FEASIBILITY STUDY- POLISH CASE – SUMMARY

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Within the framework of work package WP6 of the REGATRACE project (www.regatrace.eu), the European Biogas Association EBA, in cooperation with partners from target countries, has developed a guidebook (D6.4) providing guidelines for feasibility analysis of biomethane[1] investment projects. The document is based on general principles applicable at the European level complemented by the national partner (in Poland UPEBI) with country-specific information.

In Polish case the aforementioned guidelines were used to develop a feasibility study for the expansion of an existing AD plant to include a biogas-to-biomethane unit (*the conversion project*). In that case, the feasibility study used a range of data generated during operation of the AD plant, such as actual substrate costs, biogas yield, biogas quality, energy consumption, digestate quality and management, achieved full-load operating time, etc.

AD PLANT DESCRIPTION

The 1.8MW agricultural biogas plant selected for analysis is located in the Kujawsko-Pomorskie Province. It is owned by a producer group. Currently, it is also a waste processing plant (ZPO) therefore, according to the requirements of the National Support Centre for Agriculture (KOWR)[2], it can only process substrates with specific BDO codes (waste database).

It was assumed that the biogas plant operated by a group of local agricultural producers would continue to focus on processing local biomass, generating electricity and heat for use in the biogas upgrading process, or in the other option for the liquefaction of biomethane, or also for the liquefaction of CO2. The plant will continue to produce fertilizer in the form of digestate for use on the fields of AD plant owners.

The AD installation has benefited from the certificate support system since 2013, switched to the auction system two years ago and will benefit from this system until 2028. The question remains when and under what conditions an installation that uses the auction system can switch to biomethane production.

Technological process: the mesophilic digestion process takes place in two concrete membrane-covered digesters (6.000 m3) and an additional concrete secondary digester (3.000 m3). The fermentation process takes 40-50 days in the temperature of 40-42°C, PH is 8.

[1] Biogas upgraded to natural gas quality

[2] www.kowr.gov.pl

Substrates are received in the form of liquid and solid ones. Liquid substrates go to the initial tank from where they are dosed to the digesters with a system of pumps and pipes. Solid substrates (unless they need to be crushed) are stored in silos and then are dosed by means of a telescopic loader to the so-called alligators and go via them to the digesters.

Currently, the biogas plant has 2 CHP units with a capacity of 1.875 MW. For the plant's own needs is used approx. 8% of the generated electricity, the remaining amount is sold. Part of the thermal energy (out of 1.5 MWh) is used to heat the fermenters; the remaining amount is sold to the local Municipal Heat and Power Company (MPEC). Annually, the plant consumes 7,000 liters of engine oil for the CHP units.

The digestate is stored in two closed storage tanks with a capacity of 9,000 m3. The digestate is fully disposed of on the shareholders' fields - an area of 2,000 hectares.

Substrates

Substrates	Mg/year	cost PLN/Mg	Biogas production m3/Mg
Maize residue	14.000	70-80	200
Poultry manure	9.600	60	100
Fruit and vegetables waste	7.000	50-70	185
Beet pulp	3.800	80-100	110
Beet roots	3.600	50-60	80
Sludge from on-site sewage treatment plants	5.000	od -15 do 0	360
Biowaste cat.3	13.600	20-60	400
Distillery decoction	6.000	40-50	70

The agricultural biogas plant uses up to 100 tons of substrate per day. Substrates are delivered by barrels, in trucks on a regular basis. Some substrates are seasonally delivered like pulp and beet roots. Substrate prices depend on the distance of delivery to the plant, on the companies' interest in disposal.

SWOT ANALYSIS

The results of the SWOT analysis for the investment project under consideration are presented below.

