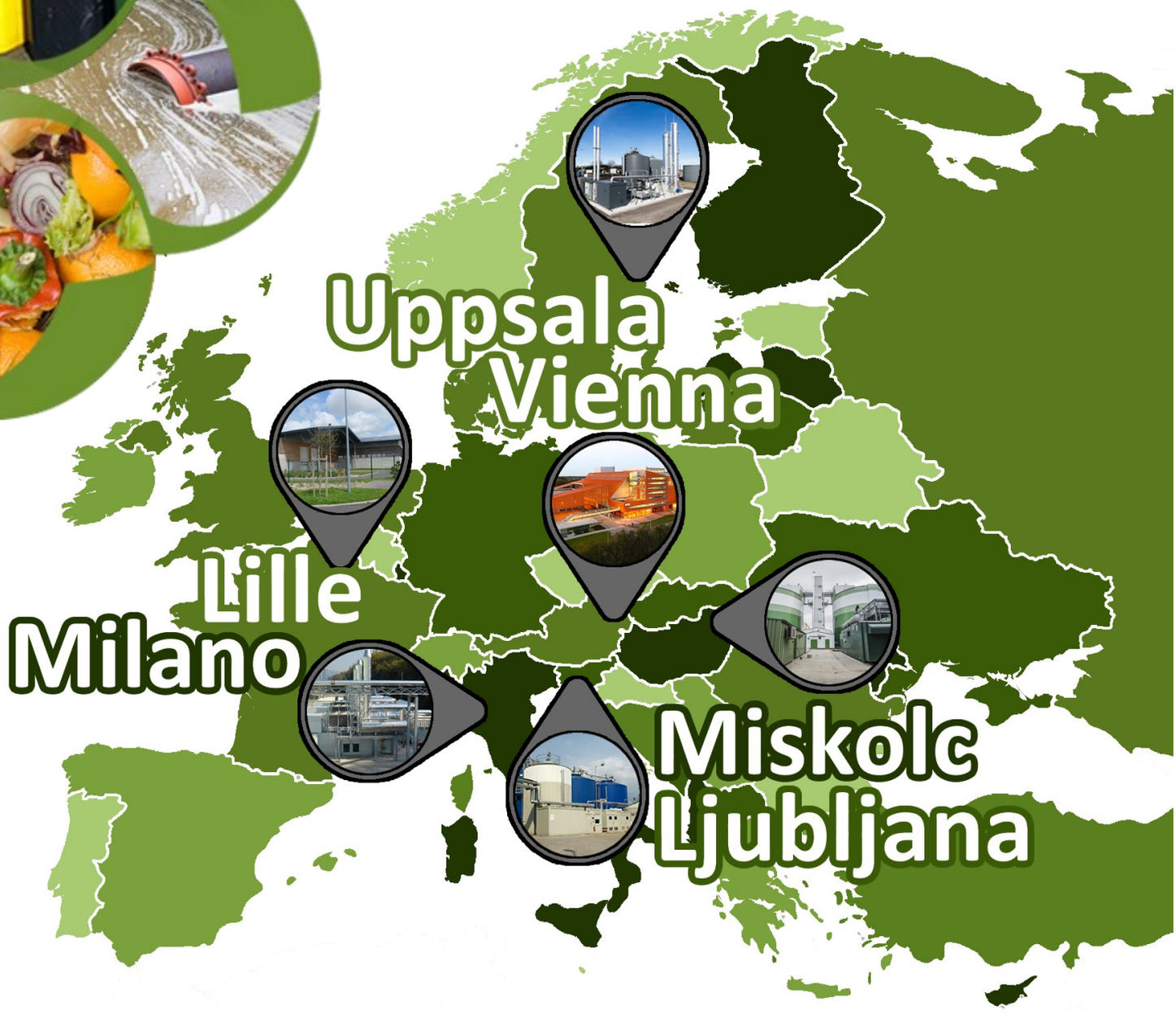
EBA
European Biogas Association

# Success Stories:

## anaerobic digestion of biodegradeable municipal solid waste in European cities



# Algal treatment of digestate for more substrate

## Ljubljana, Slovenia

**Population**: 352,349
**Area**: 903.8 km$^2$
**Density**: 390/km$^2$

**Total waste: 138,317 t**
Household waste: 126,536 t
Commercial waste: 11,718 t

Recyclable: 54,089 t
Non-recyclable: 47,506 t
Organic waste: 24,941 t

Within the local administration it is the Department for Economic Affairs and Transport that develops waste management plans and monitor the implementation of these plans, while the collection and treatment are carried out by Snaga public company.

