Swedish-Polish Sustainable Energy Platform

Protection of the South Baltic Sea through the reduction of emission coming from agricultural waste pollution.

Agricultural micro biogas plant (40 kWe/60kWt) for agrowaste with educational function

at the Agricultural School Complex Vocational Training Centre in Pszczela Wola (The Poviat Lublin). Pilot Project.

Edward Licznerski
CEO
EPC Agro-Energetyka Ltd Gdańsk

BSAP Project AGROWASTE Poland:
Nordic Investment Bank - Helsinki
& Nordic Environment Finance Corporation (NEFCO) - Helsinki

* Plan of presentation.

* Objectives of the Project, the Partners, budget project's and timetable of implementation
* Project location. Resources of fermentation biomass.
* Technology of micro bio-gas plant. Technical parameters.
* Environmental impact - forecast
* Economic effects - forecast
* Education - school syllabus
* Forecast of project development in the Region after 2014.

* 1. Objectives of the Project, the Partners, budget project's and timetable of implementation.

* The main objective of the project. Reduction of the bio-genes emission of agricultural origin to the South Baltic Sea.

The objective of the project is to design and implement an agricultural micro biogas plant to agricultural waste in an optimum location.

This Project must fulfil the conditions set out in the BSAP Fund – AGROWASTE Poland programme, which has been implemented with the participation of Helsinki Nordic Investment Bank and NEFCO:

- **Management of agricultural waste to reduce bio-genes emission into Polish rivers and the South Baltic Sea.**
- **Generation of combined agricultural bio-gas and bio-energy.**
- **Production of natural fertilizer of post-fermentation biomass.**
- **Education of young people and farmers.**

* Partners for the project. Budget of the project. Timetable.

Partners of the pilot project:

- The Poviat Lublin, as the main investor, which is the founding authority for the Agricultural School Complex Vocational Training Centre in Pszczela Wola
- Nordic Investment Bank and NEFCO in Helsinki , the partner which assures additional funding for the project,
- and EPC Agro-Energetyka Ltd Gdańsk – the general contractor to implement the project.

The budget of the „Pszczela Wola" project amounts to a total of 305 000 EUR, of which:

- The Poviat Lublin - 100 000 EUR
- Nordic Investment Bank & NEFCO in Helsinki - 200 000 EUR
- EPC Agro-Energetyka Ltd Gdańsk – 5 000 EUR

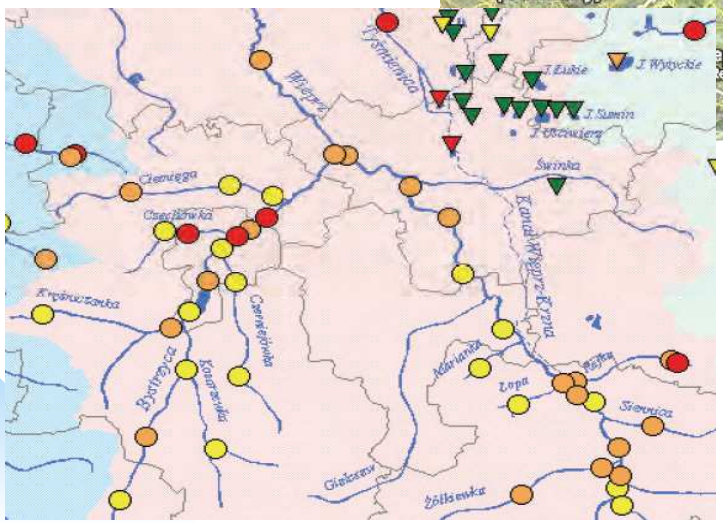
The project implementation schedule: February 2013 – October 2014.

Stages of project preparation and implementation:

- The objective study – an analysis of 3 locations and the choice of the optimum one - 31.03.2013
- Feasibility study – business plan – project schedule - 30.06.2013
- Public tender in the system „Design and build" - 4th quarter of 2013
- Starting building of the installation - 2nd quarter of 2014
- Training for teaching staff and operators - 3rd quarter of 2014
- Completion of building - 30.09.2014
- Commissioning and start-up of operations and teaching workshops - October 2014

* 2. Project location. Resources of bio-mass for fermentation.

* 2. Location. The Agricultural School Complex Vocational Training Centre in Pszczela Wola. The Poviat Lublin.



In the Region of Lublin the most polluted river is the Bystrzyca, which flows in the neighbourhood (about 200 m) from the location of the farm of the Group of Agricultural Schools, in Pszczela Wola.

