Abfallwirtschaftsbetrieb
München

Renewable Energy for Munich –
Green Electricity from Biowaste

The AWM Dry Fermentation Plant

Der zertifizierte
Abfallentsorger der Stadt

Renewable Energy for Munich – Green Electricity from Biowaste

With the production of environmentally friendly energy from kitchen and garden waste, the Munich Waste Management Company Abfallwirtschaftsbetrieb München (AWM) is breaking new ground in recycling Munich biowaste. The dry fermentation plant in the north of Munich uses the energy potential of Munich biowaste by processing it with the environmentally friendly method of dry fermentation.

AWM uses this new technology while accounting for the principles of sustainable management and practicing regional recycling management with a high value-adding chain. This is an essential contribution to protecting our climate and conserving resources.

The Dry Fermentation Plant – A Contribution to Sustainable Waste Management

Dry fermentation's innovative and efficient environmental technology complies with the principles of modern and sustainable waste management. The plant is allowed to treat up 25,000 tons of organic waste (kitchen and garden rubbish) collected through the brown bin. In 2011 2,600,000 kWh were fed into the grid, This was enough to provide 1000 Munich households with electricity, thereby saving 298,000 l of fuel. This is roughly enough electricity to satisfy the annual consumption demands of around 1,600 Munich households; this replaces about 375,000 liters of heating oil. The waste heat from the combined heat and power (CHP) plants (cogeneration plants) and the fermentation residues are also put to good use: the heat is used in the plant to heat various substance flows, and the fermentation residues are processed into finished compost which is then returned to the biomass cycle as valuable fertilizer. These aspects make the total concept both ecologically and economically attractive.

From Organic Waste to Green Electricity – AWM's Ecological Waste Management Concept

Munich, the capital of the German State of Bavaria, had already set the right course in 1989 with its ecologically oriented concept for cutting down on and recycling waste.

AWM set the standard for recycling Munich biowaste, when it introduced the three-waste-container system for those segments making up the largest quantity of domestic refuse: biowaste, paper and non-recyclable waste. Munich biowaste has been collected everywhere in brown containers since 1999; until 2008, it was predominantly recycled in private composting plants.

AWM has coupled a plan by stages with its waste management concept for optimized disposal of biowaste. The resulting plans for a separate biowaste treatment plant led to an innovative research and development project in 2003. The company BEKON Energy Technologies GmbH & Co. KG and AWM conducted a joint pilot project, "The Use of Dry Fermentation for Treating Munich Biowaste", on the waste depot Entsorgungspark Freimann. During the three-year test, it was proven that Munich biowaste, with its low percentage of interfering substances, is well-suited for this method.

Renewable Energy for Munich – Green Electricity from Biowaste

Equipped for the Future

Today's recycling concept for Munich biowaste is characterized by high disposal reliability. With the dry fermentation plant's annual capacity being 25,000 tons and an average annual input of approx. 40,000 tons biowaste from brown containers, the plant's potential is fully exploited. Biowaste quantities exceeding this level are recycled through the Munich district fermentation plant and private composting plants.

Having its own dry fermentation plant makes AWM more independent of market conditions for biowaste recycling. A further plus: The Erneuerbare-Energien-Gesetz (EEG - German Renewable Energy Sources Act) provides a long-term guarantee of compensation for electricity produced from biomass. The use of combined heat and power (CHP) generation is also compensated and a technology bonus is granted for the innovative dry fermentation.

AWM Facts & Figures

As a municipal waste management company, AWM offers comprehensive disposal services for all citizens of Munich, the capital of Bavaria. Its strength lies in the combination of technical, ecological, economical and social skills.

Each day, nearly 1,300 employees and civil servants ensure that Munich's waste disposal runs smoothly. AWM counts property managers and private households among its customers, along with commercial enterprises, public facilities and other regional administrative bodies. Each week, Munich's garbage collectors empty more than 395,000 containers of non-recyclable and recyclable waste in the three-container system.

