Feasibility analysis for Biomethane production – Summary – Belgium

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Summary

Belgium is one of the target countries within the REGATRACE project. The goal of the project is to accelerate the development of the biomethane market in each target country. One of the main drivers is the development of new biomethane production plants.

In this study the technical, legal and economic feasibility of the conversion of an existing biogas plant with CHP-units to a biomethane unit is investigated. The framework of this study is the deliverable 6.4 of the REGATRACE-project: “guidance for feasibility analysis covering biomethane investments”. The tools and methodology of this deliverable were used as a basis and starting point to calculate the feasibility of this biomethane project.

Biogas plant EcoWerf

EcoWerf is an intermunicipal organisation, responsible for the collection, treatment and prevention of organic and residual waste in 27 municipalities of East-Brabant, Flanders (Figure 1). The collection area is populated by ca. 400.000 inhabitants. Every year almost 180 000 ton of waste is collected, of which 70% is recycled and reused. EcoWerf has a composting facility for the treatment of OMSW with a capacity of 50.000 ton. In 2020 it was decided to expand the composting facility with a biogas plant. The OMSW will be first digested, whereas the digestate is afterwards composted together with green waste. The start-up of the biogas plant is foreseen in the last quarter of 2022.

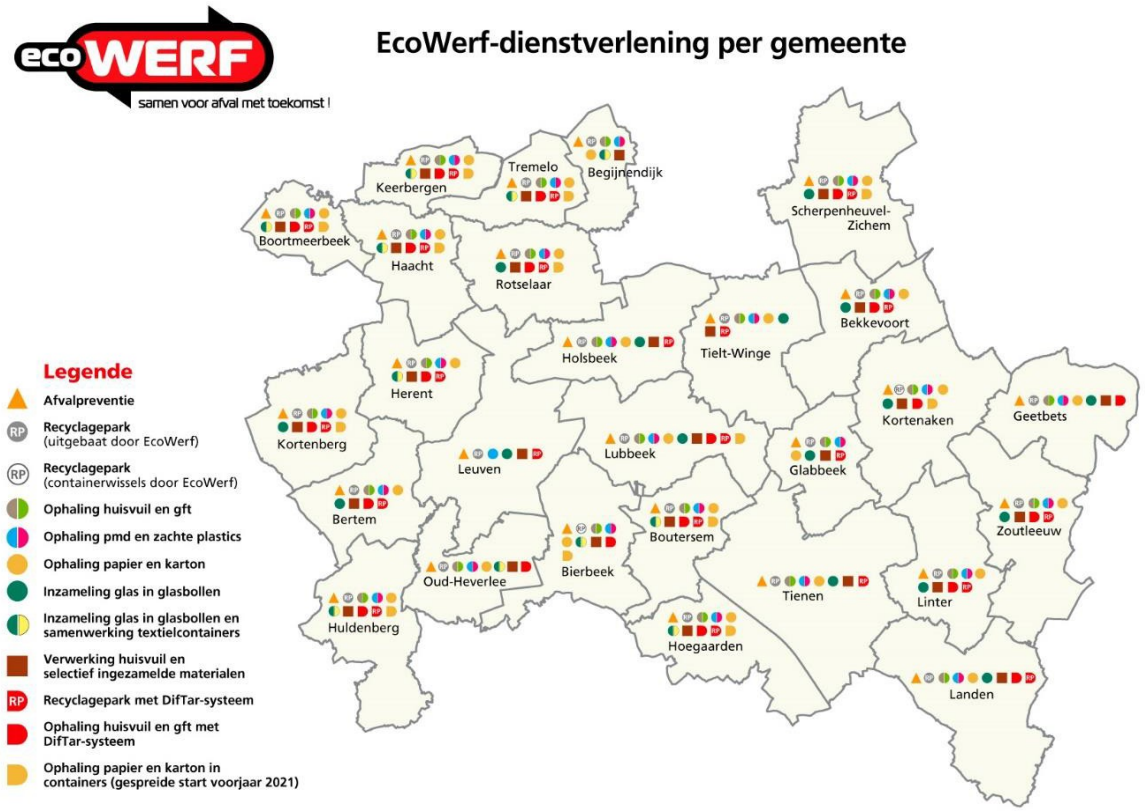

Figure 1: Collection area for organic waste of EcoWerf (source: www.ecowerf.be).

