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# THE CATALOGUE OF GOOD PRACTICES IN BIOGAS PRODUCTION

IOŚ-PIB
Institute of Environmental Protection
National Research Institute

Warsaw 2024

VISTA ANALYSE

*The document was produced as part of the project "Green transition in practice: Demonstrating and disseminating the benefits of producing biogas from bio-waste", implemented by the Institute of Environmental Protection-National Research Institute and Vista Analyse, funded by the Bilateral Cooperation Fund, the European Economic Area Financial Mechanism 2014-2021 and the Norwegian Financial Mechanism 2014-2021 (Norwegian and EEA Funds).*

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ISBN 978-83-966110-8-6

**Publisher:**
Institute of Environmental Protection - National Research Institute,
02-170 Warszawa, Słowicza Street 32


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# INTRODUCTION

# INTRODUCTION

The need for investment in renewable energy sources stems from the challenges facing the world as a whole in terms of the need to reduce human impact on the climate and the environment. One source that at the same time allows for stable production regardless of weather conditions is biogas. Thanks to its properties, biogas can be used in various sectors, such as energy, transport or agriculture. The wide range of applications and the possibility of ensuring a constant supply of biogas (and biomethane) opens up a number of development opportunities for regional and national economies, as well as local communities.

Poland has a huge potential to produce biogas from agricultural raw materials, and by also using the potential resting in biodegradable waste and sewage sludge, it can significantly modify its energy mix and improve its energy security. Norway, on the other hand, has a huge potential for biogas production from bio-waste, including that from food processing.

The catalogue presents examples of investments from Poland, Norway and other European countries, where biogas production from various substrates has been carried out successfully for many years. We would like these examples to be an inspiration for the development of the biogas and renewable energy market in Poland and Norway.

# GOOD PRACTICES IN POLAND

## GREEN ENERGY MICHAŁOWO SP. Z O.O.

Location: Michałowo, Podlaskie Voivodeship, Poland

Launch date: 2015

Installed capacity: 2 CHP modules, 0.6 MW each

**| agricultural biogas plant | energy production | private ownership |**

**SUBSTRATE**

| Substrate type | Source |
|---|---|
| Maize silage | From farm fields leased by the investor and from local farmers. |

**PROCESS**

| Processing method | Description |
|---|---|
| Anaerobic mezophillic methane fermentation | Fermentation takes place in digesters with a heating and mixing system. Plant efficiency of 98.5% in 2022. |

**PRODUCTS**

| Product type | Further use |
|---|---|
| Biogas | On-site incineration to produce energy through CHP modules. |
| Electricity | Covering 100% of the plant's own needs, any surplus is sold to the local energy provider. |
| Heat | 20% of the produced heat is used on site to aid in the fermentation process, the rest of it is supplied through a pipeline to the nearby school, Water Park and numerous other public facilities. |

Green Energy Michałowo (Zielona Energia Michałowo Sp. z o.o.), together with IEN Energy, established in 2017 an association called "Klaster Energii Michałowo" tied around two sources of energy working in sync – a biogas plant and its adjacent photovoltaic farm. The main goal of this energy cluster is to ensure energy security and eradicate energy poverty in the town of Michałowo and the neighboring Zabłudów, Gródek and Tykocin communes. The cluster was responsible for expanding the heating pipeline network in Michałowo and connecting many of the town's public facilities and utilities to it (the town hall, the cultural center, a high school, etc.).

A Data Processing Center, entirely powered with biogas is being installed nearby and is planned to make use of the waste heat from electricity production, to be converted into cold air that can cool the servers, thus creating a "trigeneration" system. The photovoltaic farm will also provide backup electricity in case of power failure.

**Sources:**

- Article from 2019 about the energy cluster https://magazynbiomasa.pl/klaster-energii-michalowo/
- Article from 2021 https://magazynbiomasa.pl/eko-dane-powstaje-serwerownia-ktora-korzystac-bedzie-z-biogazu/
- Article from 2023 about the biogas plant https://magazynbiomasa.pl/michalowo-dziala-jak-w-zegarku-985-sprawnosci-biogazowni/

## AGRICULTURAL AND HORTICULTURAL EXPERIMENTAL FARM

Location: Przybroda, Wielkopolskie Voivodeship, Poland

Launch date: 2019

Installed capacity: 0,5 MW

**| experimental biogas plant | energy production, research into new technologies |**
**| ownership of Poznań University of Life Sciences |**

**SUBSTRATE**

| Substrate type | Source |
|---|---|
| Waste from agriculture and food processing, mainly cow manure | Waste from orchard, crop and livestock production from the University's own experimental farm (400 hectares of arable land, 40 hectares of orchards) and other agricultural waste supplied by local farmers. |

**PROCESS**

| Processing method | Description |
|---|---|
| Anaerobic mezophillic methane fermentation with the use of a biotech accelerator | A biotechnological accelerator is used for substrate homogenization and hydrolysis, which makes it possible to mix different substrates together and change the substrate recipe each day (it is an additional hydrolyzer working in an acidic environment – a Polish innovative technology).<br>Biogas production efficiency: 97% |

**PRODUCTS**

| Product type | Further use |
|---|---|
| Biogas | On-site incineration in CHP modules for power generation, mainly for the facility's own use. |
| Electricity | Partially used on-site, then transferred to the power grid.<br>Yearly production: 4000 MWh/year |
| Heat | A secondary product from CHP generation; used on-site for heating needed for the fermentation processes, as well as to heat the buildings of the university's experimental farm and 58 buildings in the neighboring town.<br>Yearly production: 4000 MWh/year |

| Residues | Further management |
|---|---|
| Digestate | Used as a fertilizer on-site on the facility's own farms. The yearly yield can cover 100 ha of arable land. |

The biogas plant in Przybroda was built based on Polish technical and technological solutions, in a modular manner (mainly using bolted steel elements), thanks to which the transportation of all parts of the biogas plant except for its concrete foundations) is possible in simple containers and their assembling is fairly easy. The technological process of the biogas plant is supervised by the Ecotechnology Laboratory of the Poznań University of Life Sciences, which is the largest biogas laboratory in Poland. To date, around 2,500 different types of substrates with different biogas yields have been tested there.

