Addition of an Anaerobic Treatment Stage to MBT Plants – Based on the Example of Rostock

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Since 1 June 2005, it has been mandatory to treat municipal waste before landfilling. This pre-treatment aims to render the waste inert in order to avoid reactions in the landfill. Two pre-treatment technologies have become established in Germany: the thermal treatment of refuse in waste incineration plants and mechanical-biological treatment (MBT).

In Germany, a large number of MBT and waste incineration plants are available for the pre-treatment of municipal waste. 25% of the residual municipal waste is treated in 46 waste incineration plants (DOEDENS et al., 2007).

Waste incineration plants destroy organic substances as well as other combustible components of waste and use their energy content.

MBT plants usually separate waste into combustible fractions, mainly plastics, which can be thermally used in specific plants, and another fraction, which mainly consists of natural organic components and is treated aerobically in most cases.

In principle, mechanical(-biological) treatment processes have proven their functionality. Technical difficulties which arose during operation of such plants have meanwhile been solved to a considerable extent. However, there remains a need for optimisation in some plants and regarding certain parts of the MBT-technology (THOMÉ-KOZMIENSKY and THIEL, 2008).

At the beginning of the 1990s, the city of Rostock started thinking about the future of its waste management. 1993 saw the introduction of the German TASi regulation [Technical Instructions on Waste from Human Settlements] which stipulated the construction of pre-treatment plants by 31 May 2005. In May 1994, the EVG [Entsorgungs- und Verwertungsgesellschaft mbH Rostock – waste disposal and recycling company Rostock] was founded.

A board of consultants from various backgrounds (economy, associations, administration, environmental associations and the University of Rostock) works for the EVG and discussed possible solutions. The main question was whether to build a waste incineration plant or a MBT plant.

In May 1996, a call for proposals for the treatment of the residual waste of the city of Rostock and surrounding districts was published, addressed at technology providers all over Europe.

In June 1997, the city parliament decided on the construction of a residual waste treatment plant comprising mechanical-biological and thermal treatment at Rostock-Seehafen.

In September 1998, a waste disposal agreement was concluded between the EVG mbH Rostock and the Hanseatic city of Rostock.

The approval procedure started in December 1998 and the permit pursuant to BImSchG [German Federal Immision Control Act] for the construction and operation of the RABA [residual waste disposal plant] Rostock was granted in September 2000.

In January 2004, the city parliament of Rostock decided on a major change in the concept: the MBT plant was still to be built, but plans for an incineration facility under the responsibility of the EVG were cancelled. The **Vattenfall** Europe New Energy GmbH is currently building an RDF-fired thermal power station next to the MBT plant.

The foundation stone for the MBT Rostock was laid on 27 May 2004; operations commenced on 1 June 2005.

A fermentation facility as an addition to the MBT plant was commissioned in July 2008.

Plant Technology

The mechanical-biological waste treatment plant Rostock has been operated by the EVG since 1 June 2005. Domestic refuse from the Hanseatic city of Rostock and the districts Bad Doberan, Güstrow and Nordvorpommern is treated there. Approximately 120,000 Mg of waste are delivered and treated per annum.

In a first step, the domestic waste is treated mechanically (screening, classifying, sorting out of ferrous and non-ferrous metals, separation of plastics). Recyclable material is separated and the processed, organic fine fraction is then treated biologically.

So far, two types of final products have been derived from the refuse. Firstly, refuse derived fuel (RDF - approx. 40% of the total output), and secondly, disposable landfill material (approx. 50%) as a result of composting processes. RDF is produced in different sizes and is used as a substitute for coal in cement and power plants. One of the buyers is the Nehlsen thermal power station in Stavenhagen, which uses high-quality RDF to produce energy for the adjoining Pfanni factory. From the 2nd quarter of the year 2009, all RDFs will be delivered to the Vattenfall RDF-fired thermal power station which is being built right beside the MBT plant.

The organic refuse components are stabilised within 10 weeks, using a combination of intensive decomposition and post-maturation. The material resulting from this process is then deposited on landfills. The decomposition process requires a constant aeration of the material in the decomposition reactors. A cooling system is needed to control temperatures during the decomposition process. Furthermore, all exhaust air must be cleaned through post-oxidation before emission into the environment. Each of the three components is highly energy- and thus cost-intensive. In addition, the organic fraction still contains unused energy after the aerobic treatment.

