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Biogas Feasibility Study

UAB Dotnuva Experimental Farm, Substantiation of Biogas Power Plant Construction

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The Feasibility Study is prepared with support from EU's Baltic Sea Region Programme.

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Baltic Sea Region Programme 2007-2013

1: Background for biogas power plant construction in UAB Dotnuva Experimental Farm

Biogas is an attractive energy source that takes a part in stable economic, agricultural and rural development and environmental protection. Biogas production from livestock manure, sludge and municipal, livestock and organic waste contributes to energy sources diversification and also increases energy supply protection, competition and stability, in addition to that provides new income chances to the farmers. Biogas is a valuable energy source, because of the variety of its use – electric energy production, heating, cooling and car fuel. It, can also be supplied to natural gas network. The waste material is used for biogas production that is why it does not raise conflict and increase prices in food or feed industries. The European Parlament underlines the benefits of biogas strengthening the EU energetic independence, also decreasing gas emissions that affect climate warming.

In 2009 in EU countries more than 8 million toe (tones of oil equivalent) of energy were produced from biogas by using livestock manure, energy plants, sludge and organic waste. The biggest biogas energy development in 2006-2009 was reached in agricultural biogas power plants using raw plant biomass, agricultural and food waste. In 2009 they created 52% of energy potential in the balance of raw materials for biogas energy production, landfills – around 36%, and wastewater treatment sludge – 12%.

According to scientists the biggest production of the biogas material source in Lithuania is livestock manure. Large farms have the highest potential in building biogas power plants, farms that have established a modern livestock and poultry manure storage technologies and developed technological infrastructure. Large livestock and poultry farm distribution in Lithuania is uneven. Using the livestock manure produced on large farms and companies in Lithuania (around 2,8 million tons) it can be turned into around 72 million. cubic meters of biogas, the energy value of which 430 million. kWh.

Using 10% of the total area of unused land (that would make around 30 thousand hectares) for energy plants (maize, perennial grass and beet) in Lithuania it is possible to produce around 90 million m3 of biogas, the energy value of which would reach 520 million kWh.

Farms that are growing small numbers of livestock can build biogas power plants, in which livestock manure and plant mixtures would be used as raw materials. All the recycled biomass in the power plant can be used for growing of energy plants.

It is expected that the biogas power plant of UAB Dotnuva Experimental Farm will be constructed in a dairy cow barn in Bokštai village that keeps 290 cows and 175 heifers. Cattle are kept in littered barns, and the manure produced is constantly removed mechnically. Throughout a year there accumulates around 13600 tons of manure (around 8200 tons of solid and around 5400 tons of slurry and waste water) on the farm. Next to the cow barns there are a feed silo, farm buildings, a storehouse, garages and an electrical substation (400 and 300 kVA) located. Next to the barns there are 4 block of flats (25 flats in total). There is a good access to the barns from the district road Dotnuva-Miegėnai. Next to the barms there is a 600 ha arable land area that belongs to the farm, you can grow energy plants in there. In this project it is estimated to use 100ha of land for the growth of maize that would be used for energy supplies. The minimal distance to the crops – 0,1 km., the maximum one – 5km. The farm has experience in growing maize for silage, it also has required growing, harvesting, transporting and silage making equipment.

A current yearly usage of electricity is around 300 thousand kWh. Yearly expenses for electricity are around 178 thousand Lt. The expected biogas power plant could cover all farm electricity costs and heating energy needs in the cow barn and other nearby production buildings. In one of the production buildings (storehouse) it is planned to create a stove for wood drying. The excess heat can also be used for grain drying. In addition to that it could provide electric and heating energy to the nearby placed living homes.

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The expected biogas power plant would have not only economic but also educational, scientific, experience sharing and technological development purposes. It would be build not far from Akademija setlement, in which the Lithuanian Institute of Agriculture is located. The Institute‘s scientists could make experiments on energy plant breeding and its usage for biogas production, they could also organize production-scientific seminars. There is also the Lithuanian Agricultural Advisory Service located in Akademija that could oganize training sessions delivered by advisers to farmers and specialists. The biogas power plant could be visited by farmers, contractors, builders, school students and university students looking for ideas and practical examples.