* Location. The Agricultural School Complex Vocational Training Centre in Pszczela Wola. The Poviat Lublin.

General characteristics.

- The group of agricultural schools with the agricultural breeding farm; the area of 118 hectares; breeding cattle, pigs and farm horses
- The school runs a bee breeding technical school as the only one of this type in Europe.
- Boarding house (accommodation for 150 persons)
- The the Agricultural School Complex Vocational Training Centre in Pszczela Wola has ISO9001:2009 certificate.
- www.pszczelawola.edu.pl

* Location. The Agricultural School Complex Vocational Training Centre in Pszczela Wola. The Poviat Lublin.

Grass harvesting from the 2nd and 3rd windrow for silage.

Source: www.bioconstruct.de

Baling grass for silage.

Grinding down grass silage bales.

* Location. Resources of biomass for fermentation.

* Bio-gass and bio-energy recovery. Calculation of bio-gas substrates output with the efficiency of the installation and the technological parameters of fermentation mixture taken into account. (HRT 22, electric efficiency of motor 32%).

Available substrates at biogas plant plant location	Bovine liquid slurry	Bovine manure	Horse manure	Fermented sugar beet leaves	Fermented grass from green areas	Leftovers from processing of vegetables (Osmofrost)	Result for biomass mixture	Electric output of combined heat and power system CHP 39-42 kW
sm [%] śm	8.00	25.00	0.00	18.00	28.00	22.00		
smo [%] sm	80.00	76.00	0.00	75.00	93.00	92.00		
Quantity of substrate [t/rok]	2 760.00	560.00	0.00	150.00	460.00	240.00	4 170	
Daily portion [t/24h] for continuous mode 365 d/y	7.56	1.53	0.00	0.41	1.26	0.66	11.42	Share of dry biomass in a mixture
Quantity of substrate [%śm]	66.19	13.43	0.00	3.6	11.03	5.76		13.7 % sm
max. biogas gain [m^3/t śm]	28.00	50.00	0.00	19.00	120.00	90.00		Average working productivity of biogas plant (duration 8000 h/r)
Biogas gain [m^3/a]	77 280.0	28 000.0	0.0	2 850.0	55 200.0	21 600.0	184 930	23.12 m3/h
Content of CH_4 [%]	58.00	60.00	0.00	48.00	55.00	60.00		Average content of CH_4 in biogas mixture
m^3 CH_4/t śm	16.24	30.00	0.00	9.12	66.00	54.00		57.49 %
m^3 CH_4 from substrate	44 822.40	16 800.00	0.00	1 368.00	30 360.00	12 960.00	106 310	Average gain of CH_4
kWh of electric energy from t śm	58.80	105.00	0.00	39.90	252.00	189.00		12.14 m3/h
kWh from substrate	162 288.00	58 800.00	0.00	5 985.00	115 920.00	45 360.00	388 353	291.26 m3/24h

Source: Feasibility study, EPC Agro-Energetyka sp. z o.o. Gdańsk, dr Renata Myczko, June 2013 r.

* 3. Micro bio-gas plant technology. Technical parameters.

* Technology. The container micro bio-gas plant in the system of double stage methane fermentation of 40 kWe power.