Strengths:

- Production of green gas - biomethane.
- End-of-life recycling of bio-waste, especially animal manure from livestock farms
- Reduction of greenhouse gas emissions
- Co-generation of electricity and heat from biogas to support the process
- Guaranteed sales of electricity and biomethane
- Access to significant amounts of local feedstock - elimination of bio-waste needed
- Possibility of obtaining subsidies, preferential loans under the new NIP perspective.
- Positive impact on the environment - fitting into a circular economy, management of digestate as a valuable natural fertilizer

Weaknesses:

- Lack of legal regulations and support mechanisms for biomethane.
- Lack of reference biomethane plants in Poland

- High sensitivity of profitability dependent on local availability and price of substrates
- Lack of knowledge in the society about the importance, potential and environmental and economic impact of this type of plant

Opportunities:
- Introduction of regulations driven by the implementation of the EU Green Deal, e.g., EU Community targets for increasing the share of energy from RES on final energy consumption in power, heating and cooling, and transport.
- Growing energy demands in agricultural areas requiring certainty and quality of energy supply
- Further development of agriculture in the region and competitive processing of agricultural products requires the use of technological solutions with the highest environmental standards, especially for the management and utilization of production residues such as biogas plants
- Getting experience for the implementation of investment projects related to biomethane production
- New source of revenue for core business operations
- Getting new competence for implementation of new technology
- A local and independent source of gas for energy and transportation purposes
- Long-term biomethane offtake contracts an opportunity for project banking.

Threats:
- Lack of support systems for biomethane / significant delays in the introduction of regulations
- Increase in the price of substrates and lack of guarantees of their constant supply
- Obtaining a low sales price for biomethane, heat and digestate
- Problems with obtaining administrative permissions
- Problems with obtaining conditions for connection to the electricity and gas grids
- Technical problems with the new technology, which has not been serviced in Poland so far
- Termination of acceptance of biomethane into the gas grid in case of minimal quality deviations - disruption of supplies to customers.

FINANCIAL ANALYSIS

In order to obtain technical and financial data for the reconstruction of the agricultural biogas plant, requests for offers were sent out.
The tender inquiries were sent to, among others: Fiorentini; DMT; Envitec; Bright biomethane and Agricomp

Installation costs submitted by bidders

	unit	BIDDER 1	BIDDER 2	BIDDER 3
BUDGET	k€			
Upgrading UPG	k€	1.712	2.683	1.500
UPG on-site assembly	k€	90	92	95
Injection to the grid	k€	280	250	250-300
UPG + scrubber	k€	100	118	115
bioLNG	k€	3000	2.800	3.200
bioLNG on-site assembly	k€	80	80	85
Liquid CO2	k€	1.980	2.000	1.900-2.100

As part of our study and analysis of the potential conversion of an agricultural biogas plant into a biomethane plant, we looked as well on a second option - a biomethane plant producing liquefied

biomethane (bioLNG) especially in the case when grid connection would not be possible. We performed two separate analyses based on two different bidding procedures in which we obtained cost estimations for both solutions. It should be added that the bidding took place during the period of supply chain disruption occurring after the Covid pandemic and during the ongoing hostilities in Ukraine, and the embargo on products from Russia.

In the next section we present results of analysis for biomethane upgrading and injecting to natural gas grid.

CAPEX COSTS

The assumed costs of biomethane injection to the grid in analyzed biogas plant are:
- 4 km of pipe to connect to the PSG network - PLN 300.000 * 4km = PLN 1.200.000 net
- Analyzers and chromatograph - PLN 1.000.000 net
- Operation of the unit for upgrading of biomethane or operation of the unit for production of bioLNG
- 7800 h / year

CAPEX costs taken in the analysis:

1. **unit for the upgrading to biomethane 3 000 000 Euro (1 euro= 4,6 PLN)**
i.e., the cost of completing the installation is about 1.5 million euros
+ cost of the connection (about 300 000 PLN/km)
+ cost of chromatograph analyzer (about 1 000 000 PLN)

Estimated investment cost for biomethane plant (Euro)