The biogas plant has been prepared to operate as a peak load biogas plant, i.e. it can produce electricity during peak demand (e.g. from 6:00 to 21:00). The biogas produced during the other hours can be stored in a special dome above the digestion tank and used during peak hours.

**Sources:**

- The experimental farm's main website https://www.przybroda.pl/
- Technology producer website https://www.dynamicbiogas.com/przybroda
- Documentary about the biogas plant https://www.youtube.com/watch?v=W_uRuWgnBQM
- Article from 2013 about the biogas plant https://wir.org.pl/asp/innowacyjna-biogazownia-w-rolniczo-sadowniczym-gospodarstwie-doswiadczalnym-przybroda,175,artykul,1,3312

## REGIONAL CENTRE FOR WASTEWATER MANAGEMENT S.A. (RCGW S.A.)

Location: Tychy, Silesian Voivodeship, Poland

Launch date: 2006 (2018 completion of the WWTP modernization and opening of the Water Park)

Installed capacity: 1,09 MW (WWTP) i 1,2 MW (Water Park)

**| WWTP biogas plant | energy production | ownership of the City of Tychy |**

**SUBSTRATE**

| Substrate type | Source |
|---|---|
| Sludge from wastewater treatment | Sludge from the treatment of municipal and industrial wastewater originating from the area of the City of Tychy delivered through the municipal sewage network (about 400 km in length) managed by the RCGW. |
| Biodegradable waste from industry | Supplied by external parties (which pay the RCGW a fee for their collection). Some of it requires pre-treatment at the pasteurization station.<br>Waste throughput: 103 000 $m^3$/year |

**PROCESS**

| Processing method | Description |
|---|---|
| Anaerobic mezophillic methane co-fermentation | Sewage sludge and biodegradable waste are subjected to fermentation in 2 separate digesters, each 5500 $m^3$ in volume. The substrate is brought to 5-6% of dry mass. |
| Biogas upgrading | Using desulfurization absorbers (designed by RCGW, using turf ore) and treated wastewater (technology from T4B EKOTECHNOLOGIE – the process water absorbs $CO_2$, the biogas is later dehydrated in a scrubber) in the Biogas Treatment Station of a capacity of: 1200 $m^3$/h |

PRODUCTS

| Product type | Further use |
|---|---|
| Biomethane/Upgraded biogas | The upgraded biogas is partly used on site for treatment plant and partly compressed from 300 to 10 kPa and delivered via a 6-kilometre pipeline clad in aluminium foil (zero-diffusion technology) to the Tychy Water Park, where it is combusted in a combined heat and power plant to heat the building and pool water.<br>Biogas production capacity: 708 m3/h (as of 2020).<br>Methane content of biogas: 60% |
| Electricity from the incineration of biogas in CHP units | The energy produced covers the entirety (and exceeds it by 50%, even 94% in January 2019) of the company's needs as well as the Water Park's needs; excess energy is sold to the Tauron Group grid (about 4,500 MWh/year).<br>Electrical power: 2x 400 kW (Water Park), 2x 345 kW and 1x 400 kW (WWTP) |
| Heat from CHP unit | Covers 100% of the WWTP and Tychy Water Park's needs. Used to heat the digesters to a stable temperature of 38°C, to heat the buildings and tap water, as well as the pool water in the Water Park.<br>Thermal power: 2x 433 kW (Water Park), 2x 531 kW and 1x 394 kW (WWTP). |

| Residues | Further management |
|---|---|
| Carbon dioxide | Separated in the biogas upgrading process to biomethane and sold to industrial plants. |

The Tychy-Urbanowice Wastewater Treatment Plant and the Tychy Water Park are equipped with separate CHP units; in addition, the Water Park has a backup heat source in the form of a 1,100 kW biogas boiler. The biogas supplied to the Water Park via a pipeline is burned there in two CHP modules. At the end of 2020, RCGW became the leader of the Tychy Energy Cluster, their next goal is to make use of their energy surplus to fulfil the city's other needs. In 2021, researchers at the treatment plant succeeded in isolating colonies of biohydrogen producing bacteria living in the plant's digesters.

**Sources:**

- RCGW website https://www.rcgw.pl/
- Strona Wodnego Parku w Tychach https://www.wodnypark.tychy.pl/o-spolce
- Article from 2019 about the Tychy biogas plant https://magazynbiomasa.pl/biogazownia-oczyszczalni-sciekow-tychy-urbanowice/
- Article from 2021 about the Water Park's usage of biogas https://energetyka24.com/oze/tychy-62-mln-m-szesc-biogazu-z-osadow-sciekowych-i-odpadow
- Article from 2022 about RCGW's future plans https://www.portalsamorzadowy.pl/gospodarka-komunalna/produkuja-juz-biometan-i-wodor-teraz-przymierzaja-sie-do-biorafinerii,413250.html
- Interview from 2020 with RCGW's CEO https://t4b-ekotechnologie.pl/2020/02/rozmowa_ze_zbigniewem_gieleciakiem_prezesem-rcgw/

