Groot Zevert Vergisting, Beltrum (Netherlands)

A short introduction to GZV

Groot Zevert Vergisting (GZV; Figure 1), located in Beltrum, The Netherlands, started its biogas production in 2004. The company can process 135 kilotonnes (kt) of feedstock through mesophilic digestion per year. In 2019, GZV started with the production of biobased fertilisers and clean water from digestate. The aim is to offer a sustainable solution to the manure surplus in their region.

Table 1. Technical information of the biogas plant.

Characteristics	
Year of construction	2004
Maximum power output	6.5 MWe
Digester volume	15 000 m^3
Digestion type	Mesophilic digestion
Nutrient recovery facilities	GENIUS: decanter centrifuges, microfiltration, reverse osmosis RePeat: acidification and phosphorous precipitation

Drivers for Nutrient Recycling

In the Netherlands, manure production by livestock is greater than the amount that legally can be applied on agricultural land. Maximum application standard for both nitrogen (N) and phosphorus (P) determine the amounts of manure that can be applied. The surplus of pig manure, about 30% of the produced amount, is exported, mostly to Germany. The transport of large volumes of manure over distances of 200–400 km is costly. As a consequence, farmers are faced with high costs for manure disposal (€ 25,- per ton pig manure).

Figure 1. Groot Zevert Vergisting in Beltrum, The Netherlands.

As a solution to the manure surplus in the region, GZV decided to invest in nutrient recovery technologies to convert digestate into valuable biobased fertilisers:

- Nitrogen potassium (NK) concentrate to be used within the region;
- Cleaned water which is allowed to be discharged in a nearby stream;
- Organic soil improver with a low nutrient content;
- Secondary P resource to be used as ingredient for the production of fertilisers by fertilisers producing companies.

These biobased fertilisers can be used within the region and some of them can be exported over long distances against low costs as their volumes are reduced by processing. The processing is therefore expected to generate substantial costs savings.

Feedstocks

In 2018 GZV's co-digestion plant has increased its treatment capacity from 102 to 135 kt feedstock per year, but not all capacity was used (Table 2).

Animal manure was the major substrate (about 80% of total feedstock) but the co-substrates are responsible for a relatively large part of the biogas production, about 75% of it in 2019. Pig manure was collected from about 55 pig farms within a distance of 25 km of the plant.

Table 2. Origin of GVZ's digester feedstock (2018–2019).

Type	Origin	Mass (2018)	Mass (2019)
Manure	Pig slurry	74 kt	75 kt
	Dairy cattle slurry	5 kt	5 kt
	Slaughterhouse manure	12 kt	10 kt
Co-substrates	Waste dairy and feed industry	21 kt	18
	Glycerin	3 kt	4 kt
Total		**115 kt**	**112 kt**

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Biogas production

The yearly biogas production is roughly 9 Mio Nm^3 (Table 3). About 68% of the produced biogas is transported through a 5 km-long pipeline to a dairy factory (Friesland-Campina). The remaining 32% of the produced biogas is on-site converted into electric power and heat.

Table 3. Yearly biogas production in 2019 and average composition before desulphurisation.

Component	2019
CH_4 (% v/v)	55
CO_2 (% v/v)	43
H_2S (ppm)	1000–2000
O_2 (% v/v)	0.2
Total biogas production (Mio Nm^3)	9
Biogas per tonne of feedstock (Nm^3/t)	78

Nutrient Recovery and Reuse (NRR) Technologies

GZV follows the concept of a Green Mineral Mining Centre. Digestate is separated into a solid and a liquid fraction by a decanter centrifuge. The nutrient recovery process consist of two independent installations, GENIUS for the processing of the liquid fraction and RePeat for the processing of the solid fraction.

The RePeat process separates the P from the organic matter through extraction with water and sulphuric acid followed by precipitation and recovery of phosphorus through addition of $Mg(OH)_2$ or $Ca(OH)_2$. The solid fraction is treated in two sequential leaching steps during which 70–90% of the P is removed. What remains is an organic soil improver with a low P content. Part of the sulphate, added as sulphuric acid, precipitates with calcium as gypsum. This gypsum is either recovered together with the P fertiliser or as a separate organic gypsum-rich sludge that can be used as fertiliser. Water is continuously reused within the process. Hence, creation of an additional waste stream is prevented.