ITEM	AD	Upgrading	Total
Construction	2.365.000	550.000	2.915.000
Machinery for technology	1.950.000	3.508.261	5.458.261
CHP unit	450.000		450.000
pipelines	195.000	80.000	275.000
Measuring& steering system	275.000	200.000	475.000
Electricity network connection	80.000	528.261	608.261
Loading machine	150.000		150.000
Roads, fencing	150.000		150.000
Engineering, inspections	170.000	120.000	290.000
Land	100.000		100.000
Other (deliveries, insurance, customs etc.)	150.000	150.000	300.000
TOTAL	6.035.000	5.136.522	11.171.522

OPEX COSTS

In the analyzed case, the following data was taken into account:

1. The cost of purchasing energy from outside does not exceed ca. PLN 100 per month, as these are emergency situations when both units are out of service. For its own needs is consumed approx. 7-8% of production.
2. Heat is sold to local MPEC at a cost of about PLN 50-60 thousand per month. Costs on the side of the biogas plant are the purchase of water conditioning agents about PLN 10.000 per year.
3. The recipients of the digestate are the shareholders of the biogas plant who practically utilize 100% of the production. When it comes to the market and suppliers of substrates, the biogas plant has no problems, i.e., some substrates are delivered on an up-to-date basis, either by transport commissioned by the biogas plant or by producers' transport (depending on the

contract). The biogas plant has its own storage of substrates, obtained seasonally (corn sludge, pulp and beet roots). Contracts concluded with suppliers are either term contracts, i.e., they concern a production action like a sugar plant, or they are concluded indefinitely with a notice period specified in them. Currently, the situation of substrate procurement for biogas plants is very stable.

Assumptions concerning energy prices:
- Electricity price – 800 PLN/MWh
- Thermal energy price – 120 PLN/MWh

Energy consumption in the biomethane production process:
- 1.500 MWh/year of electricity
- 1.700 MWh/year of thermal energy

The possibility of a stable supply of about 400m3 of biomethane per hour were assumed in the financial model.

OPEX costs:

Substrates	835.304	EUR/year
Machinery maintenance	268.163	EUR/year
Constructions maintenence	14.575	EUR/year
Spare parts	20.000	EUR/year
Chemicals	10.000	EUR/year
Energy (electricity)	0	EUR/year
Fermentation residue transportation	60.826	EUR/year
Biotechnological service	12.000	EUR/year
Personnel costs	150.000	EUR/year
Administration; overheads	36.000	EUR/year
Insurance, banking	63.014	EUR/year
TOTAL	1.469.882	EUR/year

Other costs:

CHP maintenance			44.000	EUR/year
Maintenance AD machinery	2,5%	% investment	48.750	EUR/year
Maintenance upgrading unit	5,0%	% investment	175.413	EUR/year
Spare parts (inc. wear & tear)	20 000	EUR/year	20.000	EUR/year
Maintenance AD constructions	0,5%	% investment	11.825	EUR/year
Maintenance upgrading construction	0,5%	% investment	2.750	EUR/year
Maintenance total			302.738	EUR/year

PROFITABILITY ASSESSMENT

The following assumptions were applied conservatively to the financial model:

1. own contribution 25%
2. subsidy 30%
3. bank loan for 10 years with a credit grace period of 18 months.

The indicator analysis was performed for:

- Discount rate = 10% (analysis at constant prices).
- Period = 13 years consisting of: 1 year of construction + 12 year operating period

Assumptions concerning revenues:

Biomethane sales price - 1,52 EUR/m3 (15,86 EURcent/kWh)

Thermal energy sales price - 6,52 EUR/GJ (2,35 EURcent/kWh

RESULTS

IRR/NPV with a subsidy

NPV	9.630.035
IRR	80,10%
Return on invested capital (years)	1,5
Average ROE (first 12years)	61,06%

Return on investment indicators show that the project generates a positive rate of return with the subsidy, which also contributes to a positive NPV.