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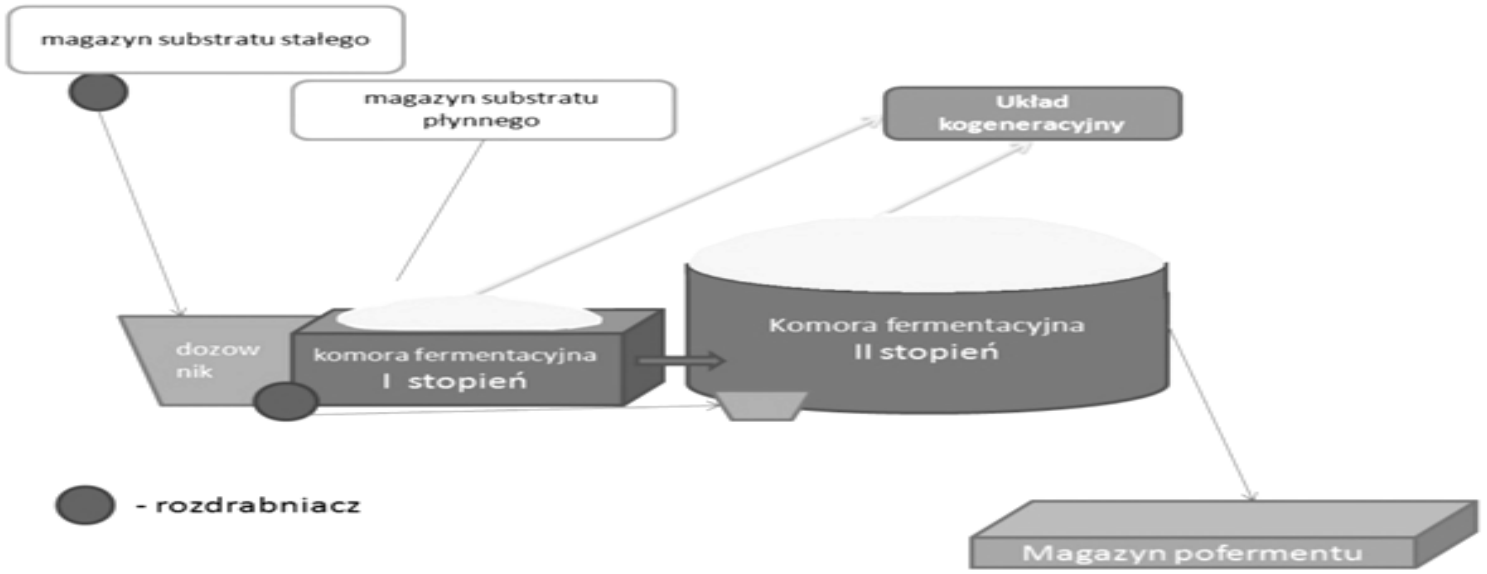
The main partner and technological consultant of the micro bio-gas plant project to be implemented in Pszczela Wola is prof. Andrzej Myczko, the Technological Natural Institute, Branch in Poznań (Instytut Technologiczno-Przyrodniczy O/Poznań).
In 2012 in Poznań, a prototype of a container agricultural micro bio-gas plant was implemented and the research on an optimum technological process has been conducted ever since. ITP Branch Poznań has excellent scientific staff and very good laboratories.
The membrane installation to purify the agricultural bio-gas.

Installation of membrane to purify agricultural biogas.

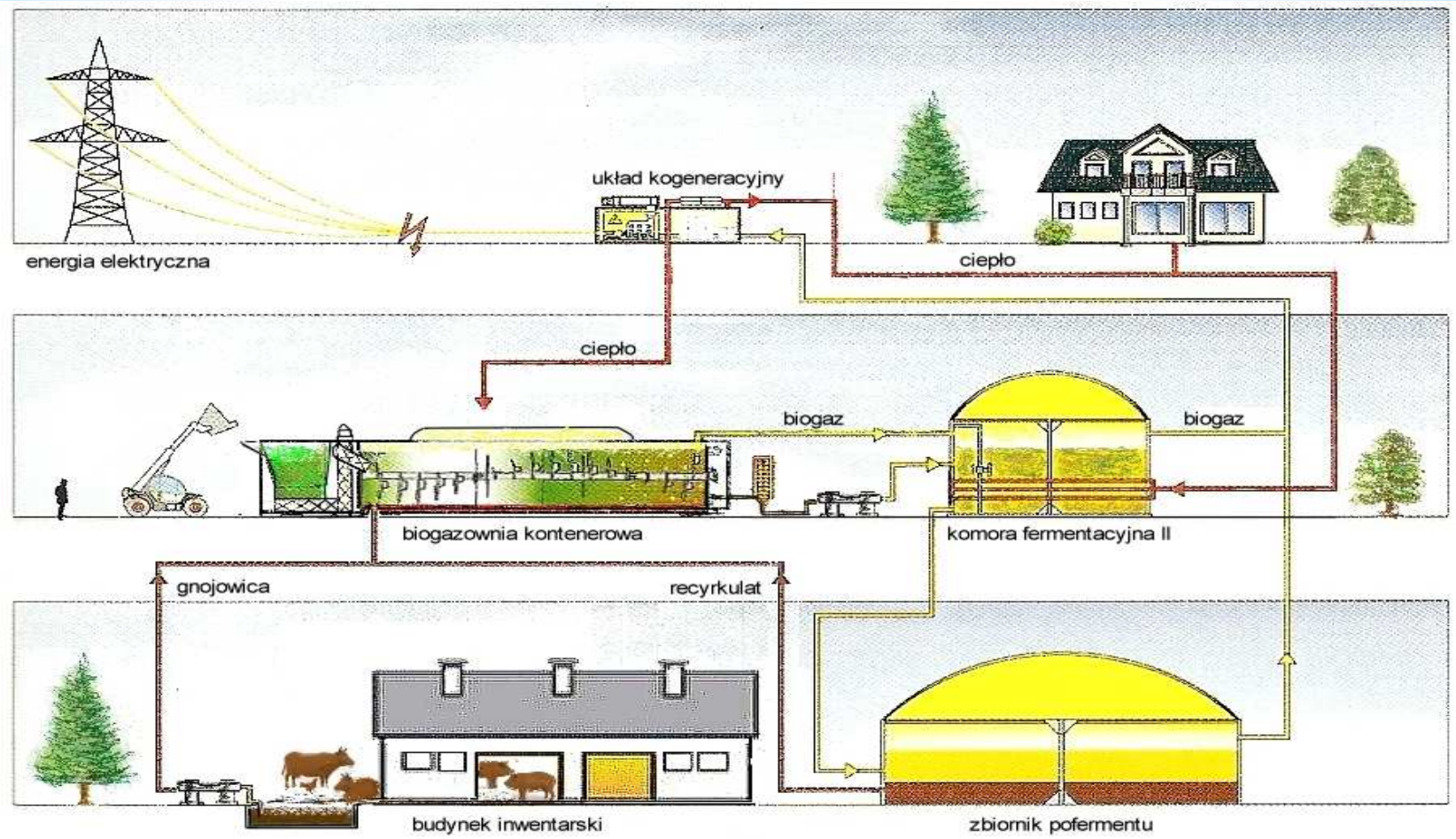
* 3. Technology. The container micro bio-gas plant in the system of double stage methane fermentation of 40 kWe power.