## WASTE TREATMENT FACILITY – WASTE MANAGEMENT COMPANY SP. Z O.O. IN PROMNIK (ZUO PGO SP. Z O.O.)

Location: Promnik, Świętokrzyskie Voivodeship, Poland

Launch date: 2016

Installed capacity: 1x 0,2 MW, 2x 0,92 MW

**| waste disposal facility biogas plant | energy and compost production |**
**| ownership of the City of Kielce |**

**SUBSTRATE**

| Substrate type | Source |
|---|---|
| Municipal waste and bio-waste | Waste is collected from Kielce and 17 nearby municipalities (about 400,000 residents); through selective waste collection from individuals and public waste collection points (for which ZUO is also responsible). |
| Sewage sludge | From the company's wastewater (generated by ZUO itself) and landfill leachate treatment plant. |

**PROCESS**

| Processing method | Description |
|---|---|
| Dry fermentation (in 2 chambers) | Green and biodegradable fraction separated mechanically from mixed municipal waste is subjected to dry fermentation in a 2-chamber digester. |
| Aerobic stabilization (composting) | The digestate from the dry fermentation process is subjected to composting, which takes place in closed chambers; later the maturation of the obtained stabilized MSW (municipal solid waste) takes place in open boxes. |

**PRODUCTS**

| Product type | Further use |
|---|---|
| Biogas | Gathered during the dry fermentation process as well as from reclaimed landfill areas (4.5 hectares) thanks to degassing wells, burned on site in CHP units to produce energy, mainly for own consumption. |
| Electricity and heat | From biogas incineration in CHP units. The obtained energy meets 100% of ZUO's needs, excess energy is sold to the local energy distributor. |

| Residues | Further management |
|---|---|
| Compost | Stabilized MSW from composting, used in the reclamation of PGO's landfills. |

PGO's Waste Treatment Facility is equipped with an on-site treatment plant for wastewater and landfill leachate (photocatalytic and ion exchange treatment), a closed-loop system for process water as well as rainwater (resulting in a water recycling rate of over 80%), as well as a device producing alternative fuel from mechanically separated high-calorie waste fractions, to be used in cement factories and industrial thermal power plants.

**Sources:**

- PGO Promnik's website https://pgo.kielce.pl/
- About the waste disposal facility https://www.mostostal.waw.pl/realizacje/ekologiczne/zaklad-unieszkodliwiania-odpadow-dla-miasta-kielce

## PRODUCTION-SERVICE-TRADE COMPANY "RADKOM" SP. Z O.O. (PPUH "RADKOM")

Location: Radom, Masovian Voivodeship, Poland
Launch date: 2010 (time of the construction of the waste disposal facility (ZUOK) and the biogas tanks)
Installed capacity: 0,67 MW

**waste disposal and composting facility | energy production and digestate management | ownership of the City of Radom |**

**SUBSTRATE**

| Substrate type | Source |
|---|---|
| Waste disposed of in a landfill for non-hazardous and inert waste | This consists in 96% of waste processed in the waste disposal facility (mainly ballast and stabilized MSW) and in 4% of waste that cannot be recovered or disposed of through any other method |
| Biodegradable waste | The organic fraction from selectively collected green waste (from public green areas and the fruit and vegetable processing industry) and the organic fraction mechanically separated from mixed municipal waste from households within Radom and its surrounding communes (around 550 tons of municipal waste arrives at the ZUOK each day). |

**PROCESS**

| Processing method | Description |
|---|---|
| Capture of landfill biogas | 50 wells, each 25 meters deep, connected through pipelines to a gas compression station. |
| Composting | The organic fraction from mixed waste is composted in tunnels (24 days) and matured in a storage yard (40 days); this results in stabilized MSW. The organic fraction from green waste is composted and matured in separate tunnels (54 days); a soil conditioner is obtained at the end. |

**PRODUCTS**

| Product type | Further use |
|---|---|
| Landfill biogas | Electricity production from cogeneration.<br>Methane content: 40-65%; $CO_2$ content: 35%.<br>Biogas production capacity: about 500 $m^3$/h. |
| Electricity and heat | Electricity from the incineration of landfill biogas in 2 CHP modules of a total capacity of 677 kW. This meets 100% of the company's demand, surpluses are transferred to the national power grid. Total electricity production: 1200 MWh/year. Waste heat from power generation is used for the plant's own needs (mainly central heating and hot water). |

| Residues | Further management |
|---|---|
| Soil conditioner "RADKUŚ" | It can be used both in garden crops and in the reclamation of degraded land. |

In addition, ZUOK also takes care of mechanically separating the high calorific fraction from the waste stream collected by and delivered to PPUH Radkom, in order to produce refuse derived fuel (proRDF); these components are not burned on site, but compressed and packaged, then stored, from where they are delivered outside of PPUH Radkom to third parties for further use.

**Sources:**

- PPUH Radkom's website http://www.radkom.com.pl/

## WWTP OF THE STALOWA WOLA MUNICIPAL DEPARTMENT (WWTP MZK)

Location: Stalowa Wola, Podkarpackie Voivodeship, Poland

Launch date: 1993 (modernization and expansion completed in 2009)

Installed capacity: 1x 0,527 MW, 1x 0,208 MW

**| WWTP biogas plant | energy production, sewage sludge treatment | ownership of the City of Stalowa Wola |**

**SUBSTRATE**

| Substrate type | Source |
|---|---|
| Sewage sludge | Municipal wastewater (industrial wastewater is handled by the Central Wastewater Treatment Plant) from the area of Stalowa Wola through a municipal sewer network of about 180 km (owned by MZK) and landfill leachate from the city's Waste Disposal Facility. |
| Industrial waste | Part of the WWTP's additional (fee-based) services for individuals, institutions, service or business entities, is handling the treatment and disposal of liquid production waste from dairy (e.g., whey), brewing and distilling (e.g., slop, distillery stock), sugar (e.g., molasses) and bakery industries, as well as contraband alcohol (at the authorities' request). |