SENSITIVITY ANALISYS

Within the model, a sensitivity analysis was performed for the chosen factors, generating the following results:

CAPEX increase by 20%

NPV	8.359.165
IRR	62,51%
Return on invested capital (years)	2
Average ROE (first 12years)	47,17%

A 20% increase in CAPEX results in a 17.6% decrease in IRR, a decrease in NPV by 1,27 million PLN, an extension of the payback period by 6 months and a 13.88% decrease in ROE. Despite this increase in CAPEX, the project still has high indicators.

Substrate price increase by 10%

NPV	9.628.716
IRR	80,10%
Return on invested capital (years)	1,5
Average ROE (first 12years)	61,05%

A 10% increase in substrate costs results in a slight decrease in ratios: IRR, NPV, ROE and a slight increase in the payback period.

Decrease in substrate costs by 10% results in a slight increase in IRR, NPV, ROE and a slight reduction in payback period.

Decrease in substrate price by 10%

NPV	9.631.355
IRR	80,11%
Return on invested capital (years)	1,5
Average ROE (first 12years)	61,07%

Biomethane price increase by 10%

NPV	11.967.342
IRR	94,18%
Return on invested capital (years)	1
Average ROE (first 12years)	73,61%

A 10% increase in the price of biomethane increases the IRR by 14,07%, increases the NPV by PLN 2,33 million, shortens the payback period by 6 months and increases the ROE by 12,55%. The increase in the price of biomethane significantly increases the project's benchmarks.

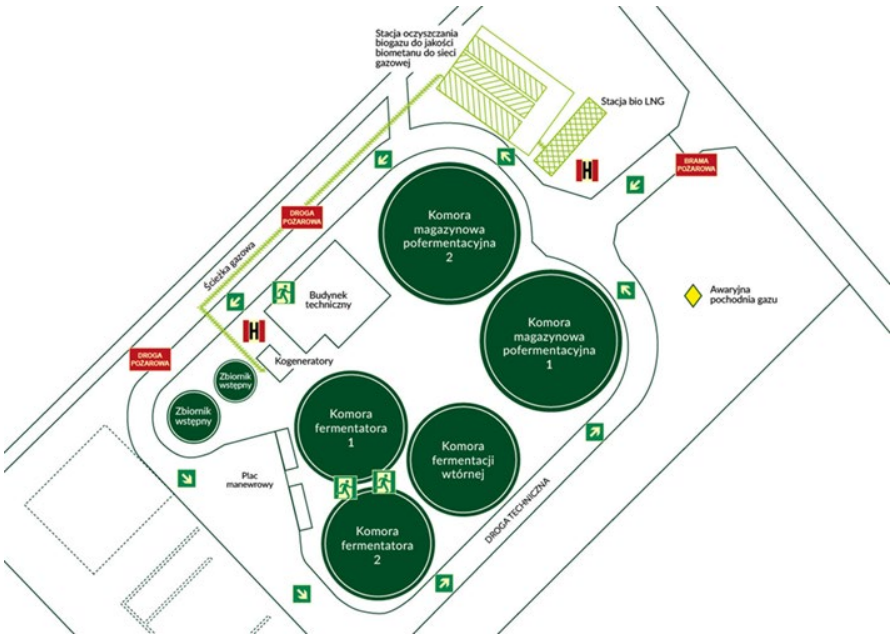
CONCLUSIONS

The financial model presented in the study for the analyzed biogas plant indicates the profitability of the investment in the biomethane plants. The prerequisite for this type of investment is the removal of basic legal barriers.

The existing legal regulations for RES support analyzed in the study do not correspond to the actual needs in the field of operation of biomethane plants, so that, in practice, they do not stimulate the development of such initiatives. As a result, despite the fact that, in accordance with the current state of the law, it has been possible for several years to inject purified agricultural biogas into distribution gas grids, to date, no such installation has started operation in the country.