In the GENIUS process, the liquid fraction is further processed into a nitrogen-potassium (NK) concentrate and clean water through a combination of dissolved air flotation (DAF), micro filtration (MF) and reverse osmosis (RO). The water is being treated by an ion exchanger (IonX) to comply with standards for discharge on surface water.

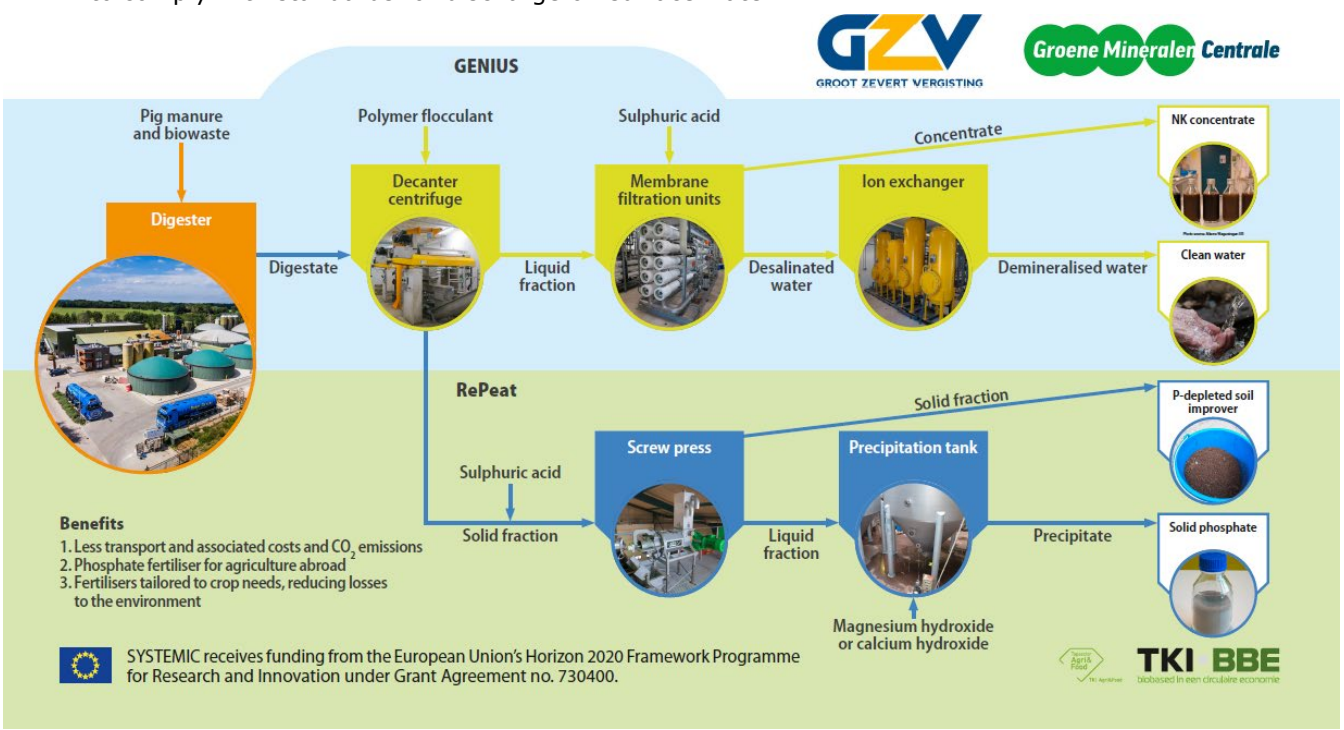

Figure 2. Simplified process scheme of the biogas plant of Groot Zevert Vergisting.

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Status of construction

Construction of the RePeat installation was finalized early 2020 and since then, the installation has been in use for eight hours per day. The RePeat installation has a treatment capacity of 2 tonnes of solid fraction per hour. The installation includes three screw presses, multiple mixing and buffering tanks, a lamella clarifier, a 60 m^3 precipitation tank and a settling tank. In 2020, GZV will further focus on further optimization of the process and the technology. Focus points are an improved dewatering of the precipitate and a reduction of the chemical consumption rate. The GENIUS installation has been in operation since January 2019. In 2019, GZV and Nijhuis Industries have further improved the efficiency of the installation. The performance of both installations is monitored by Wageningen Environmental Research.