The basic elements of the micro biogas plant installation for agricultural waste in Pszczela Wola:

- Storage of liquid manure and grass harvested (second and third crops) for silage
- Grinding the grass silage bales and preparation of fermentation biomass
- Container agricultural micro biogas plant (first stage of fermentation)
- Round (ferro-concrete) tank (the second degree of fermentation) with a flexible roof – storage of biogas
- CHP co-generation unit of 40 kWe power
- "Eco-Bag" type storage unit for post-fermentation biomass storage (a ground tank with a flexible cover)

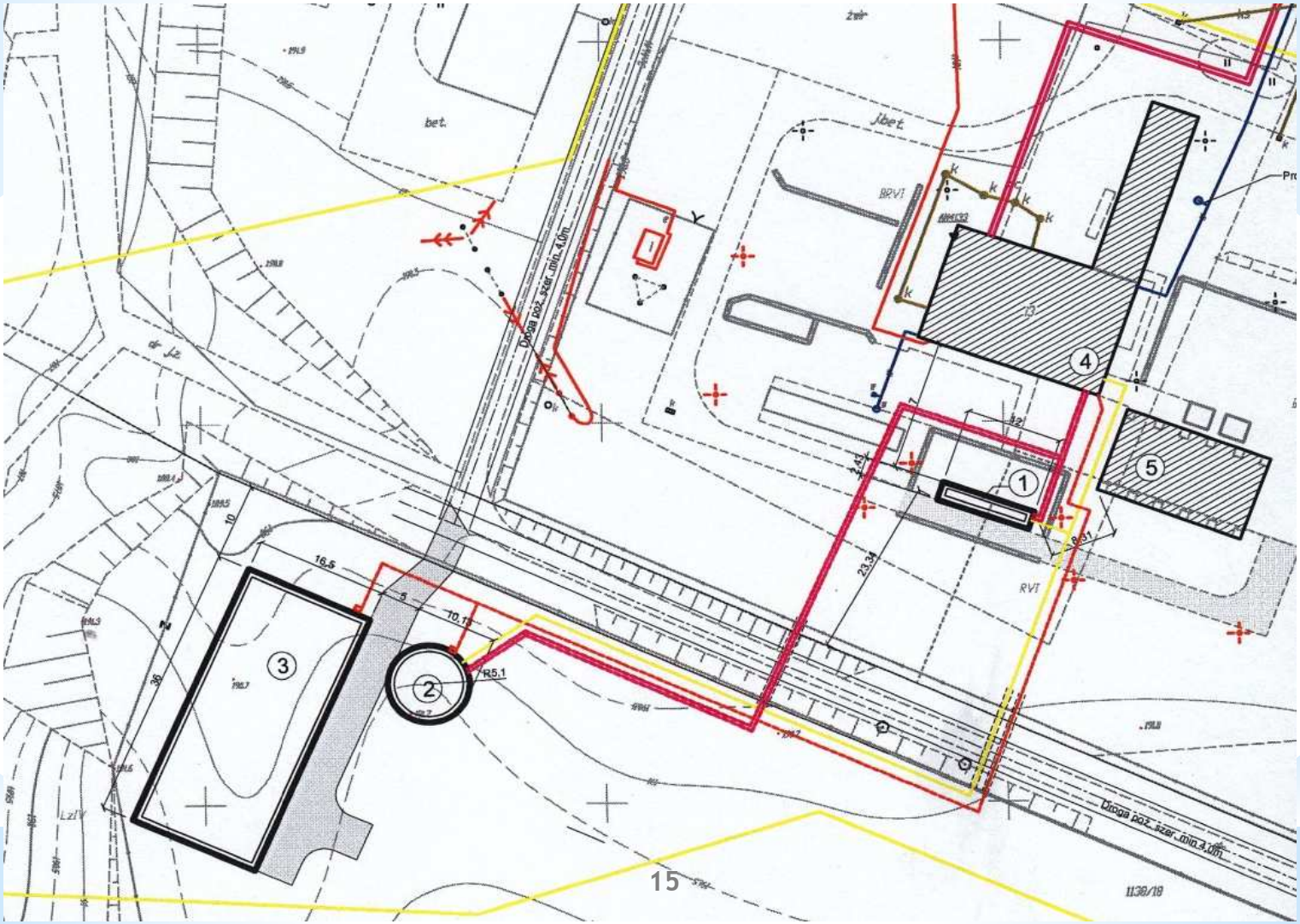


* 3. Technology. Schema. The container micro biogas plant in the system of double degree methane fermentation (40 kW power).



* 3. Technology. The land development project

for micro biogas plant in the The Agricultural School Complex Vocational Training Centre in Pszczela Wola.



* 3. Technology. The container micro biogas plant for agricultural waste.

* *The prototype of container micro biogas plant for agriculture in the fermenter of single-stage system in* wet fermentation system, *tested in the research laboratory of the Institute of Technology and Life Sciences, Branch/ Poznan.*

* 3. Technology. CHP MAN Gas Engine 40kWe/60kWt

Technical Data

Fuel / Gas quality	biogas / sewage gas
Nominal fuel calorific value	23 MJ/Nm3
Type of Cogeneration Unit	**INdoor MGM 50**
Producer	MOTORGAS s.r.o.
Nominal electrical power output	41,4
Nominal heating output VT 70 / 90 °C (kW)	60,1
Nominal voltage - frequenzy - speed	400 V - 50 Hz - 1500 ot/min
Nominal power factor	1
Operating gas pressure entering the CHP gas line	3 - 5 kPa