The current barriers to the development of biomethane in Poland are still the lack of final regulations in the law, both administrative and regulatory within the biofuels group, and decisive support for their development. As of today, there is a lack of both operational and expected subsidy support. The first biomethane plant installations will convince both the public of the new technology, but also banks and future interested investors.

In the development of biomethane, the biggest technical problem is still the aspect of connection to local gas networks. The high cost of connecting to the gas network and the problems of obtaining connection conditions, as well as the waiting time for connection, are the most serious technical barriers to the development of this technology. High hopes are being placed on bioLNG projects, where the product is off taken e.g. by customer tankers.



Location of the planned upgrading unit and bioLNG station

ASSUMPTIONS USED IN THE ANALYSIS

Income/revenue from sale/use of energy produced

Year		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Sale of thermal energy	kWh/year	990 000	1 100 000	1 100 000	1 100 000	1 100 000	1 100 000	1 100 000	1 100 000	1 100 000	1 100 000	1 100 000	1 100 000	1 100 000	1 100 000	1 100 000	1 100 000
Income from sale of thermal energy	**EUR/year**	**23 250**	**25 833**	**25 833**	**25 833**	**25 833**	**25 833**	**25 833**	**25 833**	**25 833**	**25 833**	**25 833**	**25 833**	**25 833**	**25 833**	**25 833**	**25 833**
Volume of sold biomethane	MWh	28 159	31 288	31 288	31 288	31 288	31 288	31 288	31 288	31 288	31 288	31 288	31 288	31 288	31 288	31 288	31 288
Income from sale of biomethane	**EUR**	**4 061 677**	**4 512 974**	**4 512 974**	**4 512 974**	**4 512 974**	**4 512 974**	**4 512 974**	**4 512 974**	**4 512 974**	**4 512 974**	**4 512 974**	**4 512 974**	**4 512 974**	**4 512 974**	**4 512 974**	**4 512 974**
Volume of solid fermentation residue	tons/year	20 085	22 317	22 317	22 317	22 317	22 317	22 317	22 317	22 317	22 317	22 317	22 317	22 317	22 317	22 317	22 317
Income from sale of fermentation residue	**EUR/year**	**107 013**	**118 903**	**118 903**	**118 903**	**118 903**	**118 903**	**118 903**	**118 903**	**118 903**	**118 903**	**118 903**	**118 903**	**118 903**	**118 903**	**118 903**	**118 903**
TOTAL INCOME	**EUR/year**	**4 191 940**	**4 657 711**	**4 657 711**	**4 657 711**	**4 657 711**	**4 657 711**	**4 657 711**	**4 657 711**	**4 657 711**	**4 657 711**	**4 657 711**	**4 657 711**	**4 657 711**	**4 657 711**	**4 657 711**	**4 657 711**