AWM Facilities:
– 4 work yards
– 12 recycling centers
– Second-hand department store "Hall 2"
– Fleet with 220 garbage trucks
– Waste management facility with dry fermentation plant and landfill
– Waste incineration plant

These services are supplemented by pick-up services for bulk waste, a container service, a chaffing and composting service, the 15plus service, container cleaning and many others. Comprehensive waste consultation through the Info-Center hotline, the internet, and brochures round off the offer.

The AWM Dry Fermentation Plant

The Munich based company BEKON Energy Technologies built a large-scale pilot plant for dry fermentation of biowaste on the waste depot Entsorgungspark Freimann with the support of Abfallwirtschaftsbetrieb München.

The pilot system with four digesters (biowaste reaction chambers) was completed July 2003. Initially, the plant processed 6,500 tons of biowaste per year. By May 2006, this amount had increased to approx. 9,500. The annual output of the test system most recently generated 930,000 kilowatt hours electricity, i. e., enough to supply energy to around 400 Munich households.

Plant Expansion

AWM took over the BEKON research and development plant in April 2006. The positive results in processing biowaste convinced the City of Munich to buy and further expand the existing plant. The number of digesters was increased from four to ten. AWM invested approximately 5 million euros in the plant expansion.

Since the end of 2007, up to 20,000 tons of biowaste are recycled annually with the new technology. This corresponds to two-thirds of the biowaste collected from the biowaste containers in Munich.

The dry fermentation plant is distinguished by the simple and compact construction of its digesters, and, hence, of the entire plant. Its modular design with various digesters allows plant expansion without major expenditures, should the capacity be increased sometime in the future.

Biowaste collection – AWM collects approximately 40,000 tons per year

The Process behind Dry Fermentation of Biowaste

The BEKON Company has continuously optimized the dry fermentation technology since it first built the City's pilot plant in 2003. The company meanwhile holds a number of patents on this technology.

The Process: The biowaste begins to ferment anaerobically in closed, airtight fermentation containers, called digesters. Special bacterial cultures produce biogas during the process.

The material to be fermented is constantly kept moist, creating optimal living conditions for bacteria. The liquid that issues from the fermentation is collected and fed back into the digesting matter from above, which means it is repeatedly inoculated with bacteria, so that the fermentation process is constantly kept going.

Technical Plant Data

- Allowed capacity
- Substrate throughput at 90 % availability: 22,500 tons p.a.
- Volume of the 10 digesters: 7,500 m³
- Potential bio gas yield: approx. 1,800,000 m³ p. a. using 25,500 t of substratum
- Combined heat & power plant (CHP) electric output: 3 x 190 kilowatt (electric)
- Potential electricity yield: approx. 3,400,00 kWh p. a. (with 5.5 KWh/m³ biogas energy content and a 38 % degree of efficiency (electric) for the CHP plant)
- Fermentation residues for further processing: around 17,000 tons p.a.
- Finished compost produced: 9,000 tons p.a.