Ljubljana has developed a very successful and exemplary collection system that allows a high share of material recovery. Eco-islands are installed for separate collection of packaging, as well as residual waste and are used by both citizens living in the close vicinity and the general public. Downtown Ljubljana has a network of underground containers that are on disposal to households with a valid card that is used to determine the monthly fee the households pay. In order to promote waste avoidance, households who dispose residual waste less than 6 times a month are exempt from a fee. Ljubljana encourages separate collection of biowaste by allowing households to dispose biowaste for free, up to 4 times per month. Every following disposal is charged. Individual housing areas are, however provided with a separate bin for biowaste.

### KOTO biogas plant

19 June 1947 saw the establishment of the company KOTEKS from a former Slovenian Agency for the trade of hides and textiles with pigskin leather as the main production. Over the years the company went through several changes and expanded its operation and products line. Since 2000, after the company transformed into KOTO ltd., it started acting as the concessionaire for performing the commercial public service of the management of slaughterhouse waste and infectious material of animal origin. Then in 2008, biogas production became a part of the company's activities and renewable electricity production began. The latest coming from the company is the launch of construction of the demonstration centre for growing algae.

**Digesters: 3 x 500 m3**
**Capacity: 13,000 t/y**
**Treated: 13,000 t/y (90% biowaste, 10% waste from food industry and animal by products)**
**Raw biogas: 1,800,000 m$^3$/y**
**Digestate 26,400 t/y**
**Employees: 148**

### Anaerobic digestion

The feedstock is provided by several suppliers, such as private companies (canteens, catering companies etc.) as well as markets who deliver food waste; flotation sludge from slaughterhouses and significant quantities of biowaste from municipalities, including Ljubljana itself. Biological process of biogas production takes place in heated gas-tight reactors. Produced biogas, which contain up to73 % of methane, is used on CHP unit for electricity and heat generation.

The produced biogas is burned what results in 4 GWh of electricity produced annually along with 2.8 GWh of thermal energy. 10% of the electricity is sold to the grid, while the rest is used on the spot and accounts to 50% of the facility's total need for electricity. The heat is used within the facility itself, namely for steam production needed of other processes and for the heating of the offices in cold periods.

The KOTO Company generates additional income by producing biogas apart from the existing gate fees, as according to Slovenian support schemes for the company is entitled to feed-in tariffs of 120.9 €/MWh and premium tariffs for the share of electricity used in the company which amounts to 83.3 €/MWh

### Algal treatment of the digestate

The KOTO biogas plant with its new experimental facility for algal treatment of the digestate is one of the pioneers of such technology in Europe. This facility, built and launched in July 2014 in scope of project AlageBiogas, treats the generated digestate from anaerobic digestion, currently on 100 m$^2$ in a 30 m$^3$ pond. By doing so, the quality of digestate's liquid fraction (liquor) is improved and algal biomass is produced, which can be used as an energetic substrate or processed in biorefinery. Furthermore, this technology recycles $CO_2$ emissions, effectively uses excess heat and reduces odour of digestate.

# Open market for digestate from anaerobic digestion

## Uppsala, Sweden

| | | |
|---|---|---|
| **Population**: 207,000 | **Total waste: 180,600 t** | Recyclable: 15,000 t |
| **Area**: 2,234 km$^2$ | Household waste: 127,600 t | Non-recyclable: 48,900 t |
| **Density**: 92/km$^2$ | Commercial waste: 53,000 t | Organic waste: 54,000 t |

2014

About 60% of the Swedish municipalities are separately collecting food waste to be used in AD today. The overall goal is not primarily to produce biogas, but rather to re-circulate the nutrients back to arable land. Hence, the quality of the collected food waste is very important.

Uppsala Vatten (Uppsala Water) is in charge of several municipal services, such as water, sanitation and waste management. The company has 8 recycling centres that receive all types of waste, from general household to WEEE, bulky waste, hazardous waste and more. When it comes to treatment, the company owns a sanitary landfill for waste disposal and a modern biogas plant for the treatment of biowaste. The biowaste that is treated is collected directly from households through a separate collection. Although located in Uppsala, Uppsala Vatten also receives waste from neighbouring municipalities, as well as slaughterhouses and other producers of biowaste. Uppsala Vatten also has a biomethane station installed downtown that has biomethane available for fuelling cars.