**PROCESS**

| Processing method | Description |
|---|---|
| Anaerobic mesophilic methane fermentation | Methane fermentation at a pH level of 7 takes place in 2 separate digesters. |

**PRODUCTS**

| Product type | Further use |
|---|---|
| Biogas | The WWTP is equipped with an automatic SCADA control system. Biogas is collected from the top of the fermentation tank and subjected to desulfurization to 60 ppm $H_2S$ before being relayed to the incineration process. Methane content in the biogas: 60%.<br>Average daily biogas production capacity: 1600 $m^3$/day. |
| Electricity and heat | From the incineration of biogas in 2 CHP modules, each with an electrical output of 104 kW and a thermal output of 154 kW. The CHP units can work with varying intensity depending on the current level of biogas produced and the current demand in electricity. Both types of energy are entirely consumed by the WWTP; the thermal energy covers 100% of the company's needs, and electrical energy covers 63% of its needs. |

| Residues | Further management |
|---|---|
| Treated sewage sludge | After compaction and dewatering, it is subjected to hygienization with ground quicklime at the Dewatered Sludge Storage Facility. Then, after being analyzed, it is handed over to an external company to be reused in agriculture or land reclamation. |

In order to reduce odor nuisance, parts of the WWTP (grids, raw and digested sludge thickeners, sludge predenitrification chamber, landfill) are either sealed hermetically or use air-purifying biofilters. The Stalowa Wola WWTP is striving for the best possible encapsulation and deodorization of the shed storing dewatered sludge.

**Sources:**

- Stalowa Wola Municipal Department website https://www.mzk.stalowa-wola.pl/
- About the WWTP https://www.mzk.stalowa-wola.pl/miejska-oczyszczalnia-sciekow-mos/

## MECHANICAL-BIOLOGICAL TREATMENT PLANT OF THE MUNICIPAL WASTE OF THE STALOWA WOLA MUNICIPAL DEPARTMENT (MBT MZK)

Location: Stalowa Wola, Subcarpathian Voivodeship, Poland

Launch date: 2015

Installed capacity: 1x 0.527 MW, 1x 0.208 MW

**| MBT plant biogas plant | energy, fertiliser and compost production |**
**| ownership of the City of Stalowa Wola |**

**SUBSTRATE**

| Substrate type | Source |
|---|---|
| Mixed municipal waste | Delivered from households within in the following municipalities: Stalowa Wola, Zaklików, Radomyśl nad Sanem, Tarnobrzeg; collected and delivered to MBT MZK by the MZK Waste Transport Plant. It is the organic fraction from mixed municipal waste remaining after passing through the plant's sorting line (the mechanical part of the MBT plant). Capacity: 13.5 Mg of waste/hour. |

**PROCESS**

| Processing method | Description |
|---|---|
| Anaerobic thermophilic methane fermentation | The organic fraction of municipal waste undergoes anaerobic stabilization in a digester using the LARAN technology (Strabag). Throughput: 15 000 Mg waste/year. |
| Controlled, intensive aerobic stabilization (composting) | Controlled, intensive aerobic stabilisation is applied to the green waste fraction and digested sludge. The process takes place in 6 closed compost tunnels with an accompanying air purification plant, followed by a compost maturation yard (6 weeks). Throughput: 28 000 Mg/year. |

**PRODUCTS**

| Product type | Further use |
|---|---|
| Biogas | Biogas combusted in the cogeneration module. Before incineration, it passes through a purification (desulphurisation and dehydration) and compression module. |
| Electricity and heat | From the incineration of biogas in a CHP module with an electrical power of 527 kW and a heat power of 539 kW; it is used in its entirety by the plant. |

| Residues | Further management |
|---|---|
| Fermented sludge | They are dewatered and then composted (aerobically stabilised) together with green waste. |
| Soil conditioner "Glebowitka" | Waste fraction below 20 mm from composting. It is offered for sale by the company in the "additional services" category. It can be used for gardening, vegetable and fruit crops, as well as in the reclamation of degraded soils. |
| Compost not meeting the legal requirements to be considered a soil conditioner | It is still offered for sale by the company in the "additional services" category, to be used for landfill soil reclamation as a biological layer, as it's a cheaper alternative to sand. |

An Energy Recovery Facility for the Energy Fraction of Municipal Waste is currently under construction at the MBT plant, with a capacity of 44,000 Mg/year in order to produce alternative fuel (RDF and preRDF), with the purpose of reducing the amount of waste sent to the landfill and supplying the Stalowa Wola Combined Heat and Power Plant with fuel.

**Sources:**

- Stalowa Wola Municipal Department website https://www.mzk.stalowa-wola.pl/
- About the MBT plant https://www.mzk.stalowa-wola.pl/zaklad-mechaniczno-biologicznego-przetwarzania-odpadow-komunalnych-zmbpok/
- Article from 2023 about the plant's further plans https://magazynbiomasa.pl/w-stalowej-woli-wyprodukuja-energie-z-odpadow/
- Slideshow about the MZK MBT plant https://sdr.gdos.gov.pl/Documents/GO/Spotkanie%207-9.11.2016/Prezentacja%20ZMBPOK%20%2008.11.2016%20Stalowa%20Wola.pdf

## COLLECTIVE SEWAGE TREATMENT PLANT OF THE ŁÓDŹ AGGLOMERATION

Location: Łódź, Łódzkie Voivodeship, Poland

Launch date: 2004

Installed capacity: 2,8 MW

**| WWTP biogas plant | energy production | ownership of the City of Łódź |**

**SUBSTRATE**

| Substrate type | Source |
|---|---|
| Sewage sludge | Sewage coming from households in Łódź and the neighbouring communes: Konstanynów Łódzki, Ksawerów, Pabianice, Nowosolna. Preliminary and excess sludge are thickened and sent together to the fermentation process.<br>Capacity of the WWTP (as of 2023): 210 000 $m^3$/day.<br>Capacity: 869,348 p.e. |