Method Advantages

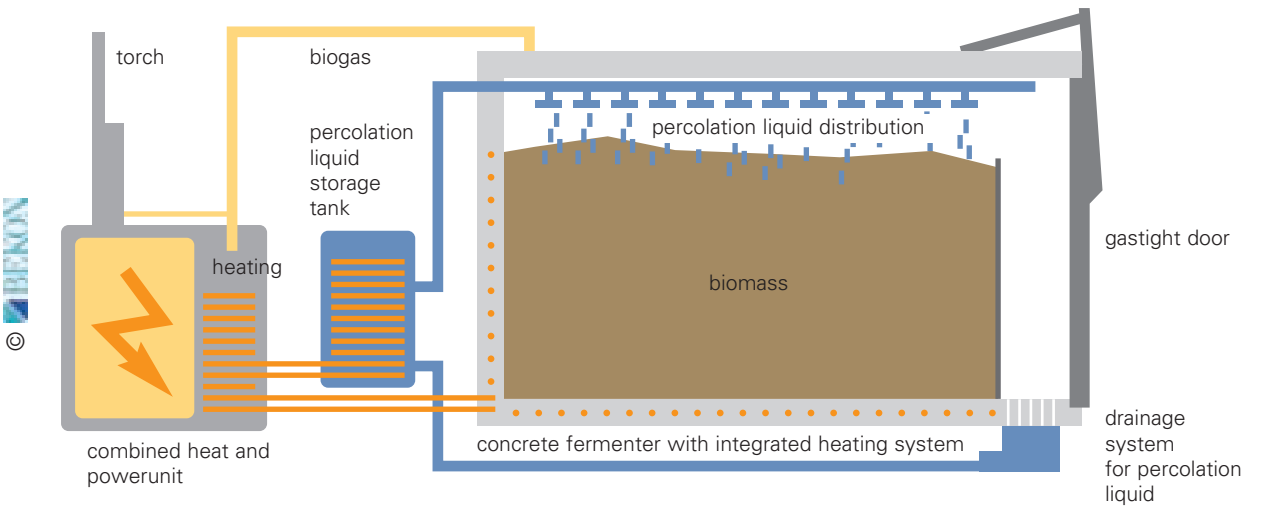
The applied dry fermentation technology allows digestion of relatively dry biowaste with up to 50 % dry matter content. Fermentation plants that work with "wet fermentation" were originally used in agriculture, to ferment liquid and solid manure. Unlike dry fermentation, wet fermentation requires that the waste matter be transferred to a pumpable, liquid substrate.

In dry fermentation, the material to be fermented is either not chopped at all or only roughly chopped. As a result, far fewer machines are required than in wet fermentation plants. The plant has no moving parts, since the material does not have to be mixed. This has a positive impact on operating costs: Wear and tear and maintenance costs are low. Energy consumption in the dry fermentation plant is considerably less than that of a comparable wet fermentation plant.

The process is practically emission-free. This benefits the environment and AWM, for this guarantees that there will be no need for retrofitting, should new pollution laws be enacted, even in the future. And the neighborhood in the north of Munich around the Entsorgungspark Freimann site also profits from the environmentally friendly plant: The receiving area is indoors, and the odor intense phase takes place in a closed system (the digesters). The result: almost no odor emission.

Method advantages at a glance:
- Simple technology
- Low maintenance costs
- Low process energy consumption
- Low susceptibility to interfering substances, such as foils or woody or fibrous constituents
- Greatly reduced emission

The Dry Fermentation Process



Plant Workflows

The digesters are run in so-called batch operation. This means: Once biomass is filled into the digesters, it remains there until the end of the retention time, without further material being added or removed. The plant is remote controlled by a computer supported operational control system.

Filling the Digester

The biowaste that is delivered is mixed with material that has already been fermented and then filled into the digester with a wheel loader.

Each chamber holds 370 to 450 tons of biowaste. To ensure that there is always enough biogas for the combined heat and power plant, a number of digesters are operated simultaneously in progressive stages. Two of the plant's digesters are filled each week.

The digester gates open upwards, which prevents a wheel loader from accidentally colliding into a gate and damaging it during filling and clearance.

Once filled, the digesters are sealed with hydraulically operating gas-tight gates. An inflatable sealing lip attached to the gate provides the gas-tight seal for the digester. Before the gate is opened, the air is again let out of the seal.

Fermentation of Waste in the Digester

Various decomposition reactions take place within the digester. The most important processes are: hydrolysis, acid formation, and methane formation. Cell water (percolate) is released during hydrolysis. The percolate contains an easily degradable organic substance and bacteria, and

represents a valuable natural catalyst in the procedure. The percolate is caught on the bottom of the digester and temporarily stored in a tank (see above photo). Here it is kept warm and then reused to spray the biomass. During the biomass's entire retention time in the digester, the percolate is kept in circulation, allowing the fermentation process to continue.