### Kungsängens farm biogas plant

The biogas plant was built in 1996 to produce biogas from manure and slaughter waste. Produced biogas was upgraded to biomethane and used in buses. New equipment was installed in 2006 in order to handle organic household waste. Up until 2010 the biogas plant produced about 500,000 m$^3$ – 1,500,000 m$^3$ of raw biogas each year.

A new reactor was built in 2010 and the biogas plant started receiving organic household waste from other municipalities. Since then, the annual production of raw biogas have increased every year. In 2014 the biogas plant produced 4,700,000 m$^3$ of biogas. In 2015 - 2016 a new reactor and new pre-treatment plant for household waste will be built.

**Digesters: 2 x 2,400 m$^3$**

**Capacity: 40,000 t/y of biowaste (85%) and slaughter waste (15%)**

**Raw biogas: 4,700 000 Nm$^3$/y**

**Biomethane: 3,000 000 Nm$^3$/y**

**Digestate: 43,000 t/y**

**Employees: 9**

### Anaerobic digestion

The liquid waste is pumped in the receiving pocket or the settling tank and solid waste without plastic packaging is shipped into the plant's pre-treatment hall where material is emptied as it arrives packaged in plastic wrapping. The household waste later undergoes separate pre-treatment and is later mixed and diluted in a mixing tank to a substrate with 15% solid content. It is then pumped into a temporary storage tank before pumped through heat exchangers to one of the three hygienisation tanks. Then it finally reaches the digester. Digestion takes place through a continuous anaerobic thermophilic process at 52°C with continuous stirring. The produced biogas and the residue are stored and then collected in a gas dome. As the gas from the digester and digested residues can exceed a temperature of 50°C, they are cooled down in a water-cooled gas cooler.

### Biogas upgrading

The gas is fed from the gas holder to a gas upgrading facility which extracts $CO_2$ from the gas so that the methane content of the upgraded gas exceeds 97%. Gas upgrading is equipped with a thermal incinerator that burns the methane abrasive particles that occur in the plant. Using the thermal incineration the methane emissions are within the range of 0.3% of the incoming methane amount. Biomethane is transported to the filling station or used for heat production in a gas boiler at the biogas plant. Biogas can be also flared in case of any malfunction on the site.

### Swedish digestate market

Sweden has been assessing the quality of digestate as organic fertiliser since 1999 when the country launched the quality assurance scheme ”Certifierad återvinning” ("Certified recycling") and has been building trust among users of organic fertiliser. Today, 99% of organic fertiliser produced in co-digestion plants (most of them using food waste from households as substrate) is used on agricultural lands. Approx. 80% of all organic fertilisers are certified according to the certification scheme.

# Biomethane injection into the national grid

## Lille, France

**Population**: 1,091,438
**Area**: 611.45 km$^2$
**Density**: 1,785/km$^2$

**Total waste: 663,904 t**
Household waste: 591,594 t
Commercial waste: 72,310 t

Recyclable: 109,935 t
Non-recyclable: 450,877 t
Organic waste: 30,782 t
2013

The Urban Community of Lille Métropole (Lille Métropole Communauté Urbaine) is the intercommunal structure gathering the commune of Lille and surrounding metropolitan area that lies in France. The Urban Community stretches to 85 communes.

The Metropolitan area of Lille is responsible for waste collection and treatment and gives a mandate through a public tender to a company to do it. The Metropolitan area creates and owns the collection and treatment facilities, while the private companies exploit them through public-private partnerships. There are 17 infrastructural facilities that are used for collection and treatment of waste. Apart from 11 waste collection centres, 4 civic amenity sites, the Metropolitan area of Lille also owns a centre for energy recovery that treats non-recyclable waste and an organic recovery centre for the treatment of biowaste. Since the implementation of selective collection in 1994, the Metropolitan area of Lille has in place a separate collection of biowaste.

### Organic Recovery Centre

The location for the Organic Recovery Centre was chosen in 2000. Completed in 2007, the Organic Recovery Centre has been put into operation progressively starting in September the same year. A Transfer and Handling Centre of residual household waste is associated with the treatment site. It now occupies 57,000 m$^2$.