**PROCESS**

| Processing method | Description |
|---|---|
| Anaerobic mesophilic methane fermentation | The sludge (primary and surplus) from the municipal wastewater, after thickening, goes into 4 closed digesters, each with a capacity of 10,000 m3. |

**PRODUCTS**

| Product type | Further use |
|---|---|
| Biogas | From sludge fermentation in the digesters, it is then purified of hydrogen sulfide and silicon compounds. It is burned on-site in 3 CHP modules. |
| Fermented sewage sludge | After degassing, thermal hydrolysis and mechanical dewatering, it is directed to the Sludge Incineration Facility with a throughput of 159 tons per day. The obtained heat is used to dry sludge and sewage screenings. |
| Electricity | From on-site incineration of both biogas and dry fermented sludge. This covers 70% of the WWTP's demand in energy. Total electrical power of the generators: 2,8 MW |
| Heat | Recovered from electricity generation. Covers 100% of the WWTP's demand, including building and tap water heating, as well as heating needed during the technological processes. Total thermal power: 3,5 MW |

| Residues | Further management |
|---|---|
| Residue from sludge incineration | Leftovers from the process are disposed at the "GOŚ-Laguny" landfill. |

In 2023, a modernization took place that included the construction of a sludge thermal hydrolysis system, which will improve the efficiency of sludge digestion, increase biogas production and reduce the mass of sludge requiring incineration while improving the degree of sludge dewatering.

**Sources:**

- Łódź Waterworks and Sewage System Company website https://zwik.lodz.pl/
- Analysis of Biogas Desulphurization Process in GOŚ ŁAM http://bazekon.icm.edu.pl/bazekon/element/bwmeta1.element.ekon-element-000171498073

## "HAJDÓW" WWTP OF THE MPWiK IN LUBLIN (MUNICIPAL WATERWORKS AND SEWAGE COMPANY)

Location: Lublin, Lublin Voivodeship, Poland

Launch date: 2000

Installed capacity: 2x 0,85 MW

**| WWTP biogas plant | energy production | ownership of the City of Lublin |**

**SUBSTRATE**

| Substrate type | Source |
|---|---|
| Sewage sludge | Municipal and industrial wastewater delivered to the WWTP through a 960 km-long sewer network operated by the Company, spreading across the Lublin agglomeration (Lublin, Świdnik, Wólka, Konopnica, Głusk, Niemce). |

**PROCESS**

| Processing method | Technology used and technical specification |
|---|---|
| Anaerobic mesophilic methane fermentation | The biogas produced in the digesters is later purified and burned in two CHP modules. |
| Biogas upgrading | The biogas is first desulfurized using a turf ore and a biological bed, followed by dehydration and removal of siloxanes (via activated carbon filters). |

**PRODUCTS**

| Product type | Further use, recipients and details |
|---|---|
| Upgraded biogas | 85% of the biogas is directed to the CHP system, 5% goes to gas boilers and the final excess of biogas (around 10%) is burned using a flare.<br>Capacity: 724 m3 biogas/hour<br>Methane content: 61-68%. |
| Electricity | The company produces 11,600 MWh of electricity annually, which covers 62% of the WWTP's demand. Another 7% is covered by a photovoltaic farm. Electrical power: 2x 851 kW. |
| Heat | 84% of thermal energy is produced by the CHP set, the rest is supplied by gas boilers, which together covers 100% of the WWTP's needs, including the amount needed to heat sludge in the digesters. Thermal power: 2x 926 kW. |

| Residues | Further management, recipients and details |
|---|---|
| Fermented sewage sludge | After being dewatered and thickened, it is transferred to an external company to deal with, whereas the small amounts of its liquid part are disposed of in the nearby sludge lagoons. |

In 2020, the construction of a photovoltaic power plant was completed at the WWTP with an annual electricity production of up to 2050 MWh, which cost over 8 million PLN.

**Sources:**

- MPWiK's main website https://www.mpwik.lublin.pl/

- Article from 2014 about the biogas plant https://www.teraz-srodowisko.pl/aktualnosci/MPWiK-Lublin-wykorzystanie-biogazu-216.html
- Article from 2020 about the WWTP's photovoltaics https://gospodarczy.lublin.eu/centrum-informacji/blog/oczyszczalnia-sciekow-hajdow-zasilana-elektrownia-fotowoltaiczna/

# GOOD PRACTICES IN NORWAY

## VEAS WASTEWATER TREATMENT PLANT

Location: Asker, Norway

Launch date: 2020

Installed capacity: 85 GWh/y

**|WWTP biogas plant | liquid biogas production | Public ownership |**

**SUBSTRATE**

| Substrate type | Source |
|---|---|
| Sewage wastewater | 100 mill. $m^3$ of wastewater per year from 800 000 individuals in the metropolitan area of Oslo, Norway. |

**PROCESS**

| Processing method | Description |
|---|---|
| Anaerobic digestion | A sedimentation tank collects biomass that pass through a sludge thickener before entering a biogas reactor operating at 37 degree Celsius. CO2 is separated by amine scrubbing and the biogas is upgraded to liquid biomethane. |

**PRODUCTS**

| Product type | Further use |
|---|---|
| Liquid biogas | Produces 10 mill. $Nm^3$ per year (60GWh). In 2023, 88 percent was upgraded to biomethane. Used in transport vehicles, such as buses and trucks. Until 2021 the biogas was used to produce electricity and heat for consumption on site. |
| Ammonium sulphate | Produces 5 000 t per year for use as liquid fertilizer. |
| Soil | Produces 45 000 t per year of soil products based on sludge. Used in the agricultural sector. |
| Heat energy | Produces 110 GWh per year of heat energy supplied to district heating system. |

VEAS AS is a stock based company owned by three municipalities in the Oslo area, with a wastewater treatment plant located in Asker, Norway. The plant was built in 1976 and the main objective of the treatment plant is to clean wastewater before it is released into the fjord. It has also produced biogas from the biomass contained in the wastewater since 1992. As part of a long-term strategy to better exploit valuable resources in the wastewater, and reduce costs of the municipalities' citizens, a new process facility for biogas-upgrading was installed in 2020. The new process facility separates $CO_2$ from the biogas to make liquified biomethane that can be used in vehicles such as buses and trucks.

