption or processing, oil and fat, organic compost able kitchen waste, frying oil and kitchen waste from canteens and restaurants) Green wastes (Non-hazardous waste from forestry exploitation, compost able wastes) Animal faeces, urine and manure (Slurry and manure) Sludge's from municipal wastewater treatment plants (WWTP)		
Waste		
Which fermentable biological wastes accrue at your company?		
Which quantities of waste volumes per substance group accrue with you?		
Is a waste analysis available?		
If a waste analysis is available, can you attach these with?		
If a waste analysis is available, what are the values for:	dry substance:	
	pH value:	
	Temperature:	
	contained inhibitors (as: sodium, potassium, calcium, ammonium, ammonia, sulphur, heavy metals, branched out fatty acids):	
How looks the current treatment of the waste groups? (e.g. what happens with the waste, also the transportation routes up to the utilization/treatment)		
What do you pay for the waste treatment?		
Is a surface or tanks present for the storage of the substrates/ wastes?		
Wastewater		
Which wastewater volume develops at your company per year?		
Which wastewater volume develops at your company per hour?		

Is a wastewater analysis (data admits?) available?	
If a wastewater analysis is available, can you attach these with?	
If a waste water analysis is available, what are the values for:	pH value:
	BOD (biochemical oxygen demand).
	COD (chemical oxygen demand):
	Temperature:
	Contained inhibitors (sodium, potassium, calcium, ammonium, ammonia, sulphur, heavy metals, branched out fatty acids):
What do you pay for the waste water treatment?	
What is the current wastewater treatment?	
Biogas	
What do you know about biogas and polygeneration of biogas?	
What is your opinion about biogas?	
How would the price structuring have to look that for you the use and production of biogas would be interesting?	
How would the acceptance of a biological gas facility be in your neighborhood?	

Place, date: ______________________

Name: ______________________

Signature: ______________________

4 Copyright and disclaimer

5 Project consortium

The project consortium of ProBioPol consists of seven partners from Romania and Germany.

- AGIMUS GmbH, Germany
- The Regional Environmental Center for Central and Eastern Europe – Country Office Romania (REC Romania), Romania
- SC Project Developer SRL (ProDev), Romania
- Asociatia Generala a Inginerilor din Romania (AGIR), filiala Cluj and filiala Sibiu, Romania
- Dr. Dragos Balan, Germany/Romania
- target GmbH, Germany
- BioKraft Karstädt GmbH & Co. KG, Germany

For more information visit www.biogaz-romania.ro or send an email to info@probiopol.eu