Organic recovery was primarily intended to promote an advanced and responsible way to recover the nutritious and energy potential from biowaste through digestate and biogas. Successful intake of such waste stream is ensured by the establishment of separate collection systems upstream from the treatment, such as door-to-door, green waste recycling centres and civic amenity sites and collection of leftovers in canteens and other public institutions.

**Digesters: 3 x 1,900 m$^3$**
**Capacity: 108,000 t/y**
**Treated: 64,702 t**
**Raw biogas: 7,400,000 m$^3$/y**
**Biomethane: 4,111,000 m$^3$/y**
**Digestate: 34,000 t/y**
**Employees: 39**

### Anaerobic digestion

This is the treatment process applied to organic waste, the biodegradeable fraction of household waste. Before waste is pumped into the digesters, it is crushed and then subjected to a biological pre-treatment in the presence of oxygen. Prepared and grounded waste is then digested in three anaerobic digesters through a thermophilic process at 57°C. The retention time is 3 weeks, during which the waste is pre-heated, while consuming of about 10% of the raw biogas produced.

### Biogas upgrading

The total cost of investment of €90 million, including the bus depot resulted in a new facility consisting of 2 scrubbing towers. Raw biogas is compressed to a pressure of 9 bar which is then injected in two scrubbing towers with total upgrade capacity of 1,200 Nm$^3$/h. The beads in the scrubbers are used to increase the contact surface between the water and the biogas. The biogas flows upwards and water, at approximately 15°C, from top to bottom. Pollutants such as hydrogen sulphide ($H_2S$) and $CO_2$ are then dissolved in water. In the column, biogas has the required concentration of methane. It remains to dry to give him all the qualities of a fuel.

### Biomethane injection

In October 2010, Lille Métropole won the license to operate the pipeline connecting the Organic Recovery Centre to the filing of nearby bus terminus. Thus the first bus filling trials of biomethane have been successfully completed in late 2010. In parallel, Lille Métropole has continued to work with contracting GrDF and GDF Suez to inject biomethane produced by the ORC in the natural gas network.

In July 2011, the valve was officially opened for the first time in France. Since 2012, a subsidized feed-in-tariff of biomethane was obtained and a 15 years contract was signed defining the price of green energy. The price of biomethane in 2012 was 125 €/MWh.

# Households: waste out, energy in Vienna, Austria

| | | |
|---|---|---|
| **Population**: 1,805,681 | **Total waste: 1,011,961 t** | Recyclable: 227,444 t |
| **Area**: 414.65 km$^2$ | Household waste: 932,007 t | Non-recyclable: 660,746 t |
| **Density**: 4,326/km$^2$ | Commercial waste: 79,954 t | Organic waste: 123,771 t |

The City of Vienna is responsible for the entire chain of waste management from collection to treatment and, finally, disposal. At least once in six years, Municipal Department 48 (MA 48) develops a Waste Management Plan, as well as a Waste Avoidance Programme, both on behalf of the Provincial Government of Vienna. Every year, the Austrian capital produces roughly one million tonnes of waste; more than 350,000 tonnes of this volume are collected separately. In fact, Vienna introduced separate waste collection already in the early 1980s. By 1991, this system covered all of Vienna. 1991 was the year when biowaste started being collected separately, too.

Waste is collected in over 400,000 garbage containers, 17,000 trash cans and 19 waste collection points. Salvage materials like paper, glass and plastic bottles are collected and disposed of separately, as is organic waste. Non-recyclable and bulky wastes are treated thermally and subsequently deposited in the department's own environmentally compliant landfill.

## Wiener Kommunal-Umweltschutzprojektgesellschaft gmbH (WKU)

WKU isa 100% subsidiary of the City of Vienna. It was founded in 2002 to project the third incinerator (MVA Pfaffenau) and the first (and only) biogas plant in Vienna. The first biogas plant was opened in 2007 next to the existing waste incinerator in Simmering. The main reason was the EU-Regulation 1774 (now: 1069) and the necessity for treatment of liquid or semi liquid kitchen waste from big kitchens and other catering companies. 13 May 2015 was a monumental year as biomethane flew into Vienna's gas network

**Digesters: 27,000 m$^3$**

**Capacity: 24,000 t/y**

**Treated: 22,000 t**

**Raw biogas: 1,700,000 Nm$^3$/y**

**Biomethane: 1,000,000 Nm$^3$/y**

**Employees: 5**

## Anaerobic digestion

The delivery of the biowaste is carried out in a closed hall, after being emptied from the collection vehicles into a feed hopper system. Thus an automatic feed of bio-waste treatment possible. Liquid waste can be pumped directly from the tank wagons.