Products and market

The NK concentrate has an N content of about 6.9 g kg^{-1} of which >90% is N-NH_4. The NK concentrate is used as an alternative for synthetic fertilisers on arable land and grass land in the region of the plant. About 20–30% of the digestate is converted into clean water that can be discharged on surface water. The solid fraction was shipped to Germany in 2019 but will be processed into a low-P organic soil improver and P fertiliser from 2020 onwards. The low-P organic soil improver will be used on sandy soils in the region of the plant. Besides, GZV investigates the opportunities of it to become an alternative for peat in potting soil. The P precipitate is yet recovered as a sludge which needs a further dewatering and drying step after which it can be used as a raw material in the fertiliser industry.

Table 4. Average composition of the recovered products in 2019 (GENIUS, n:10) and March 2020 (RePeat, n:1).

		GENIUS			RePeat	
	Ingoing Digestate	NK concentrate	Solid fraction of digestate	Clean water	Low-P organic soil improver	P precipitate[a]
Dry matter (g kg^{-1})	84	43	306		368	128
Organic Matter (g kg^{-1})	60	16	232	<d.l.	330	66
N-total (g kg^{-1})	7.2	6.9	12.1	0.003	6.5	5.4
N-NH_4 (g kg^{-1})						
P-total (g kg^{-1})	1.7	0.16	8.9	<0.0001	3.0	6.5
K-total (g kg^{-1})	4.2	8.2	4.4	<0.0004		1.25
S-total (g kg^{-1})	0.8	4.8	2.2	0.0004	4.8	8.5

[a] *Phosphorous precipitate before thermal drying.*

Economic benefits

Long distance transport of digestate or solid fraction of digestate to Germany is costly. Implementation of the GENIUS and RePeat process enables GZV to sell their products to farmers in the region of the plant, thereby saving costs for transport.

Sustainability goals

- Balanced fertilisation with products from co-digested pig slurry.
- Replacement of synthetic N fertiliser by biobased liquid fertiliser containing 10–15 g L^{-1} N-NH_4 and 10–15 g L^{-1} K_2O.
- Recovery of the non-renewable element P in a valuable concentrated product to be used elsewhere, as fertiliser or secondary raw material for fertiliser producing industries.
- A substantial decrease in CO_2 emissions associated with transport.

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Monitoring data (mass flow)

Mass (Figure 3) and nutrient (Figure 4) balances were derived for the GENIUS installation at GZV over a period of four months. The aim was to evaluate the overall performance and efficiencies of separation processes. The first decanter centrifuge recovered 65% of the P from the digestate into a solid fraction with a dry matter content of 30%. Prior to the first decanter, $MgCl_2$ was dosed to improve the removal of P from the digestate. The first and second decanter, together removed 90% of the P from the digestate. The solid fraction of the second decanter is fed to the post-digester. The microfiltration unit effectively removed most of the remaining P as well as organic N. As a drawback, the microfiltration unit produced a large amount of sludge most of which was disposed of as manure. The remaining liquid fraction after microfiltration was concentrated by a factor 2.1 by the two subsequent RO units. After polishing by the IonX clean water remains, of which nearly half was reused within the process. In terms of end products, every 100 t of digestate was processed into 16 t of solid fraction, 37 t of sludge (trucked off-site), 27 t of NK concentrate and 14 t of clean water (discharge/evaporation). In 2020, GZV will further optimize the system in order to minimize the amount of sludge from microfiltration that needs to be trucked off-site and to increase the percentage of clean water produced. Furthermore, GZV will focus on improving the quality of the products from the RePeat installation.