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2: Biogas power plant's energy indicators

It is expected to process the manure of the cows kept in the barns of UAB Experimental Farm of Agriculture and the silage of energy crops (maize) grown on the same farm in the planned biogas power plant. It is also possible to process plant waste from grain, fruit and vegetable processing firms.

Around 13600 tons of cattle manure and 3000 tons of plant biomass are planned to be processed into biogas per year (Table 2.1). A flow of 45.5 tons of raw materials per day must be ensured of which 37.3 tons of cattle manure and 8.2 tons of plant silage. Taken that 1ha of maize biomas productivity is 30 tons, the farming land area needed is around 100ha.

Table 1: Amounts of materials used for biogas production.

No.	Raw material	Amount		
		Tons\per year	Tons\per day	%
1.	Cattle manure	13,600	37.3	82
2.	Plant biomass	3,000	8.2	18
In total		16,600	45.5	100

The biggest part of the raw material flow consists of the manure collected in the barns of the Experimental Farm (82%), therefore, the biogas power plant is needed to be build closer to the cattle barns and the location, in which there would be possible to install silos of around 3000 tons in capacity. In this case the complicated logistics of raw material supply would be avoided and silage transportation costs would be reduced.

Solid livestock manure (around 22 tons per day) would be delivered to biogas power plant by using a mobile loader, and liquid slurry (around 15 tons per day) – would be pumped by using pumps from the collection tank. Energy plant silage would be prepared in the territory of the biogas power plant and transported to the power plant by using mobile laoders.

The quantity of the biogas made can be determined by the biogas output from diffeent types of materials on the basis of the information in Tables 2.1 regarding the quantities of the materials and taken into account the theoretical outputs from the materials planned to process: 1 ton of cattle manure yields 25m3 of biogas, and 1 ton of plant biomass (maize) – around 200 m3. The calculated biogas production potential from various types of materials is illustrated in Table 2.2.

Table 2: Calculated biogas production potential from various types of materials.

No.	Raw material	Quantity	Dry matter		Biogas yield	Biogas quantity	
		Ton per year	%	Ton	M3/ton	Thousand m3 / year	%
1.	Cattle manure	13600	10	1360	25	340	36
2.	Plant biomass	3000	30	900	200	600	64
In total		16,600	13,6	2260	-	940	100

It is estimated to produce around 940 thousand m^3 of biogas in the planned power plant. Out of that amount the biggest quantity is expected to be extracted from plant biomass – around 600 thousand m^3 per year and 340 thousand m^3 from cattle manure.

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The produced biogas is planned to be used for electric and heating energy produced in the cogeneration power plant. The power of the cogeneration power plant is determined based on theoretical biogas calorific contend and the efficiency of electric conversion. It is assumed that methane concentration in the produced biogas is around 55%, and 1 m^3 of biogas can yield 2 kWh of electric energy and 2,5 kWh – heating energy. The estimated electric power capacity of the biogas power plant would be 235kWh. Having evaluated the inequalities of biogas production, it can be determined that the nominal cogeneration electric power would be 250kWh.

Biogas power plant's cogeneration unit would produce around 1,88 million kWh of electric energy and around 2,35 million kWh of heating energy per year. The biogas power plant's energy indicators are shown in Table 2.3.

2.3 table. Biogas power plant's energy indicators.