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The biogas installation is dimensioned to process 51.700 ton of organic waste per year (Table 1). The main feedstock will be OMSW. During the winter months when the amount of OMSW declines, ensilaged grass clippings will be used as a complementary feedstock.

Table 1: Feedstock composition of the biogas plant.

Waste stream	(ton/yr.)	DM (%)
OMSW	40.000	36,5
Grass resideus	7.000	40,0
Green waste	4.700	50,0

The yearly biogas production is estimated at 4 924 461 Nm^3, with a methane content of 58%. The biogas will be valorised in two CHP-units, with an electrical capacity of two times 901 kWe. The expected electricity and heat production are 11,3 GWh/yr, and 11,8 Gwh/yr respectively (Table 2).

Table 2: Production data biogas plant.

Biogas production	4.924.461 Nm^3/ yr.
	562,14 Nm^3/h
	28.468 MWh/ yr.
Electricity production	11.260 000 kWh/ yr.
Heat production	11.806 000 kWh/ yr.
Electricity demand biogas installation	1.638.000 kWh/ yr.
Heat demand biogas installation	755.000 kWh/ yr

The generated electricity will be used onsite to provide in the electricity demand of the biogas plant, the composting facility and offices onsite. The expected electricity demand is 3,5 GWh/yr. The produced heat will be used to maintain the required temperature for the digestion process and to heat the ambient air of the composting facility to improve the composting process.

Business model of biogas plant

The business model of the biogas plant is based on four main revenue streams:

1. Avoided costs of electricity and heat consumption

The site of EcoWerf has a high electricity and heat demand, which results in high energy costs. With the biogas plant EcoWerf can provide enough energy for the whole site, and therefore avoid the further purchase of (fossil) electricity and gas. The avoided costs are estimated at €434 490/yr.

2. Revenues for renewable electricity sale

It is estimated that there will be an overproduction of renewable electricity (6.122 MWh/yr.). The excess electricity will be injected in the electricity grid and sold on the market. The average price for electricity was €46.1/MWh on the ENDEX (year ahead) market in 2021. This results in an expected revenue of € 328.324.

3. Subsidies for renewable electricity production

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The production of biogas from OMSW is subsidised in Flanders if it is valorised in a CHP-unit. The net produced electricity is awarded with certificates, which have a fixed value of €93/certificate. The expected income for the certificates is estimated at 820 260 €/yr.

4. Subsidies for primary energy savings

Apart from the subsidy for renewable electricity production, biogas plants can also apply for a subsidy that reward the primary energy savings of a CHP-unit. The energy production with a CHP-unit is more efficient than the separated production of electricity and heat. For each MWh of primary energy savings, the biogas plants receives one certificate with a fixed value of € 31/certificate. The expected income from the subsidies for primary energy savings is estimated at 171.553 €/yr.

Conversion to biomethane upgrading

The current concept of the biogas plant is to valorise the biogas in two CHP-units and to maximise the self-consumption of the produced electricity and heat. Nevertheless, EcoWerf is already looking to the future and wants to investigate the feasibility of the production of biomethane for several reasons:

- The CHP-units are paid off after eight years. EcoWerf wants to investigate the possibilities to valorise the biogas when the CHP-units are end-of-lifetime.
- The biomethane market is rapidly developing. Biomethane offers new, interesting sale markets, which could be more profitable as the current setup.
- EcoWerf wants to reduce the carbon footprint of their activities. Currently, the diesel consumption of the garbage trucks is one of the biggest contributors to the total carbon footprint. Biomethane could be used as a eco-friendly replacement for the fossil diesel consumption.
- It is estimated that around 4% of the biogas will be flared as a consequence of maintenance or calamities. Injection in the gas grid can act as a buffer in times of overproduction and avoid the flaring of biogas.

In this study, the feasibility of three scenarios is investigated. The starting point of each scenario is the excess biogas, which is not required to provide in the electricity demand of the EcoWerf site. For each scenario the costs and revenues are determined, to calculate the final profit. One must be cautious in the interpretation of this profit, as it does not account for the production cost of the excess biogas, only for the valorisation.