Thermal gradient of heating system	90 / 70 °C
Flow of water in the heating circuit (kg/s)	0,72

Exhaust Gas Emissions

Compliance with emission limits according to Czech Government Regulation No. 146/2007 Sb	
Under 200 kW fuel input emission limits are not limited	
NOx @ 5% O2 dry gas (mg/m3)	no limits
CO @ 5% O2 dry gas (mg/m3)	no limits
NMHC @ 5% O2 (mg/m3)	no limits

Noise

Noise pressure level of unit at distance 1m (without anti-noise cover)	97 +- 3 dB/A/
Noise pressure level of unit at distance 1m (with anti-noise cover)	75 +- 3 dB/A/
Exhaust noise pressure level at distance 5 m from outlet	73 +- 3 dB/A/

* 3. Technology. "Eco-bag" storage to store post-fermentation biomass.

* Post-fermentation biomass. **Variable natural solid and liquid fertilizer.**

* 3. Technology. Technical parameter of micro biogas plant (40 kWe power) in The Agricultural School Complex Vocational Training Centre in Pszczela Wola.

Parameter	Quantity	Unit
Biogas production per year	184 930.0	Nm^3r^{-1}
Biogas production per hour	21.1	$Nm^3\ h^1$
Methane content in biogas	57.5	%
Methane production per year	106 310.4	$Nm^3\ CH_4\ r^{-1}$
Methane production per hour	12.14	$Nm^3\ CH_4\ h^{-1}$
Theoretical power output	39-42	kW
Theoretical heat output	52-55	kW
Total production of power energy	388.35	MWh r^{-1}
Total production of heat	1 597.6	GJ r^{-1}
Power requirements of the installation	35.0	MWh r^{-1}
Surplus of power to be sold	353.3	MWh r^{-1}
Heat requirements of the installation	479.3	GJ r^{-1}
Surplus of heat to be used	1 118.3	GJ r^{-1}

Source: Feasibility study, EPC Agro-Energetyka sp. z o.o. Gdańsk, dr Renata Myczko, June 2013 r.