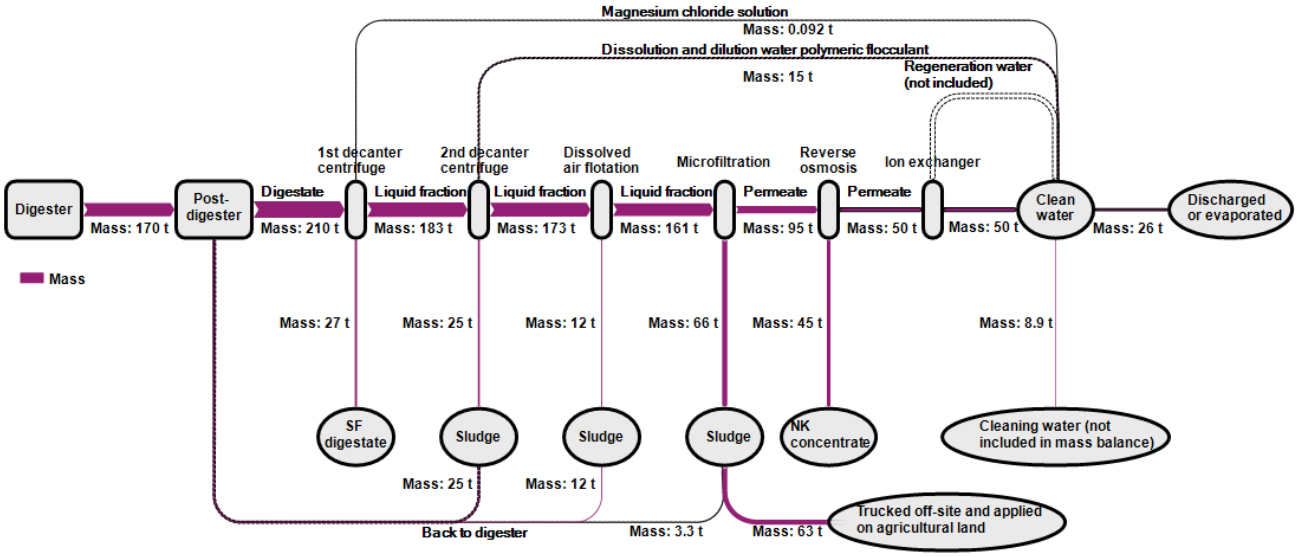

Figure 3 Mass flows at Groot Zevert Vergisting for period October 2019–January 2020 (n: 4). Values expressed in tonnes per day (t d^{-1}).