The biogas is produced by mesophilic wet process. After crushing the solids and the separation of ferrous parts other contaminants such as plastic, wood and inert waste are screened. The remaining smallest light and heavy materials are deposited in a compact rake sand trap system. The substrate is then fed into two intermediate buffer tanks and then forwarded to sanitation in the fermentation reactor. The residence time in the fermentation reactor is 20 days.

## Biogas upgrading

It starts with desulfurization of the raw biogas. In order to feed it as biomethane into the gas grid, it is necessary to separate the carbon dioxide contained in the biogas. This separation is carried out by a modern membrane separation process. This ensures that from the biogas with a methane content of 64%, a new gas is produced – biomethane, with a methane content of 99%. After quality control, the biomethane is compressed to the feed pressure of up to 70 bar and then arrives at the Wien Energie customers.

## Energy for the city

The upgrading of biogas to biomethane to be fed into the natural gas grid has won in recent years clearly more relevance and offers many advantages. Biomethane is a full replacement for natural gas, so that the entire spectrum of use of natural gas is covered. Wien Energie customers are now available with $CO_2$-free gas supplies, which is used for gas water heaters, gas stove and the refuelling of vehicles. This represents a further step towards increasing the share of renewable energy sources and reduction of gas imports to the City of Vienna. The further processing to biomethane also allows a better utilization as the gas is easy to be stored.

# From aerobic to anaerobic digestion and additonal benefits

## Milan, Italy

**Population**: 1,337,155
**Area**: 181.76 km$^2$
**Density**: 7,365/km$^2$

**Total waste: 665,641 t**

Recyclable: 215,668 t
Non-recyclable: 330,158 t
Organic waste: 119,815 t
2013

The City of Milan has signed a service agreement by which it gives the mandate to a private company for the management of environmental hygiene service throughout the city. The main services covered by the contract are: kerbside collection, household waste recycling, streets and public green areas cleaning and washing, emptying baskets and abandoned waste collection. The separately collected waste, such as paper, plastic and glass, is then delivered to specialized installations that provide their proper recycling, while residual waste is forwarded to a waste incinerator.

The collection of kitchen waste began in 2012 and since 2014 100% of the city is covered by collection of food and organic waste, after the final phase of implementation took place. The waste is collected in degradable bags inside 10 l ventilated containers, previously given to citizens, and then deposited in the relevant brown condominium container.

### Montello anaerobic digestion plant

Montello started to process organic waste back in the 1990s, with the initial aim of obtaining a simple "sanitation solution" for biowaste diverted from landfills. In 1997, an aerobic composting treatment was developed for the production of "composted mixed soil improver".

The results achieved have led to new technologies and, consequently, investing in pre-treatment and anaerobic digestion phases that would considerably improve the existing intensive aerobic treatment.

Anaerobic digestion, which is also well-known in Italy for a long time for stabilisation of biological sludge, is not very popular in the treatment of waste of organic origin, on contrary to what is happening in the rest of Europe. Yet, the success story in Montello proves the opposite.

**Digesters: 45,200 m$^3$**

**Instaled power: 12.8 MW$_{el}$**

**Capacity: 342,000 t/y**

**Project under construction:** biomethane plant

**Organic fertiliser: 45,000 t/y**

**Employees: 98**

### Anaerobic digestion

The plant, located in Montello, consists of an initial waste pre-treatment phase, followed by anaerobic digestion and a subsequent aerobic composting phase of the digestate, coming from the dehydration of the digested waste, aimed at the production of quality organic fertilizer. The anaerobic digestion, on the other hand results in biogas production, that is used for generation of electrical and thermal energy.

The adopted process is WET type, in a continuous stirred tank reactor, or CSTR, with the use of the biogas produced by the anaerobic digestion process in electro-thermal co-generation groups.