Cash flow forecast

YEAR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Revenue from sales	**4 191 940**	**4 657 711**	**4 657 711**	**4 657 711**	**4 657 711**	**4 657 711**	**4 657 711**	**4 657 711**	**4 657 711**	**4 657 711**	**4 657 711**	**4 657 711**	**4 657 711**	**4 657 711**	**4 657 711**
Substrates cost	948 837	1 054 263	1 054 263	1 054 263	1 054 263	1 054 263	1 054 263	1 054 263	1 054 263	1 054 263	1 054 263	1 054 263	1 054 263	1 054 263	1 054 263
Personnel costs	150 000	150 000	150 000	150 000	150 000	150 000	150 000	150 000	150 000	150 000	150 000	150 000	150 000	150 000	150 000
Maintenance (in that spare parts)	75 685	302 738	302 738	302 738	302 738	302 738	302 738	302 738	302 738	302 738	302 738	302 738	302 738	302 738	302 738
Other material costs	10 000	10 000	10 000	10 000	10 000	10 000	10 000	10 000	10 000	10 000	10 000	10 000	10 000	10 000	10 000
Fermentation residue transportation	60 826	60 826	60 826	60 826	60 826	60 826	60 826	60 826	60 826	60 826	60 826	60 826	60 826	60 826	60 826
Other operational costs	30 328	30 328	30 328	30 328	30 328	30 328	30 328	30 328	30 328	30 328	30 328	30 328	30 328	30 328	30 328
Reparations cost	80 686	80 686	80 686	80 686	80 686	80 686	80 686	80 686	80 686	80 686	80 686	80 686	80 686	80 686	80 686
Total direct and indirect costs	**1 356 361**	**1 688 841**	**1 688 841**	**1 688 841**	**1 688 841**	**1 688 841**	**1 688 841**	**1 688 841**	**1 688 841**	**1 688 841**	**1 688 841**	**1 688 841**	**1 688 841**	**1 688 841**	**1 688 841**
EBITDA	**2 835 579**	**2 968 870**	**2 968 870**	**2 968 870**	**2 968 870**	**2 968 870**	**2 968 870**	**2 968 870**	**2 968 870**	**2 968 870**	**2 968 870**	**2 968 870**	**2 968 870**	**2 968 870**	**2 968 870**
Depreciation	1 118 946	1 118 946	1 118 946	1 118 946	1 118 946	1 015 790	1 061 275	1 106 761	374 026	374 026	388 870	401 320	383 053	419 380	470 551
EBIT	1 716 633	1 849 924	1 849 924	1 849 924	1 849 924	1 953 080	1 907 595	1 862 109	2 594 844	2 594 844	2 580 000	2 567 550	2 585 817	2 549 490	2 498 319
Interest paid on the loan		-328 778	-303 834	-277 394	-249 367	-219 659	-188 168	-154 788	-119 404	-81 898	-42 142	-744 506	0	0	0
Amount subject to income tax	1 716 633	1 521 146	1 546 090	1 572 530	1 600 557	1 733 421	1 719 427	1 707 322	2 475 439	2 512 945	2 537 858	1 823 044	2 585 817	2 549 490	2 498 319
EBITDA	2 835 579	2 968 870	2 968 870	2 968 870	2 968 870	2 968 870	2 968 870	2 968 870	2 968 870	2 968 870	2 968 870	2 968 870	2 968 870	2 968 870	2 968 870

Income tax	257 495	228 172	231 913	235 880	240 084	260 013	257 914	256 098	371 316	376 942	380 679	273 457	387 873	382 423	374 748
Operating cash flow (interest paid, taxed)	2 578 084	2 740 698	2 736 956	2 732 990	2 728 786	2 708 857	2 710 956	2 712 772	2 597 554	2 591 928	2 588 191	2 695 413	2 580 997	2 586 446	2 594 122
Investment cash flows (subsidized)	0	0	0	0	0	-118 750	-363 884	-363 884	-521 384	0	-118 750	-150 000	-409 370	-409 370	-409 370
Cash flow from operating and investment activities	2 578 084	2 740 698	2 736 956	2 732 990	2 728 786	2 590 107	2 347 072	2 348 888	2 076 170	2 591 928	2 469 441	2 545 413	2 171 628	2 177 077	2 184 753
Financing															
Loan servicing (repayment + interest)		-744 506	-744 506	-744 506	-744 506	-744 506	-744 506	-744 506	-744 506	-744 506	-744 506	0	0	0	0
Financing cash flow		-744 506	-744 506	-744 506	-744 506	-744 506	-744 506	-744 506	-744 506	-744 506	-744 506	0	0	0	0
Cash flow	**2 578 084**	**1 996 192**	**1 992 450**	**1 988 484**	**1 984 280**	**1 845 600**	**1 602 565**	**1 604 381**	**1 331 664**	**1 847 422**	**1 724 935**	**2 545 413**	**2 171 628**	**2 177 077**	**2 184 753**