The facilities also include the ability to receive CBG from external sources and convert it to LBG. The plant also supplies surplus heat to the local district heating system, produces liquid fertilizers and soil products sold to the agricultural sector. There are also plans to capture the CO2 that is extracted from the biogas and purify it such that it can be sold to the food- and drinks industry.

**Sources:**

- Company web page: www.Veas.nu

## GREVE BIOGAS – „THE MAGICAL FACTORY"

Location: Tønsberg, Norway

Launch date: 2015

Installed capacity: 120 GWh (biogas)

**| Food waste and agricultural biogas plant | biogas and fertilizer production| Public ownerhsip |**

**SUBSTRATE**

| Substrate type | Source |
|---|---|
| Food waste | Food waste is sorted by households in the region and collected by the municipal waste management. It currently receives food waste from around 1.2 million citizens. |
| Animal manure | Around 77 000 t of manure from cattle and pig livestock is delivered from farmers in the region of Vestfold. |

**PROCESS**

| Processing method | Description |
|---|---|
| Anaerobic digestion | Food waste and manure is mixed in containers where biogas is produced. The biogas is upgraded and delivered to costumers through pipelines, and as CBG and LBG. |

**PRODUCTS**

| Product type | Further use |
|---|---|
| Biogas (CBG & LBG) | Sold to a distribution company that sells the biogas to be used for industrial purposes and as fuel in the transportation sector. |
| Biofertilizer | Used as biofertilizer by the local farming industry. Reduces the need for synthetically produced fertilizers. |
| Green $CO_2$ | Used in a local green house that produces tomatoes, to increase output. |

The Magical Factory is Norway's first and largest facility that produces biogas and biofertilizer. In 2023, 56% of all animal manure delivered to biogas facilities in Norway was delivered to the facility. Part of the biogas that is produced is certified by ISCC (International Sustainability & Carbon Certifictaion) which documents that the substrate used are waste products and manure, and that the biogas is produced in a sustainable manner.

**Sources:**

- Company web site: www.dmfas.no

## BIOKRAFT AS

Location: Levanger, Norway

Launch date: 2018

Installed capacity: 155 GWh/y

**| biogas plant for food processing waste and paper industry | liquid biogas production| Private ownership |**

**SUBSTRATE**

| Substrate type | Source |
|---|---|
| Fish ensilage | The facility receives around 70 000 t fish silage from the salmon fish-farming industry each year. |
| Processed water from paper production | The facility receives processed water from a nearby paper and pulp production facility. |

**PROCESS**

| Processing method | Description |
|---|---|
| Anaerobic digestion | Has developed its own concept called HOLD Technology™ (High Organic Load Digestion) to optimize large scale biogas production. |

**PRODUCTS**

| Product type | Further use |
|---|---|
| Liquid biogas | The plant has a capacity to 12, mill. $Nm^3$ methane per year, which is equivalent to 120 GWh. Used in the transportation sector, and notably by the shipping operator Hurtigruten. |

The plant was put into operation in 2018 and was one of the largest plants in the world for producing biomethane. Its primary substrates are fish silage from the domestic fish-farming industry, in addition to waste water from the nearby paper and pulp factory (Norske Skog). The plant is well connected to transportation infrastructure and can receive substrate by shipping, train and trucks. Biokraft AS have decided to increase its production with an additional 90GWh liquid biomethane at an estimated net investment cost of 180 mill. NOK. Production is estimated to start at the end of 2024.

**Sources:**

- Produksjonsanlegg | Biokraft - Norge
- CountryReport2021_Norway_final.pdf (ieabioenergy.com)
- Growth and projects | Biokraft

## RÅ BIOPARK

Location: Storfjord, Norway

Launch date: Planned production start in 2026

Installed capacity: 60GWh/y

**| waste biogas plant | biomethane production | Public ownership |**

**SUBSTRATE**

| Substrate type | Source |
|---|---|
| Organic matter from food waste, sewage, fish industry. | 41 municipalities in the region. Expects 63 000 t organic waste each year. I will also receive organic waste from households, businesses, livestock manure, wastewater, and the fish industry located along the coast. |

**PROCESS**

| Processing method | Description |
|---|---|
| Anaerobic digestion | Anaerobic digestion of wet to semi-solid organic waste materials. The specific technology is not yet decided. |

**PRODUCTS**

| Product type | Further use |
|---|---|
| Liquid biogas | Expects to produce liquid biogas equivalent to 60GWh per year. |
| Biochar | Used as soil improvement, as an additive in cement, in district heating and in the process industry. |
| Bio-$CO_2$ | For use in the food- and drinks industry and green houses. |

The compost facility in Skibotn in Storfjord is to be upgraded and modernized with a biogas facility that will convert the organic matter into liquid biogas. It will receive a wide variety of organic waste, including food waste from households and businesses, livestock manure from local farms, wastewater local municipalities, and organic material from the fishing industry. The facility will also have technology to clean the air for smelly substances before its release. It is planned to produce food grade quality $CO_2$ from the biogas upgrading. The business is owned by 6 waste management companies. The leftover biomass after biogas production will be used to produce biochar.