*4. Environmental impact – forecast.

* Environmental impact. Reduction of bio-genes emission.

Table 4. Estimation of fertilizing value of digestate using indicator method, biogas plant in Pszczela Wola								
Available biomass substrates	Bovine liquid slurry	Bovine manure	Fermen -ted sugar beet leaves	Fermen- ted grass from green areas	Leftovers from processing of vegetables Osmofrost	Total for biomass mixture	Total for digestate mass	Total mass of fertilizing compounds
sm [%] śm	8.00	25.00	18.00	28.00	22.00	13.7	3.5	460.7 t/t
smo [%] sm	80.00	76.00	75.00	93.00	92.00	81.41	65.4	252.3 t/a
Quantity of biomass [tonnes/year]	2 760.00	560.00	150.00	460.00	240.00	4 170	**3 628**	**3 628 t/a**
Total nitorgen (N) [% sm]	2.6-6.7	1.1-3.4	0.2-0.4	2.5-3.5	0.5-8.6	0.26-0.69	0.29-0.76	**10.4-27.5 t/a**
Phosphorus (P_2O_5) [% sm]	0.5-3.3	1.0-1.5	0.7-0.9	1.5-2.0	1.8-5.4	0.13-0.36	0.15-0.40	**5.3-14.4 t/a**
Potassium (K_2O) [% sm]	5.5-10	2.0-5.0	2.5-4.5	2.0-5.2	1.3-21.5	0.45-1.16	0.50-1.28	**18.1-46.3 t/a**
Magnesium (Mg) [% sm]	0.3-0.7	1.0-1.3	0.2-0.4	0.8-1.9	0.3-13.5	0.08-0.31	0.09-0.34	**3.2-12.5 t/a**

Source: Feasibility study, EPC Agro-Energetyka sp. z o.o. Gdańsk, dr Renata Myczko, June 2013 r.

* Environmental impact. Assessment of avoidance levels of air pollution emission.

	Mass of electric energy emission indicator in 1MWh	388.35 MWh r^{-1}	Mass of heat energy emission indicator in 1MWh	443.78 MWh r^{-1} 1597.6 GJ r^{-1}
	[kg/MWh]		[kg/ MWh]	
CO_2	877.0	340.59 t r^{-1}	322.6	143.16 t r^{-1}
NOx	1.5	0.58 t r^{-1}	0.6	0.27 t r^{-1}
SO_2	3.2	1.24 t r^{-1}	0.45	0.20 t r^{-1}
CO	-	-	5.2	2.31 t r^{-1}
Dust	0.27	0.10 t r^{-1}	1.4	0.62 t r^{-1}
B(a)P	-	-	1.8	0.80 t r^{-1}

* 5. Economic effects - forecast.

5. Economic effects of a micro biogas plant. The Agricultural School Complex Vocational Training Centre in Pszczela Wola. The Poviat Lublin.

Tab. The exploitation costs of micro biogas plant [PLN/Year]

No.	COSTS / EXPENSES	Price per unit	Unit	Quantity	Value
1	average property tax	-	-	-	3 200
2	service charge	20	manhour/month	150	36 000
3	other costs incl. technical inspections and repairs.	-	-	-	58 000
4	cost of substrates: waste biomass incl.:				108 900
4.1.	cost of slurry and manure	20	t/a	3320	66 400
4.2.	cost of grass silage blocks and other silage	50	t/a	850	42 500
5	insurance	4 000	-		4 000
6	TOTAL				210 100
7	Depreciation		%	9,4	131 900