1. Biogas-CHP: excess biogas is valorised in a CHP, similar to the current set-up
2. Biomethane injection: the biogas is upgraded to biomethane, injected in the gas grid and sold as green gas
3. Bio-CNG: the biogas is upgraded and compressed to bio-CNG to supply the cargo-fleet of EcoWerf. Currently all trucks of EcoWerf run on diesel, resulting in a high fuel cost. The excess bio-CNG is sold locally.

As an extension to the study the legal and technical requirements for the recovery of CO_2 from the off-gas from the biomethane upgrading are investigated, as well as the economic feasibility on request of EcoWerf.

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Legal and technical framework biomethane

The study starts with an overview of the current legal and technical specifications for the production and use of biomethane when injected in the gas grid or used as a transport fuel. Extra attention is given to gas quality and sustainability criteria.

- Gas quality. The quality requirements for the injection of biomethane are approved by the federal government and published by Synergrid. The technical regulations G8/01 describe apart from the gas quality, the procedures and rules for the safe injection of biomethane. With this regulation, Synergrid wants to ensure the proper operation of all gas appliances and productions processes, connected to grid.
- Technical regulations for injection on the distribution gas grid. These regulations describe the rules and requirements for the connection, management and access to the distribution gas grid. The regulations are issued by the Flemish regulator for gas and electricity. These guidelines stipulate the responsibilities of the biomethane producer and the gas grid operator, concerning gas quality control, odorisation and gas injection.
- Sustainability criteria. Europe regulates the sustainability and emission reduction criteria for the use and production of biomethane. Depending on the physical state (gaseous or liquid), and the end-use, different criteria count. Because the feedstock of the EcoWerf biogas installation is 100% biowaste from households, no sustainability criteria are enforced. Only if the biomethane is used as a transport fuel, a GHG-reduction of 65% has to be guaranteed.
- Registry systems. To avoid double counting and guarantee the origin of biomethane once injected in the gas grid, a registry system is necessary. In Flanders, the guarantees of origin (GO / 1 per MWh biomethane) are issued by a product coordinator, in this case the Flemish regulator for electricity and gas. The TSO, on its turn, is responsible to deliver all production data to the product coordinator and calculate the required amount of GO's. The average value of a green gas GO in Flanders was €20 in 2021, significantly lower than in neighbouring countries. If biomethane is used as a transport fuel, a stricter product regulation has to be followed, including a proof a sustainability and a registration on a federal database.

Legal and technical framework liquid CO_2

The production of liquid CO_2 as a side-product of the production of biomethane is a rather new technology, and not yet implemented in Belgium. Nevertheless, the demand of biogenic CO_2 is rising, as is the focus on low-carbon production processes. Therefor the legal and technical framework of liquefying CO_2 and the economic impact were investigated.

The liquid CO_2 is mainly used as a fertilizer in greenhouses, a food additive for carbonising drinks or as a conservative, an eco-friendly cooling agent, an acidic additive or as a feedstock in the chemical industry. In order to reach a high purity, the off-gas is dewatered and cooled down under high pressure until the condensation point of CO_2 is reached. Other impurities like nitrogen or methane are still gaseous at this stage, resulting in a pure CO_2-stream.

The most used quality framework for liquid CO_2 is issued by the European Industrial Gases Association, imposing the requirements for food grade CO_2. Food grade CO_2 is accepted as the standard in the food and beverages industry, as well as in the horticulture. Other industrial applications require lower quality, resulting in a diverse set of requirements depending on the end-use.

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Economic feasibility analysis biomethane

The feasibility of three scenarios is determined. The starting point of each scenario is the excess biogas, which is not required to provide in the electricity demand of the EcoWerf site (ca. 20 GWh biogas per year). An overview of the general parameters of the biogas installation in its current set-up is given in Table 3.

Table 3: General parameters biogas installation EcoWerf in current set-up.