**Sources:**

- www.raa.bio

## SØMNA BIOGASS

Location: Sømna, Norway

Launch date: 2026

Installed capacity: 70GWh

**| agricultural biogas plant | biogas and biomethane production | Public- and private ownership|**

**SUBSTRATE**

| Substrate type | Source |
|---|---|
| Livestock manure | Livestock manure from local farmers. |
| Fish silage and -sludge | Supplied from fish-farming industry. |

**PROCESS**

| Processing method | Description |
|---|---|
| *Undecided* | *The use of climate-neutral technologies is planned.* |

**PRODUCTS**

| Product type | Further use |
|---|---|
| Biomethane | The plant expects to produce 70 GWh. |
| Biofertilizers | The plant expects to produce 100 000 $m^3$. |
| Bio-CO2 | Plan to sell CO2 captured from the biogas upgrading. |

A facility to produce biogas from livestock manure is planned in the municipality of Sømna in Northern Norway. The project is an initiative from local farmers where 58 farmers retain some ownerships in the project. Other stakeholders are local fish farming industry and municipalities. Local farms supply the livestock manure that is used as a substrate. After the production of biogas, the remaining biomass is processed into fertilizers that is distributed back to farmers. The project has received significant support from Innovation Norway of 95 mill. NOK.

**Sources:**

- Company web page: www.somnabiogass.no
- Article on construction start (8.2.2024): https://biogassbransjen.no/2024/02/08/forventer-byggestart-pa-nytt-biogassanlegg-na-i-2024/

# GOOD PRACTICES IN EUROPE

## AVR BIOWASTE FERMENTATION PLANT IN SINSHEIM

Location: Sinsheim, Rhine-Neckar, Germany

Launch date: 2019

Capacity: 35 000 MWh of thermal energy

**| biowaste biogas plant | biomethane production | private ownership |**

**SUBSTRATE**

| Substrate type | Source |
|---|---|
| Municipal biodegradable waste | Biodegradable waste from selective waste collection – bio-waste (kitchen waste, small garden waste especially soft and green, hair and animal fur) and green waste (larger garden waste such as branches), rid of its non-organic parts. Annually, an average of 68,000 tons of bio-waste and 5,000 tons of municipal green waste arrive at the plant. |

**PROCESS**

| Processing method | Description |
|---|---|
| Thermophilic anaerobic methane fermentation | Takes place in two horizontal digesters with a capacity of 2,250 $m^3$ each. |
| Biogas upgrading to biomethane | Biogas undergoes upgrading with the help of a membrane system developed by Vorwerk, where the biogas is first purified of micropollutants and unwanted volatile substances (including desulfurization, activated carbon filtration) so that at the final treatment stage, a polymer membrane from manufacturer Evonik only has to separate carbon dioxide from methane. |

**PRODUCTS**

| Product type | Further use |
|---|---|
| Biomethane | Biogas turned into biomethane (97% methane content) is transferred to the national gas distribution network. Annual production of biomethane: 35 million kWh of thermal energy. |

| Residues | Further management |
|---|---|
| Digestate | Dewatered and processed into a high-quality compost (in 13 tunnels), it is later sold in both wholesale and retail. 12 tons of compost are produced yearly. |

The AVR plant complex in Sinsheim was built on the site of a reclaimed landfill.

**Sources:**

- Biogas plant main website https://www.avr-biogas.de/bg/Home/
- Brochure about AVR https://avr-bioterra.de/media/AVR_Flyer_Bioabfallvergaerung/#page/1
- Brochure about biogas production https://avr-bioterra.de/media/AVR_BAVA_2023/#page/1
- Brochure about biomethane https://www.avr-biogas.de/media/AVR_BAVA_GAS_2023/#page/1
- Shareholder page https://www.mvv.de/en/about-us/group-of-companies/mvv-umwelt/renewable-energies/biowaste-anaerobic-digestion/sinsheim-biowaste-anaerobic-digestion-plant
- Biogas upgrading technology https://www.friedrich-vorwerk.de/en/news/news-and-projects/avr-biogas-gmbh-construction-of-a-biogas-upgrading-plant-in-sinsheim.html

## HAMBURG WASSER

Location: Hamburg, Germany

Launch date: 2011

Capacity: 1 350 m3 biomethane/h

**| WWTP biogas plant | biomethane production | ownership of the City of Hamburg |**

**SUBSTRATE**

| Substrate type | Source |
|---|---|
| Sewage sludge | From the Köhlbrandhöft municipal wastewater treatment plant (producing 4,000 $m^3$ of sludge per day) handling the sewage network of approximately 5,500-kilometers in Hamburg and 17 surrounding municipalities, as well as 200,000 Mg/year of sewage sludge from other municipalities and companies, for an additional cost. |
| Fermented sewage sludge | Dewatered and stored after the fermentation process in a hermetically sealed "basin" in order to dry it out. |

**PROCESS**

| Processing method | Description |
|---|---|
| Anaerobic methane fermentation | Takes place in 10 digesters of a total capacity of 80,000 $m^3$, for about 20 days. |
| Landfill biogas capture | Biogas from a heated, hermetically sealed storage facility for digested sludge, connected to the stream of biogas directed to biomethane conversion. |
| Biogas upgrading to biomethane | Takes place in 2 GALA systems purifying the biogas from its carbon dioxide, water and unpleasant odours. |
| Incineration of dry digested sludge | Incineration of 63,000 tons of dry digested sludge per year in the VERA system (through fluidized bed combustion (FBC), 800°C) to produce electricity, with the recovery of secondary raw materials (including lime, phosphorus). |