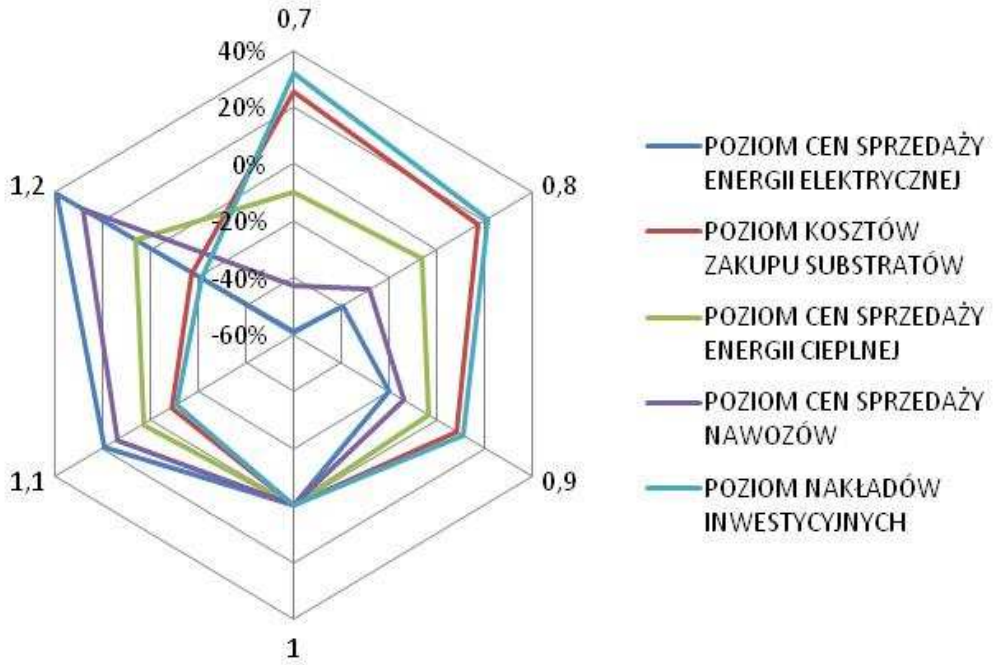
Tab. Annual revenues will be generated from the sale of electricity, heat and fertilizer. Therefore the annual revenues are as follows [PLN/Year]

No.	KINDS OF INCOME	Price per unit	Unit	Quantity	Value
1	electric energy	0,65	PLN/kWh	388 350	252 428
2	heat energy	37	PLN/GJ	1 118	41 377
3	fertilizer	50	PLN/t	3 628	181 400
4	Total				475 205

* Key economic indicators. Forecast.

For the value of outlays at an amount of 305 000 EUR, generated financial surplus, the level of discount rate, NPV and IRR were calculated:

- **NPV** = 291 500 EUR thus, it meets the criteria for a positive assessment of the investment effectiveness;
- **IRR** = 14% is higher than the discount rate adopted.
- Period of outlays return is **6.32 years**.



Conclusions: the biggest impact on the NPV value amongst the risks examined, comes from the level of sales prices of energy and fertilizers.

* 6. Education – school syllabus.

6. Education. Practical work in the micro biogas plant and the laboratory of RES.

* Starting from the new school year 2013/2014, the Agricultural School Complex Vocational Training Centre in Pszczela Wola a has launched a new training course: renewable energy technologies. The agricultural micro biogas plant shall support the practical occupational training.

* 7. Forecast for project development in the Region of Lublin after 2014.

* 7. Forecast of project development. Potential of the Region of Lublin.

In line with the above-mentioned main environmental objective (the reduction of biogenes emission to the Baltic Sea) also the below-mentioned additional purposes and effects shall be achieved:

- Agricultural micro biogas plant installed in Pszczela Wola shall serve for educational purposes both for 250 students of the School and for individual farmers, and it shall increase the educational potential of the school and its attractiveness amongst the youth getting the opportunity to find their first job in a new occupation in the Region of Lublin.