The high energy costs and the so-far unused remaining energy of the biogenic material led to the decision to introduce a future-oriented and environmentally acceptable additional stage in waste treatment: energy generation through fermentation, this in the wake of a reassessment of the waste flows.

The new additional fermentation facility uses technology by KOMPOGAS and increased the input capacity from 120,000 tons to the now permitted 135,000 tons of refuse per annum. This was made possible by the fact that through the fermentation process, biological degradation already takes place before intensive decomposition and thus reduces the pollution to be treated with RTO (Regenerative Thermal Oxidation, used for exhaust air cleaning), the weak point of the process so far. After comprehensive tests, the facility was commissioned in the 1st quarter of 2008.

The feeding of the fermentation facility requires a change of the material flow in the separation process of the MBT plant. Half of the biomass which used to be fed into the intensive decomposition reactors before the introduction of the new facility now has to be fed into fermentation. This can be done by feeding the organic material into a catch bin after the separation of hard material. On the other hand, sedimenting material is fed directly into the rotting tunnel after the separation of non-ferrous metals.

Automatically controlled conveyor belts carry the highly organic material - in evenly distributed cycles - from the catch bin into the three horizontal fermenters. An automatic agitator mixes the material in the fermenters, which comprise a volume of 1,200 m^3 each. The fermenters provide an anaerobic environment with an average water content of 75% and a relatively constant temperature of 53.5°C (128.3°F), thus offering optimum conditions for the production of biogas. The material remains in the fermenter for 10 to 12 days.

The desulphurised biogas is then used by two gas engine-operated CHP stations (2 x 625 kW electric) to generate energy and heat. This way, 12,000 MWh/a electrical energy are fed into the public grid by the EVG.

The waste heat of the CHP stations is used to heat the fermenters and adjoining building parts. A complete use of thermal energy, both of the CHP stations and the waste gas heat, will be achieved with the commissioning of the Vattenfall thermal power station where it is fed into the steam cycle.

Fermentation residues are carried off via a combined wet/dry-discharge and are subsequently united with the other organic components for rotting. This process optimises the subsequent decomposition.

In addition to the treatment of the biological part of domestic waste, food that has passed its shelf life and leftovers may also be added. The yearly input of leftovers from meals amounts to 4,000 tons.

The overall concept of the plant at the seaport is completed by the RDF-fired thermal power station which is expected to be commissioned by Vattenfall Europe New Energy Ecopower Gmbh in the 1st quarter of 2009. Exhaust air, which so far had to be cleaned and burnt (RTO) at the EVG's expense, and RDFs will be delivered to this station in the future. This also enables the recovery of energy of methane (approx. 0.1% of exhaust air) produced in the aerobic stage.

The EVG uses state-of-the-art technology to generate energy from waste in an environmentally friendly way and recovers energy from RDFs without creating further pollution through transportation. This makes the EVG a pioneer well beyond the borders of Mecklenburg-Western Pomerania. MBT, fermentation and the thermal power station allow for a complete energy recovery and together constitute one of the most modern waste management sites in Germany.