PRODUCTS

| Product type | Further use |
|---|---|
| Biomethane | The biogas from the digesters, after being upgraded into biomethane, is fed into the gas network of the City of Hamburg. This biomethane supplies a total of around 5,700 households with gas for heating and cooking. |
| Electricity | From the incineration of a portion of the produced biogas in order to fulfil the WWTP's own needs; 89,000 MWh of energy per year comes from the incineration of dry digested sludge, partly used by the WWTP itself and partly transferred to the municipal power grid. |
| Heat | From the incineration of part of the biogas to fulfil the WWTP's own needs, as well as the needs of the nearby Tollerort container terminal, from the incineration of dry digested sludge, which is primarily used to dry fermented sludge. |

| Residues | Further management |
|---|---|
| Ash | From the burning of digested sewage sludge, it is later disposed of in its conditioned form.<br>Ash yield: 65 Mg/day<br>Lime recovery yield: 9 Mg/day |

Hamburg Wasser is promoting a solution titled Hamburg Water Cycle (HWC) to individuals involving, among other things, the separation of black water and gray water using vacuum toilets, in order to save water and energy and also to improve biogas production processes later on. The HWC also includes solutions regarding rainwater retention and the (re)usage of gray water at home. The HWC's solutions are designed for both private households and bigger utility facilities, such as at Hamburg's environmental education center, the Gut Karlshöhe Environmental Center.

A fourth VERA II incineration line is currently under construction in cooperation with the Südholstein wastewater treatment plant and the municipal plant of the City of Lübeck, as a response to the increasing volumes of sewage sludge produced and the increasing demand for energy.

The 5 wind turbines at the Hamburg Wasser plant at the Port of Hamburg produce a total of 40,000 MWh of electricity annually; photovoltaic farms are also in the making.

A new device is currently under construction in Hamburg aiming to recover heat (12-22°C waste heat) from treated wastewater before it is discharged to the end of line waterbody (the Elbe river). This heat combined with energy from heat pumps will power a local district heating network serving 39,000 households as of 2025. The same water used for heating will also, via heat exchangers, be used to cool water in the Arctic Ocean zone of the Hagenbeck Zoo.

**Sources:**

- Hamburg Wasser biogas plant website https://www.hamburgwasser.de/umwelt/energiegewinnung/biogas
- Concept of HWC https://www.hamburgwasser.de/umwelt/vorsorge/hamburg-water-cycle
- Information brochure https://www.hz-inova.com/wp-content/uploads/2020/08/HZI_Reference-sheet_Hamburg.pdf
- Brochure Hitachi Zosen INOVA https://www.hz-inova.com/wp-content/uploads/2020/08/HZI_Reference-sheet_Hamburg.pdf

## CVO LILLE

### (CENTRE DE VALORISATION DES DÉCHETS ORGANIQUES – BIOWASTE RECOVERY CENTRE)

Location: Sequedin, Hauts-de-France, France

Launch date: 2007

Capacity: 673 $m^3$ of biogas/h

**| biowaste biogas plant | biomethane production | ownership of Séquoia (Suez) |**

**SUBSTRATE**

| Substrate type | Source |
|---|---|
| Biodegradable waste | Green waste from public green spaces, biowaste from at home waste sorting and from waste collection points, as well as from the catering and commercial sectors (mainly city markets and school cafeterias). Waste collected from the Lille metropolitan area (1.2 million inhabitants).<br>Content of dry mass before fermentation (after substrate processing): 25-30% d.m. |

**PROCESS**

| Processing method | Description |
|---|---|
| Thermophilic anaerobic methane fermentation | In 3 closed horizontal digesters, 1900 $m^3$ each (Strabag type), at a temperature of 57°C. |
| Composting of the digestate | Takes place in 22 tunnels for 3 weeks and then a minimum of 4 days at temperatures above 60°C for hygienization; maturation takes place in a closed hall for 3 weeks. The process uses rainwater collected throughout the year from all the Plant's roofs for compost watering. |

**PRODUCTS**

| Product type | Further use |
|---|---|
| Biogas | 10-20% of the biogas produced is consumed to heat the digesters.<br>Biogas production capacity: 1 million $m^3$/year<br>Methane content: 55-60% |
| Biomethane | The remaining biogas is upgraded into biomethane using FLOTECH technology, which involves dissolving $CO_2$ and $H_2S$ in water. The biomethane is then compressed and sold to the national gas grid. |

| Residues | Further management |
|---|---|
| Digestate | After being mixed with some coarser biodegradable fractions (>55 mm), it is subjected to composting.<br>Compost production capacity: 19,300 Mg/year |
| Compost | Most of it is sold to local farms, whereas 10% of it is distributed for free at waste collection points to private individuals from the MEL, for personal use. |

CVO's original intention was to turn biomethane into fuel to feed MEL's public transport vehicles, but for financial and technical reasons it proved more advantageous to sell it to the national gas distribution network. Part of the Lille metropolitan area's bus fleet currently runs on biomethane fuel produced in the CVO via the national gas network.

**Sources:**

- Loos-Sequeding Port website https://portsdelille.com/les-ports/port-de-loos-sequedin/
- Article from MEL's website about the CVO https://lillemetropole.fr/communique-de-presse/mieux-trier-pour-mieux-recycler-la-metropole-europeenne-de-lille-pionniere-en
- Article from 2018 about the CVO Lille https://www.bioenergie-promotion.fr/57663/le-centre-de-valorisation-organique-de-lille-pionnier-francais-de-linjection-de-biomethane/
- Article from 2022 about the compost from CVO Lille https://objectifmetropolesdefrance.fr/lille-un-compost-made-in-metropole-pour-les-habitants/