The fermentation process takes place at a mesophile temperature ranging from 34 to 37° C. Integrated bottom and wall heating in the digester maintains this temperature. A heat exchanger can also be used to thermally adjust the added percolate. This allows optimal, economic control, since the heating energy is self-supplied by the waste heat from the incineration process in the combined heat and power plants (see: Electricity & Power Production from Biogas).

The biowaste spends 4 to 5 weeks in the digester, depending on the quality and condition of the substrate and the time of year. At the end of the detention time, the fermentation chamber is completely emptied and then refilled.

Composting Fermentation Residues

At the end of the fermentation process, the fermented biomass is removed with the wheel loader. The biomass then enters a downstream composting process, without further processing or additives. The fermented biomass leaves the digesters at decomposition stage 3 to 4. Further decomposition then takes place near the plant, on a covered area with a sealed bottom. Because the low-structured fermentation residues contain a high content of moisture they have to be drained using a mattress of shrub cuttings. To reach the necessary temperature for the hygienization of the fermentation residue the input of structured material is mandatory. Through this process decomposition stage 5 is reached. After several filtering processes a high-quality product is generated. The finished compost is subject to strict quality assurance by the Bundesgütegemeinschaft Kompost e.V. and bears the RAL quality mark. There are various possibilities for using the finished compost, thanks to its high quality. Private use and use in gardening are both possible, as is agricultural use.

Compost piles: fermentation residues are stacked

Electricity & Power Production from Biogas

The ten digesters at the plant continually produce biogas throughout the year. Approximately 13 % of the biomass used is converted in the process, with the methane content of the biogas amounting to roughly 50 to 60 % by volume.

The biogas accumulates in the digester above the fermenting substrate, where it is temporarily stored during fermentation. Costly external gas storage is not necessary, since the combined heat and power plants are regulated according to the gas that is available. The biogas produced from the biowaste is dried, and then the gas quality and quantity are measured. A gas control path, a gas compressor and an activated carbon filter for desulfurization are used to feed the biogas to the three combined heat and power plants. Even though the sulphur content is low, (attributed, above all, to the fact that, in Munich, primarily raw plant waste and not food and animal waste (protein carriers) are disposed of in the biowaste container), the specifications of the combined heat and power plants make a reduction of sulfur necessary.

The biogas is completely converted into electricity in three combined heat and power plants, each with 190 kilowatts (electric). In case of malfunction emergency, the biogas is burned by the excess gas burner (torch). The biogas burns completely in the combined heat and power plants, where an electricity supplying generator is driven producing alternating current. The generated electricity is fed into the public network.

The waste heat produced during combustion is optimally used by the combined heat and power plant. It serves as process heat and dries the various substances in drying boxes set up especially for this purpose.

The core of the plant: the garage-like digesters

Marketing the End Products

Dry Fermentation of Biowaste Creates Valuable Products with Definite Return on Investment

Process End Products

Biogas
The Munich pilot plant has been supplying biogas since 2003. Up to 50 to 60 % of the gas mix volume is made up of high-energy methane. Further components are carbon dioxide (40 to 45 % by volume) and traces of hydrogen sulphate, nitrogen, hydrogen and ammonia. Biogas serves as the energy source for producing renewable energy. It is turned into electricity and heat in the combined heat and power (CHP) plant.