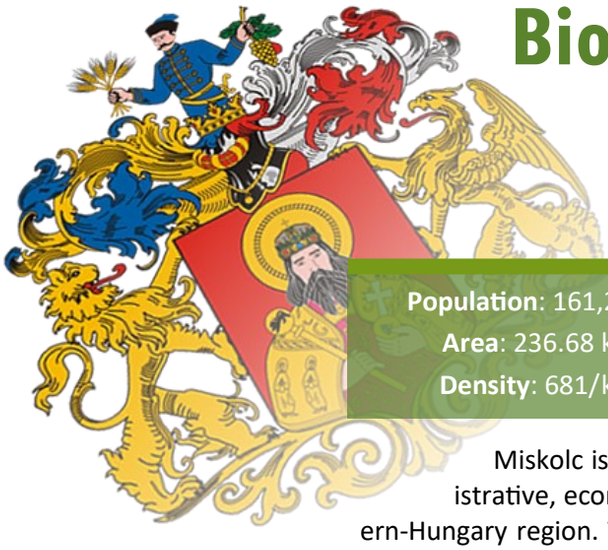
What comes out of the digesters are biogas, which it is then dehumidified and organic fertiliser used for urban areas and parks.

Of particular interest could be that there is a water collection system of first and second rains to decrease the consumption of water required for the process.

The Montello plant also has a project under construction that will result in biomethane production and its injection into the gas grid.

### Benefits from anaerobic digestion

The company has identified several advantages and benefits, such as energy production - maximum recovery of both electric and thermal energy, thanks to the high yield of the multi-phase process; wide field of application and flexibility, as the same plant can process different types of organic waste. Plant operation is entirely automatic, including the separation of unwanted components unsuitable for anaerobic digestion and composting. After all, organic material is converted into energy, contributing to a reduction of $CO_2$ emissions and consequently to a reduction of the greenhouse effect. The plant allows an annual saving of approximately 90.000 tonnes of $CO2_{eq}$.



# Biogas plant turns a problem into profit and benefit

## Miskolc, Hungary

**Population**: 161,265
**Area**: 236.68 km$^2$
**Density**: 681/km$^2$

**Total waste: 43,846 t**
**Household waste: 40,175 t**
**Commercial waste: 3,671 t**

Recyclable: 7,057 t
Non-recyclable: 30,718 t
Organic waste: 2,400 t

Miskolc is the fourth most populated city in Hungary and is known as the administrative, economic, scientific, educational, cultural and touristic centre of the Northern-Hungary region. The city is the seat of Borsod-Abaúj-Zemplén County located in the direct neighbourhood of three countries: Slovakia, Ukraine and Romania.

The mechanical treatment facility of the wastewater treatment plant was built in 1978 with 140,000 m3/d capacity. From 1989 to 1994, a biological treatment facility was built with 70,000 m3/d capacity. During 2014 and 2015, the plant was upgraded and refurbished enabling the removal of nitrogen and phosphorus. Currently, the daily amount of the wastewater is normally between 35,000 – 45,000 m$^3$.

Performance of the sewage sludge drying facility did not meet the expectations. The produced dewatered biological excess sludge and raw sludge were transported to a biogas plant in far for a long time. In parallel to the refurbishment, a city-owned biogas plant was established in 2015 enabling the in-site treatment of the sludge.

### Miskolc Biogas Plant

The Miskolc Biogas Plant was built on the sewage-treatment plant site in Miskolc between 2011 to 2014. The total investment cost was €7.8 million co-funded up to 91.5% by the EU and the Hungarian Government. The storage capacity of the two fermenters is 8,000 m$^3$ with the maximum power output of 875 kW$_{el}$. The plant produces biogas from excess-sludge and primary -sludge as well as electricity from biogas directly used within the wastewater treatment plant. The waste heat is used for heating the fermenters. The plant is operated by Biogas Miskolc Ltd., a company indirectly owned by the Municipality of Miskolc.

Currently, the average biogas production of 5,500 m$^3$/day which derives from sewage sludge only covers 80% - 92% of the electricity demand of the plant.

**Digesters: 2 x 4,000 m$^3$**
**Instaled power: 875 kW$_{el}$**
**Raw biogas: 5,500 m$^3$/day**
**Organic fertiliser: 45,000 t/y**
**Electricity production: 6.5 GWh/y**
**Heat generation: 6.4 GWh/y**
**Employees: 8**

### Anaerobic digestion

The plant inlcudes the initial waste pre-treatment phase followed by anaerobic digestion and a subsequent dehydration of the digested waste. It is a mesophilic one in two digesters at 36°C-37°C temperature.