Parameter	Value	Units
Operation time	8150	h
Biogas production	4.924.461	$Nm^3/yr.$
	28.476.188	kWh/yr.
Electricity production	11.260.000	kWh/yr.
Heat production	11.806.000	kWh/yr.
Electricity consumption biogas plant	1.638.000	kWh/yr.
Electricity consumption EcoWerf	2.500.000	kWh/yr.
Heat demand biogas plant	755.000	kWh/yr.
Heat demand EcoWerf (excl. composting installation)	500.000	kWh/yr.
Lower heating value methane	9,97	kWh/Nm^3
Methane content biogas	0,58	-

For each scenario (biogas-CHP, biomethane injection and bio-CNG), the operational and investment cost were determined, as well as possible revenues. It should be noted that only the costs and revenues related to the valorisation of the biogas, either in a CHP or upgraded, were considered and the production cost for the raw biogas. Therefore, the economic analysis cannot be used to evaluate the feasibility of the entire biogas plant.

The economic data for the bio-CHP scenario were retrieved from 'Rapport 2021 Deel 1: Rapport OT/Bf voor projecten met een startdatum vanaf 1 January 2022', issued by the Flemish Agency for Climate and Energy. These data are based on a survey of all relevant biogas plants in Flanders and are used by the Flemish government to calculate the required subsidy for new biogas plants. For biomethane scenarios, two different companies provided detailed information on the OPEX and CAPEX of both upgrading and injection, as the production of bio-CNG.

Table 4: Economic feasibility of three scenarios: bio-CHP, biomethane injection and bio-CNG.

Parameter	Unit	Biogas-CHP	Biomethane injection		Bio-CNG	
			Company 1	Company 2	Company 1	Company 2
CAPEX	€	817.397	1.404.800	1.320.000	149.780	140.600
OPEX	€/yr.	110.606	156.107	149.375	203.049	196.316
Subsidies	€/yr.	824.716	0	0	0	0
Revenues	€/yr.	321.593	656.584	656.584	2.134.186	2.134.186
Balance (+/-)	€/yr.	**953.963**	**359.997**	**375.209**	**1.781.358**	**1.797.270**

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The feasibility analysis (Table 4) clearly shows that the bio-CNG scenario is the most profitable. The determining factor for the profit of this scenario is the avoided cost of diesel. This scenario fits perfectly in the ambition of EcoWerf to reduce their footprint and decarbonise their fleet of collection trucks. The switch from diesel trucks to gas vehicles also imply investments in new trucks or the conversion of the current fleet. These investment costs are not considered within the scope of the study.

The feasibility of the injection scenario depends heavily on the revenues from biomethane GO's. In the current analysis, a price of €20/GO was considered. This is rather conservative as the prices for GO's in the Netherlands and Germany are in the range of €70 to €100 per GO. A further development of the domestic biomethane market, or European market, could result in higher prices for the green gas GO, with a beneficial effect on the feasibility.

Economic feasibility analysis liquid CO_2

The analysis of the economic feasibility of liquid CO_2 is an add-on on the original study of the conversion to biomethane (Table 5). The production of liquid CO_2 is interesting as it creates an extra end-product, but even more important it lowers the carbon footprint of the process significantly.

Table 5: General parameters liquid CO2-production.

Parameter	**Unit**	**Waarde**
CO_2 production	kg/yr	2.873.489
Price liquid CO2	€/kg	0,035

The economic analysis results in a negative balance for the production of liquid CO_2. Currently the market price is too low to have a profitable project (Table 6). Nevertheless, the production of CO_2 can create interesting market opportunities. Recovering and reusing CO_2 can lead to a negative carbon balance of the biomethane. In Germany, the market price of biomethane is already heavily correlated with the carbon intensity of the biomethane, going as high as €200/GO. This price would lead to a positive result for the biomethane injection scenario of almost 4 million euros, easily compensating for the high investment cost of the CO_2-liquefaction unit.

Table 6: Economic feasibility of liquid CO2 production.

Parameter	**Unit**	**Company 1**	**Company 2**
CAPEX	€	904.000	1.520.000
Energy demand	kWh/Nm³ biogas	0,225	
	kWh/kg CO_2		0,21
OPEX	€/yr	92.421	58.450
Revenues	€/yr	92.778	92.778
Balance (+/-)	**€/yr**	**-90.043**	**-117.672**

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