Electricity
Three combined heat and power plants, each with 190 kilowatts electric output, generate the electricity. The dry fermentation plant's ten digesters together supply enough biogas to generate approximately 3,400,000 kilowatt hours of electricity per year. This is roughly enough electricity to satisfy the annual consumption demand of about 1,300 Munich households. Biogas from biowaste, as a renewable energy source, is funded in accordance with the Erneuerbare-Energien-Gesetz (EEG – German Renewable Energy Sources Act). For the electricity produced in the expanded plant, AWM receives a basic payment, a CHP bonus (see "Heat Output") and a technology bonus of 2 cents per kilowatt hour, pursuant to the 2004 version of the EEG law. This funding is far better than that of the existing plant's compliance with EEG 2000. The increased payment for feeding the electricity is guaranteed by the EEG act for a period of 20 years. Since 2009 the AWM gets an additional 1 Cent/kWh because of the minimal noxious emmissions of the combined heat and power plants.

Heat Output
The heat is used as process heat to warm the plant and the adjacent commercial building. A further portion of the heat is used to dry the sieve residue and further substance flows. This combined heat and power generation is particularly encouraged by the EEG (CHP bonus).

Combined heat and power plants (CHP)

Compost
The finished compost is certified by the federal quality assurance association Bundesgütegemeinschaft Kompost e.V.
Since fall 2008, the ecological premium product is also offered in smaller quantities as Munich Potting Soil, ("Münchner Blumenerde"). The compost is mixed with

special substrates and long-lasting fertilizers, using a long-tried recipe. "Münchner Blumenerde" is suitable for house and terrace plants and is sold in 45-liter sacks at selected recycling centers

The AWM is currently setting up a system of regional soils like special topsoil for gardens or balcony plants. Starting in 2012 loose soil in bigger quantities will be sold at the waste depot Entsorgungspark Freimann.

Through the use of local aggregates logistic and energy costs are saved. Because the basis for the Munich Soils ist the high qualitiy compost produced by the AWM, the percentage of turf and fertilizer is much lower compared to conventional soil. This substitution of turf and fertilizer saves energy and is an important contribution to the protection of marshes and the climate.

The Dry Fermentation Plant's Contribution to Environmental Protection

Not only Munich citizens benefit from dry fermentation to recycle their biowaste: Many small, individual units within the plant's overall concept contribute to environmental protection and once again attest AWM's ecological approach to dealing with waste produced in daily life.

One particular focus, here, is the regional concept – from collecting waste in nearby Munich districts to avoid long transport paths, to producing biogas as a renewable energy source and then feeding the energy into the public power supply system, to marketing the finished compost at the Munich recycling centers. All of the procedure's end products – energy, heat and compost – remain in the Munich area. They are used locally, with large ecological and economical benefits.