The feedstock from three different sources comes into the homogenization tank in the pre-treatment phase: biodegradable waste, dehydrated sludge from the load station and a mixture of biological excess sludge and raw sludge as the output from the wastewater treatment and thickening process by a direct pipeline (5%-6% of the mixture). If necessary, pasteurization is achievable prior to homogenization. The biogas is produced in the digesters with the retention time of 18-23 days. The purified biogas is supplied to a locally deployed gas motor unit that produces not only electricity but also waste heat used for heating up the homogenization tank. The digested sludge is dewatered and currently used for reclamation. $FeCl_3$ tincture is used for desulphurization.

### Biowaste to the rescue - adding biowaste for increased production

A development project aimed at increasing the biogas production from 5,500 m$^3$/day to 8,000 m$^3$/day started at the end of 2015 and is planned to continue in 2016 through enhanced processing of biodegradable wastes (expired foods, food scrap, waste from milk industry, etc.). In 2016, the public transportation system will be upgraded by the acquisition of 75 new CNG buses which will be entering service in March 2016 replacing 40% of the total public bus fleet. A new CNG filling station is also being implemented, however the city's aim is to produce biomethane from biogas to be used as fuel for the CNG buses. The estimated yearly amount of gas required for the CNG fleet is around 2.05 million kg. Theoretically, 37.5% of the required gas could be covered by the biogas plant, but this may rise up to 65% after intensification.

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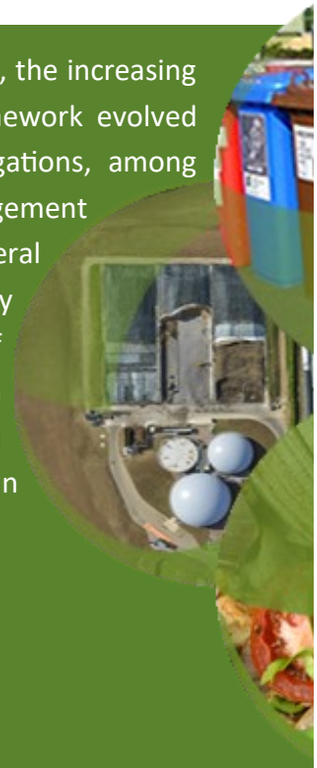

Since 1975, the European Union has been focusing on a common concern across Europe, the increasing amounts of municipal solid waste and how best to treat them. The EU's legal framework evolved considerably since then, establishing recycling targets and separate collection obligations, among several other measures, in an effort towards creating a more sustainable waste management system which minimises the impacts on our environment, economies, health and general well-being. Waste management is yet again in the spotlight of the latest Circular Economy Package, which was published in December 2015 and aims towards "closing the loop" of product lifecycles through greater recycling and re-use, and bringing benefits for both the environment and the economy. Under its new proposal for reform, the European Commission puts forward the following measures to be considered by the European Parliament and member states:

- A common EU target for recycling 65% of municipal waste by 2030;
- A binding landfill target to reduce landfill to maximum of 10% of all waste by 2030;
- A ban on landfilling of separately collected waste;
- Promotion of economic instruments to discourage landfilling

All across Europe, it is always the local authority who in charge of waste management as most of the municipal solid waste is generated by activities within their limits and competences. Many recycling technologies exist, but some new waste streams are emerging in high quantities which need to be properly treated. Without increased efforts and improvements coming from the local authorities, the newly imposed waste targets will remain far from being achieved.

The European Biogas Association brings you 6 cities which are already ahead of time in terms of biowaste management, including sewage sludge from waste waters. These cities have applied anaerobic digestion as the best option for the treatment of biowaste coming from urban activities as a share of the total municipal solid waste. The publication you have in your hands shows all the benefits and opportunities a biogas plant brings to the local authority including energy recovery through electricity and heat generation, replacement of fossil fuels used in public bus fleets, renewable biomethane available for use for the local communities through existing gas grids. These cities and regions are now getting all the attention from the European perspective as they are constantly and deservedly considered as the real examples of good practices and forerunners in sustainable waste management.