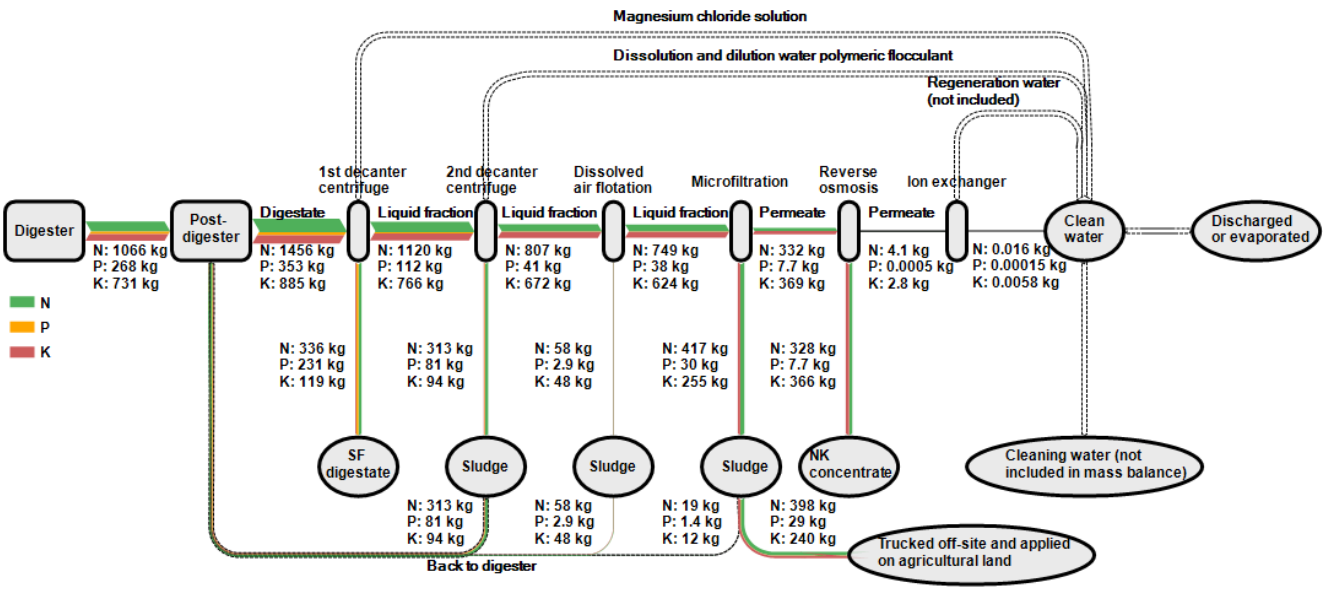

Figure 4 Total nitrogen (N), phosphorus (P) and total potassium (K) mass flows at Groot Zevert Vergisting for the period October 2019–January 2019. Values are expressed in kilograms per day (kg d^{-1}).

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Monitoring data (energy flow)

Groot Zevert Vergisting produced about 47,837 MWh energy as biogas (Figure 5) of which 68% was sold to a nearby dairy factory of Friesland Campina via a direct 5-km long pipeline. The remaining 32% of the biogas was converted into 5,461 MWh electrical energy by the combined heat and power (CHP) installation. Of this electrical energy 40% was sold via the grid and 60% was used on-site for the biogas plant and GENIUS installation. Only roughly 40% of the thermal energy produced by the CHP can be used on-site due to thermodynamics, amongst others losses in the CHP itself and losses as low temperature exhaust gas.

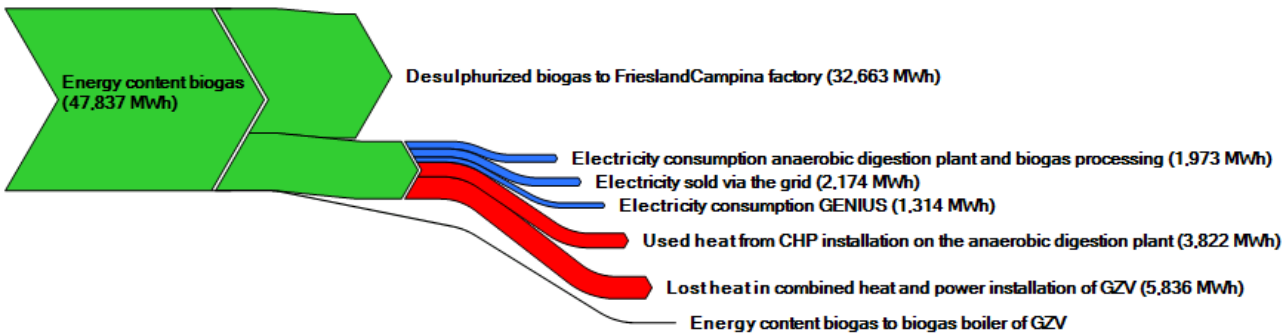

Figure 5 Energy balance of Groot Zevert Vergisting in 2019.

Key Performance Indicators (KPI's)

A KPI is a tool to understand how an organization is performing:

KPI_1: EBIT (Earning Before Interest and Tax) margin in % of revenues.
KPI_2: EBITA (Earning Before Tax, Interest And Amortization) margin in % of revenues.
KPI_3: Substrate Financial Productivity → total revenues per tonne of feedstock.
KPI_4: Biogas Financial Productivity → net revenues of biogas (energy / green certificates) per cubic meter of biogas delivered.
KPI_5: Digestate Financial Productivity → costs/revenues generated by digestate per tonne of feedstock.

As compared to the other demonstration plants, GZV has a high biogas financial productivity. Processing and disposal of digestate is still costly because GZV does not generate revenues from all produced biobased fertilisers yet.
NK concentrate is blended into Green Meadow Fertiliser (GWM). The farmer to whom the GWM is delivered pays for the amount of N that he is given. From these revenues the storage, transport and application by GZV of the GWM on the farmer's land are paid.

Table 7. Economic KPI's of the GZV demonstration plant.

KPI	
EBITA margin	49% / €
EBIT margin	12% / €
Substrate financial productivity	34.52 € / tonne feedstock
Biogas financial productivity	0.32 € / m^3 biogas
Digestate financial productivity	-3.63 € / tonne feedstock