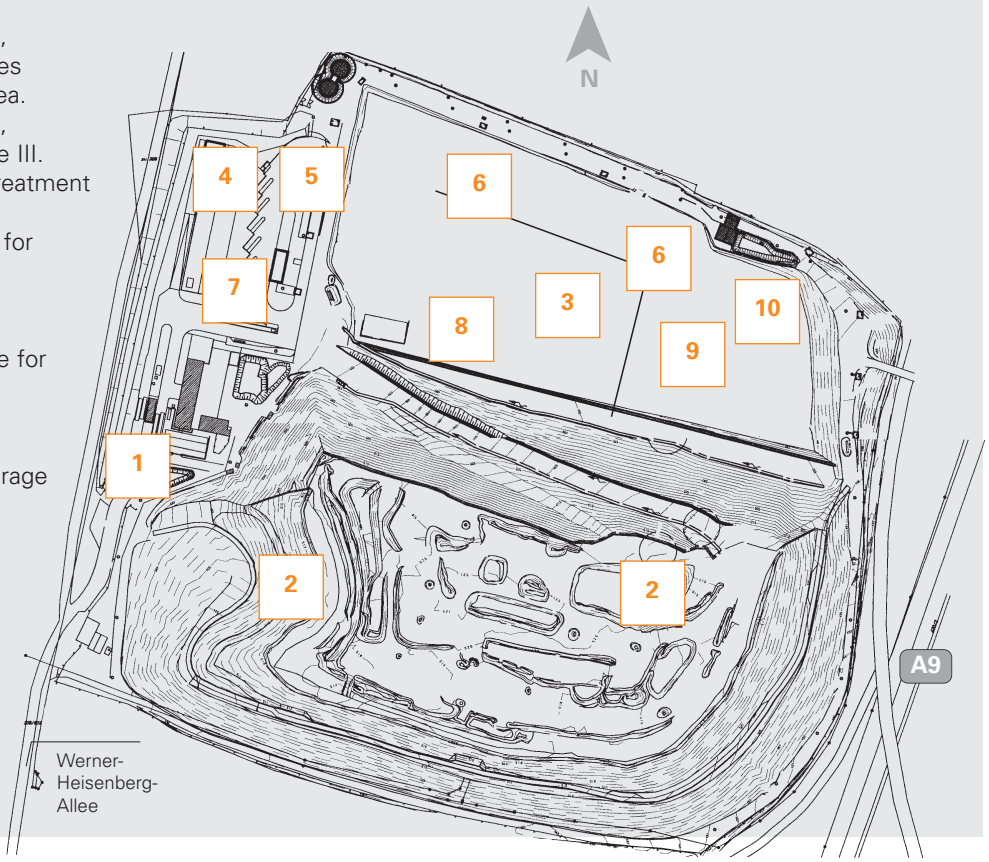
By using the dry fermentation technology, AWM creates a closed cycle for recyclable materials, thereby reducing energy consumption, emissions and costs. In addition, fermentation allows 20 to 25% reduction of organic waste mass, and the final composting step results in further reduction of about 50 %. This allows for further reduction of the great magnitude of Munich biowaste by over 50 %.

Structural features of the plant also contribute to resource conservation. Rain water that falls on the building roofs, for example, is collected and used to moisten the nearby landfill in the Entsorgungspark Freimann.

With the production and energetic exploitation of biogas, AWM also contributes to climate protection, since green electricity reduces the use of fossil fuels, such as coal, petroleum and natural gas. The innovative technology also reduces uncontrolled discharge of methane into the atmosphere as the biomass decomposes. Thus, dry fermentation makes a significant contribution to climate protection.

AWM supports the Federal Ministry of the Environment, the Bundesumweltministerium, in reducing CO_2 emissions in Germany. In line with the current discussions on greenhouse gas reduction and climate change, AWM commissioned the environmental institute bifa in 2007 to assess the effects of Munich waste management CO_2 reduction from 1997 to 2006. The detailed results are summarized in the brochure "Erfolge des Abfallwirtschaftsbetriebes München beim Klimaschutz" (Abfallwirtschaftsbetrieb München's Successes in Climate Protection"). Consequently, the dry fermentation plant for Munich biowaste is a further important contribution to climate protection.

1) Scales
2) Northwest landfill, construction stages I and II, landfill area.
3) Northwest landfill, construction stage III.
4) Leachate water treatment plant.
5) Reloading station for biowaste.
6) Bale storage.
7) Recycling center, future point-of-sale for Munich Soils.
8) Plant for dry fermentation.
9) Interim waste storage area in case of emergency.
10) Transfer point for asbestos mineral fibre.



Site of the Dry Fermentation Plant

Address:
Entsorgungspark Freimann –
Trockenfermentationsanlage
Werner-Heisenberg-Allee 62,
80939 Munich, Germany

Driving Directions:
Highway A9 heading to Nurnberg, exit Fröttmaning; follow the "Entsorgungspark Freimann" signs. Please note that tours must be arranged in advance.

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Construction of the expanded dry fermentation plant was supported by a one-time subsidy of 50,000 euros from the German Department of Health and Environment within the framework of awards for innovative measures (biomass / renewable energy).

1st Construction Stage:
Construction Start on pilot plant: 2003
Completion of pilot plant: June 2003

2nd Construction Stage:
Construction start on the expansion: January 2007
Commissioning of the expansion: December 2007

Official Opening: February 14th, 2008

AWM®

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