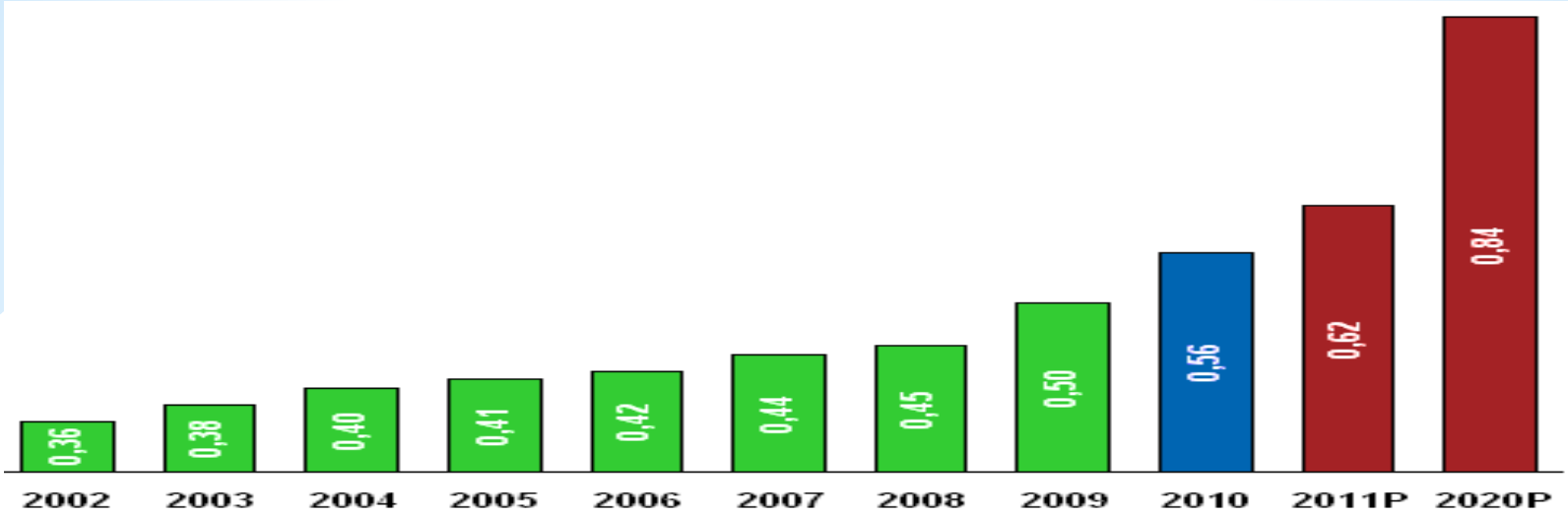
- An additional income shall be ensured to the farmers, owing to the sale to the grid of "green" electricity generated from micro biogas and the use in their farms of the surplus of waste heat (about 70%) from the process of fermentation.

- The additional income of the farmers shall be the bio-fertiliser acquired from the post-fermentation biomass, owing to which the farmers will be able to replace a part of artificial fertilizers by it.

- Another very important additional environmental impact, owing to the recycling of the agricultural waste and the generation of combined bioenergy shall be the prevention of CO2 emission.

An additional result of all the above effects shall be a clear advantage: cleaner and healthier environment, an increase in the competitiveness of the communes, which are determined to propagate the implementation of the project in their area.

* 7. The forecast of the project implementation. A permanent increase in the electricity prices up to 2020 - and after 2020, the agricultural subsidies of EU will come to an end.



The growth forecast of electricity prices for household appliances in Poland 2020 [PLN/kWh].
Source: GUS

Analysing the potential of waste biomass in the region of Lublin, we shall take into account the fact that apart from the typical biomass from agricultural waste – in the Province of Lublin the grass from the second and third crop has not been used from about 250 000 ha (so it makes up waste)!!!

That is why the propagation of the analysed project of micro biogas plant in the region of Lublin – the Polish agricultural centre - is very crucial.

The restructuring of farms in Poland oriented at agro-energy, as a secondary source of farmers' income – is a great opportunity for the sustained development of Polish agriculture.

* 7. Forecast of project development. The climate for the cooperation with Sweden and Finland is good - but the main barrier is in Poland the lacking support for renewable energy law RES.

Chances - the risks

Ministerstwo Rolnictwa i Rozwoju Wsi

Projekt flagowy „Zrównoważony rozwój obszarów wiejskich" w ramach Strategii UE dla regionu Morza Bałtyckiego

Within the pillar of PROSPERITY (TO MAKE THE BALTIC SEA REGION A PROSPEROUS PLACE):
"Poland and Sweden have been indicated as leaders of this project. During the earlier work, it was determined that the project shall relate to two areas:

- the creation of friendly environment for innovations in rural areas
- the youth in rural areas.

Source: MinRol Departament Programowania i Analiz, 2012

- For 3 years there has been a debate on the law on renewable energy but the regulations are still missing !!! The legal solutions announced for the support of the RES law are disappointing.
- Auction RES Support System, which has been promised by the Ministry of Economy – is not supposed to stimulate the development of the small market of RES.
- **This is a signal to investors that the implementation of RES investment projects shall be suspended in Poland, as the risk is very high.**

* Ending. 2013 and the subsequent years.

*Summary.

Their remains only hope that the barriers hindering the RES development in Poland shall not affect substantially good relations with the European Union, and our small pilot project on agricultural micro biogas plant for agrowaste in Pszczela Wola, supported financially by the Nordic Investment Bank and NEFCO – shall favour the development of such contacts.

The good climate for this project has been created by the Poviat Lublin.

* Thank you for your attention.

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