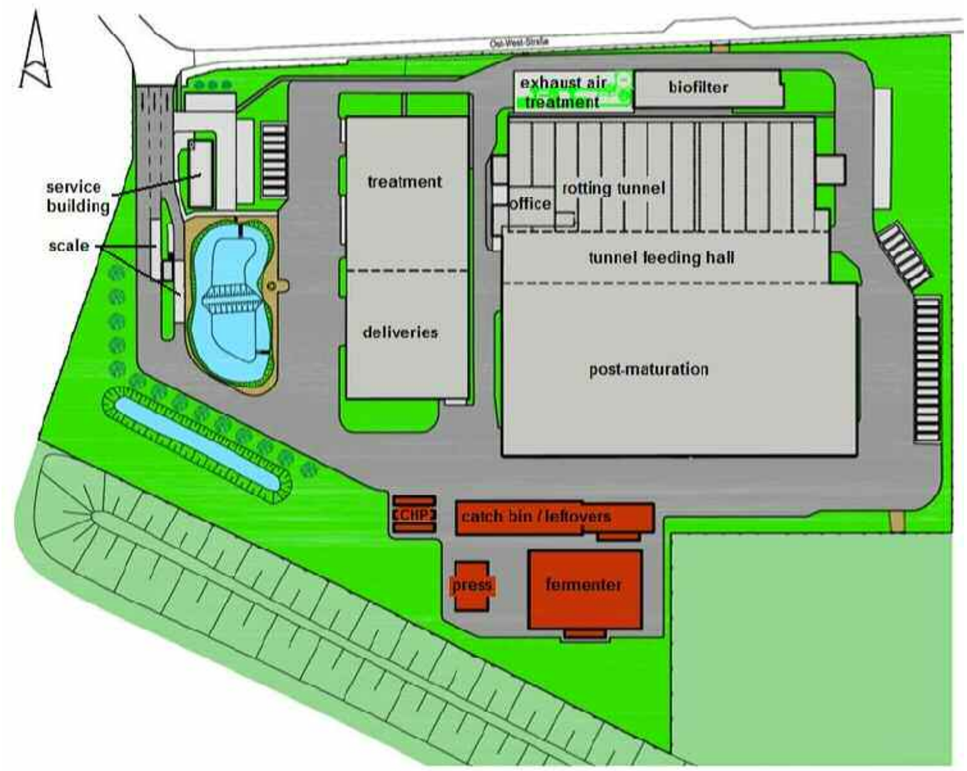

Figure 1: Layout plan of the MBT plant with aerobic and anaerobic treatment facilities

The functional principles of the MBT plan are outlined in the following flow chart (figure 2):

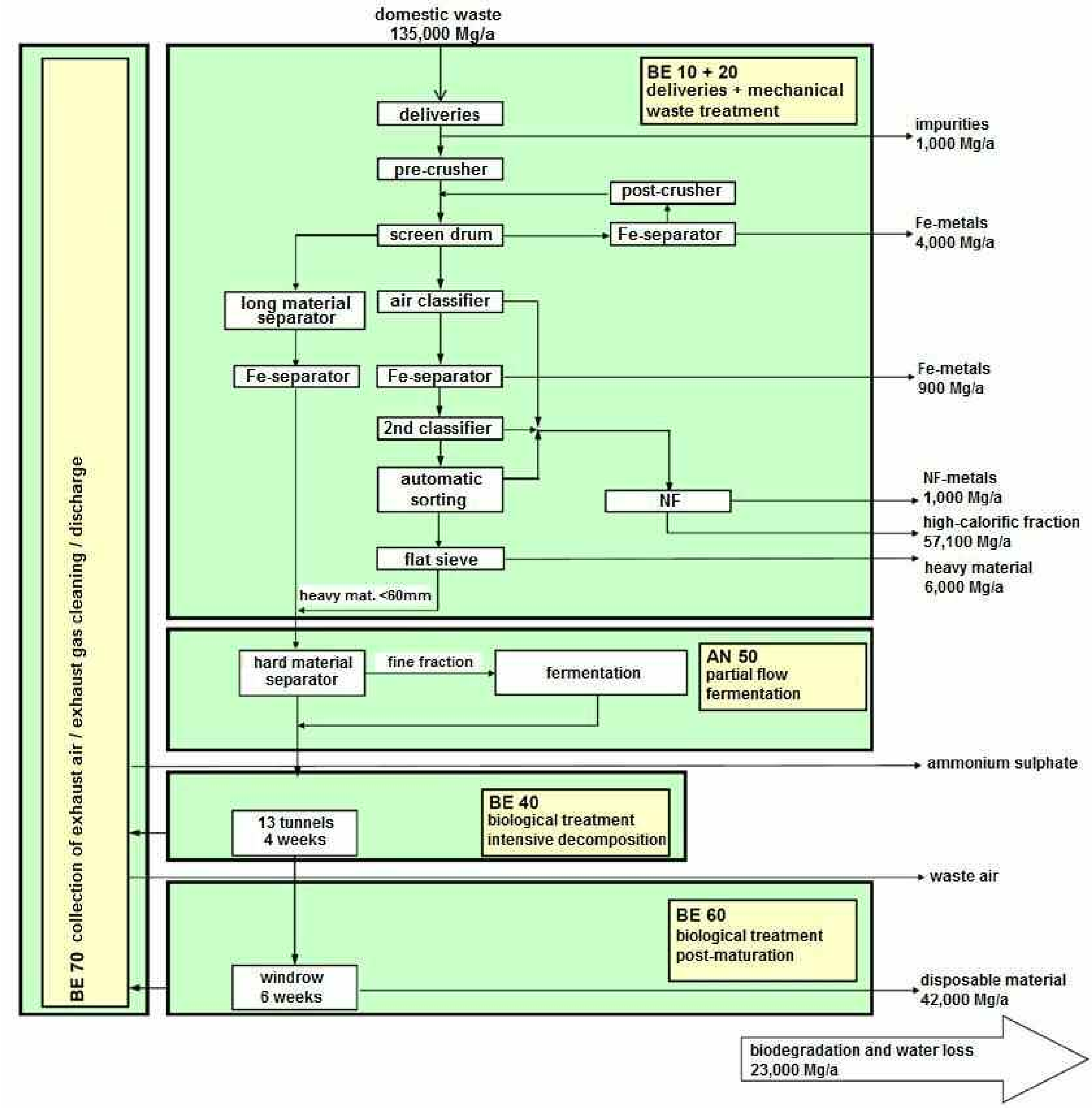

Figure 2: Process flow chart of the MBT plant Rostock

The operating units (BE) shown in figure 2 are explained below:

BE 10 + 20 delivery + mechanical waste treatment

- encapsulated delivery and preparation hall
- single-line layout: organic line
- crushing aggregates
- classification of the waste flows
- use of air classifiers and AutoSort systems

AN 50 partial flow fermentation

- hard material separator

- fermentation

BE 40 biological treatment – intensive decomposition

- encapsulated rotting tunnel (13 tunnel modules, air circulation with cooling, rotting period 4 weeks)

BE 60 biological treatment – post-maturation

- closed windrow (rotting period 6 weeks); objective: observation of storage criteria pursuant to AbfAblV [German Waste Storage Ordinance]

BE 70 collection of exhaust air / exhaust gas cleaning / discharge

- separated collection and redirection of exhaust air from hall areas and highly or lightly polluted process exhaust air from areas of biological treatment
- use of air circulation as far as possible to reduce volumes
- treatment of highly polluted process exhaust air with a combination of acid scrubber and RTO
- treatment of lightly polluted process exhaust air with a combination of air humidifier and encapsulated biofilter
- discharge of exhaust air via stack; objective: observation of emission limit values pursuant to 30th BImSchV [German Federal Immission Control Ordinance]

What is the point of adding fermentation to the MBT plant?

Between 1990 and 2003, the waste management industry succeeded in reducing CO_2-equivalent emissions by approximately 45 million tons per year. This makes up almost 20% of the total reduction in Germany (TROGE, 2007). The federal government is planning to raise the share of renewable energies in Germany to 16% by 2020. The waste industry's biogas plants will and must make their contribution too. Switching from aerobic to anaerobic treatment or respectively adding anaerobic stages to existing plants is supposed to play an increasing role in the generation of electric power. From the authors' point of view, this only makes sense with regard to ecological aspects if the waste heat of electricity generation is used as well.

As regards the addition of anaerobic treatment to MBT plants, the following possibilities are conceivable. However, operational experience differed considerably.

- with partial flow dry fermentation (reliable in operation)
- with full flow dry fermentation (process water treatment after dewatering of fermentation residues)
- with full flow wet fermentation (percolation, demanding, facilities in Heilbronn and Buchen decommissioned) (DOEDENS et al., 2007)

In its Environmental Report 2008 “Environmental protection in the shadow of climate change”, the German Advisory Council on the Environment (SRU, 2008) underlines the benefits of adding anaerobic treatment to MBT plants.

In aerobic processes, the energy content of organic material is fully converted into unusable heat. The different possible combinations with anaerobic partial or full flow concepts, however, allow for a recovery of energy. Fermentation can thus contribute to an improved economic and ecological situation of MBT plants (SRU, 2008).

Subsidisation pursuant to the EEG [German Renewable Energy Sources Act] is not earmarked for mixed municipal waste. § 8 of the EEG refers to ‘recognised biomass’ according to the German Biomass Ordinance; mixed municipal waste does not belong to this category (BiomasseV § 3 no. 3). According to § 3 (1), the EEG promotes energy generation from biomass. The use of biomass in the context of fermentation as a part of MBT is now being subsidised increasingly. The MBT plant Rostock receives aid, too.

Following the separation of native organic material, individual waste code numbers can be allocated. Due to the separation, the refuse fed into fermentation no longer falls into the category ‘mixed municipal waste’. The native organic fraction is allocated the waste code number (AVV-Nr.) 191212, no mixed municipal waste is involved here (TISCHER and GASSNER, 2006).

§ 2 (3) no. 5 of the German Biomass Ordinance stipulates: “Without prejudice to paragraph 1, the following are biomass [...] Biogas produced through anaerobic fermentation [...].” This enables subsidies.

§ 3 of the act on granting priority to renewable energy sources (EEG) gives another definition of ‘renewable energies’: “[...] energy from biomass, including biogas, landfill gas and sewage treatment gas, as well as the biodegradable fraction of municipal waste and industrial waste.”

§ 64 of the new EEG furthermore states “that the entitlement to payment of a tariff for electricity from biomass shall only apply where proof can be furnished that [...] when generating the electricity from the utilised biomass, a certain reduction in greenhouse gases is achieved.” This reduction is subject to proof.

In the statement of reasons for the new EEG, the future general entitlement of MBT plants to remuneration is explained as follows:

“The term ‘biomass’ is not conclusively defined in the legal text. [...] The general term ‘biomass’ as used at this point includes biogenic energy sources in solid, liquid or gas state of matter. In general, these are biodegradable products, residues and waste from vegetable or animal origin from agriculture, forestry and related industries.

[...] The explicit statement that biomass in this context also includes biogas originates from Directive 2001/77/EC of the European Parliament and of the Council on the promotion of electricity from renewable energy sources where biogas figures as a separate renewable energy. [...] In further implementation of Directive 2001/77/EC, the biodegradable share of industrial and municipal waste is also defined as ‘renewable energy’. Additionally, it must be taken into consideration that only the part of electricity generated from the defined material is subject to the enlarged scope of application of the law. Furthermore, it must be noted that the principle of exclusiveness still applies to the payment of a tariff and that electricity generated from mixed industrial and municipal waste will not be remunerated in the future either.”

The EVG’s Fermentation Stage

In recent years, the general ecological conditions for anaerobic technologies have improved decisively due to technological developments and the Renewable Energy Sources Act [EEG] (TURK et al., 2008).

In Rostock, a partial flow fermentation facility and a CHP station were added to the existing MBT plant. This enabled an increase of its input capacity from 120,000 t/a to 135,000 t/a. Reserves for seasonal fluctuation and additional processing options for organic waste are set up. The fermentation stage is aimed at recovering the energy of biogenic mass. Therefore, half of the biomass which used to be fed into the intensive decomposition reactors is now treated in the fermentation facility.

The generated biogas is then used by a gas engine-operated CHP station to produce electricity and heat. The electricity generated in the CHP plant (12,000 MWh/a) is fed into the grid. The residual heat is used for preheating and drying on the site. The fermentation stage reduces the effort for exhaust air cleaning in the following rotting process.

The EVG’s MBT plant in Mecklenburg-Western Pomerania is the first to use municipal waste for biomass fermentation and to recover energy in this environmentally friendly way. In combination with the RDF-fired thermal power station, which is operated by the Vattenfall Europe New Energy GmbH, a comprehensive energy recovery is achieved through fermentation at Rostock-Überseehafen. Even the plant’s exhaust air, which so far had to be cleaned and burnt using regenerative thermal oxidation, will soon be burnt together with the refuse derived fuels produced on site. The proximity of MBT plant and thermal recovery adds further ecological and economical advantages.

The investment volume for the fermentation facility was 8 million euros. This investment formed the basis for stable costs and reliable waste disposal.

In this way, the EVG covers its own energy consumption and additionally feeds 3,700 MWh/a into the public grid. The waste heat of the CHP stations is used to heat the fermenters and adjoining building parts. The complete use of the thermal energy is covered by a contract starting in 2009.

Fermentation residues are carried off via a combined wet/dry-discharge to the rot.

The Fermentation Unit - KOMPOGAS Dry Fermentation

Existing aggregates like screens, shredders and magnetic separators can be used for the preparation of the material. They crush the delivered material, free it from magnetic matter and screen it down to a particle size of less than approx. 60 mm. The screened material is fed into the catch bin. Oversize material can be crushed again or be fed into another recycling line (e.g. RDF...). The treatment is supposed to only crush material if necessary. If possible, leftovers from meals, biowaste etc. should exclusively be screened in order to maintain the actual material structure.

The basic principle always remains the same: the horizontal plug-flow fermenter that guarantees a very high energy efficiency and maximum reliability of operation. It can be fitted into MBT and composting plants as a standardised module construction (ZEIFANG, 2008).

The process temperature is 55°C (131°F), i.e. within the thermophilic range. Waste heat from the CHP station delivers the heat required for the treatment.

The digested material is pressed for further conditioning and thus separated into a liquid fraction (re-circulated material) and a solid fraction (raw compost). In most cases, the re-circulated material is used for mashing the new material so that no supplementary extern liquids are required.

The continuous mode of operation enables a stable generation of biogas (Universität Rostock et al., 2007).

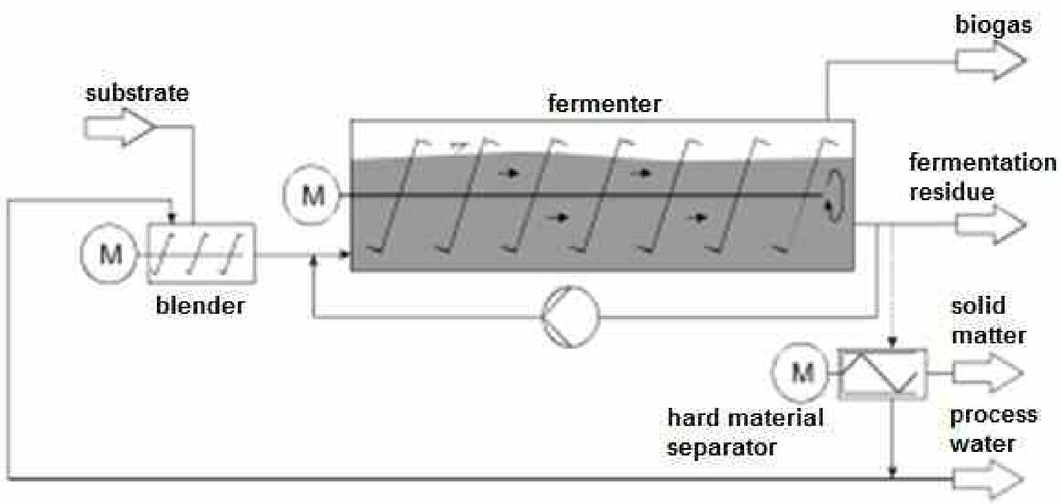

Figure 3: Continuous dry fermentation with plug-flow fermenter (KOMPOGAS) (Gülzower Fachgespräche, 2006)

Benefits of the Retrofitting of the MBT plant Rostock

Provisional calculations indicate today already that the retrofitting creates an ecological benefit for the Hanseatic city of Rostock (EVERS, 2008).

The EVG's CHP station will have produced approximately 8 million cubic metres of biogas by the year 2008. With a methane content of 58%, a calorific value of approx. 46 GWh can be expected. This energy will be used to generate 11 GWh electricity (net) and 25 GWh waste heat for auxiliary cooling or respectively district heating.

This reduces carbon emissions as follows:

- electricity: 6.8 Gg related to the electricity mix of Germany
- district heat: 5.5 Gg related to natural gas heating or 2.3 Gg related to CHP district heating from natural gas (fossil methane).

With a maximum output (currently 810 Gg p.a.) a reduction of the overall emissions of Rostock by 12.3 Gg, i.e. approx. 1.5%, can be achieved.

The dynamic climate alliance objective of Rostock intends a reduction of carbon emissions by 2% p.a..

The generated electricity is sufficient for illuminating the city of Rostock; 10 to 11 GWh of electricity are needed for city lighting per year.

According to the framework concept "climate protection", each citizen of Rostock uses 0.75 MWh of electricity at home per year. In theory, approximately 14,500 inhabitants of Rostock could cover their yearly consumption of household electricity with carbon-free power by the EVG. This for example equals the number of inhabitants of the Südstadt district.

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