Biogas production	Biogas production per year, thousand m^3	940
	Biogas production per day, thousand m^3	2,6
	Biogas production per hour, m^3	117,5
	Estimated methane concentration, %	55
Cogeneration power plant energyc characteristics	Electric power, kW	250
	Heating power, kW	300
	Requirement for biogas per hour, m^3	125
	Production of electric energy per year, m kWh	1,88
	Production of heating energy per year, m kWh	2,35
Biogas power plant's energy requirements	Electric energy requirements by technological equipment per year, thousand kWh	190
	Heating energy expenses to keep biomass temperature, thousand kWh	500
	Backup gas boiler capacity, kW	100

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3: Technological scheme and necessary equipment for biogas power plant

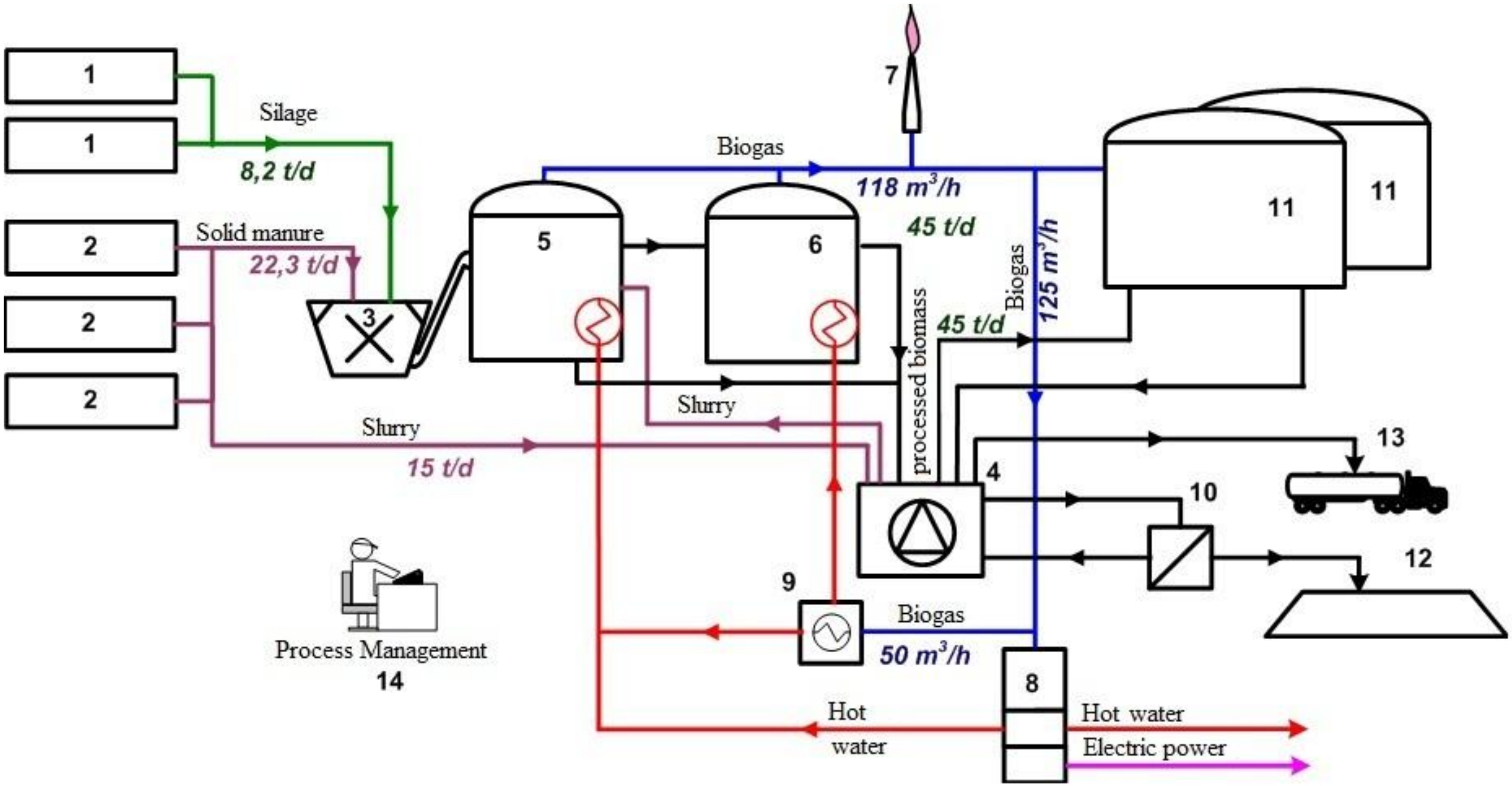
The structure and technological scheme of biogas power plant is based on different aspects: type and composition of raw materials, the way of its supply, the type and size of bioreactors, process parameters, the utilization of recycled substrate, the quantity and composition of the produced biogas, the type and quantity of energy conversion equipment and the users of the produced energy. There are several types of biogas power plant technological schemes used in agriculture that depend on the types of raw materials:

- Recycling livestock manure
- Recycling energy plants
- Recycling organic waste and energy plant mixtures.

A technological scheme, equipment construction and size of a power plant depend on the type of raw materials. In the planned biogas power plant it is planned to recycle cattle manure and energy plant (maize) silage. In the territory of the biogas power plant it is expected to create a silage trench (Illustration 3.1.), in which all the necessary silage for the power plant will be prepared. Chopped green plant biomass will be delivered to motor transport equipment, therefore, during the planning period it is crucial to take into consideration the proper pavement for different driving acessess as well as to the silage production zone. Silage for material mixing and dosage equipment will be transported by a mobile loader.

Solid manure disposal and transportation equipment and machinery used in the livestock farm barns plant will be adjusted for the power plant planned for construction. Solid manure and feed remains that are collected from the concrete floor will be delivered straight to dispenser 3 by a loader. Maize silage, unused feed, green meadow grass, etc will be loaded into it. Slurry will be delivered from barns 2 to the biogas power plant reactor by slurry pumps 4. The dosage equipment‘s purpose is to load solid or dry materials to the reactor and to dose them according to the schedule.

It is planned to erect two biogas reactors 5 and 6 with the capacity of 3000 m^3 in the biogas power plant. Heat exchangers have to be installed in them in order to keep the fixed temperature of recycled biomass (35-40 ^oC). The heat exchangers would be supplied with hot water from the cogeneration block 10 or hot water boiler 11. The main source of hot water would be a cogeneration device, and to start the power plant or in the case of the cogeneration device repair a hot water boiler would be used. Biogas, natural gas or liquid fuels can be used for the hot water boiler.



3.1 illustration. Biogas power plant, recycling livestock manure and plant biomass, scheme: 1- Trench silos; 2 – dairy barn; 3 – silage and manure dosing; 4 –pumping station; 5,6 – biogas reactors; 7 –biogas torch; 8 – cogenerator; 9 – extra hot water boiler; 10 – recycled biomass separator; 11 – recycled biomass capacity; 12 – composting yard; 13 – recycled biomass transportation equipment; 14 – technological process control equipment.

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Due to uneven biogas production or uneven use for cogeneration, an excess of biogas might appear, which must be burned. There has to be planned an automatically igniting biogas torch 7, the capacity of which is 150 m^3/h. It has to be established at a proper distance from other equipment, based on fire protection regulations.

Biogas has to be clean from the moisture, small admixtures and sulphuretted hydrogen. In order to get rid of water vapor it is enough to establish a biogas piping in the ground, in which the concentrated moisture goes to a specially installed wells. The liquid accumulated in the wells can be supplied to biogas reactors, therefore, its transportation means have to be taken into consideration. In addition,special biogas coolers can be used, which condense and remove moisture. Small particles are also removed, if moisture removing equipment is working properly.

The equipment that removes sulphuretted hydrogen is planned to install in the biogas reactors of the biogas power plant..In this case an air dispenser supplying air to the biogas reactors has to be thought of. Special surfaces for oxygen bacteria which break down sulfur compounds have to be provided for inside in the upper part of it. The emitted elemental sulfur falls into the substrate present in the reactor and is removed with the recycled biomass.

The produced biogas will be used for the production of the electricity and heating in the cogeneration equipment 8. Cogeneration equipment provided for in the planned power plant. Its cooling systems and the heat produced in the heat exchangers will be used for the technological needs of the biogas power plant and the heating of premises. The excess of electricity and heating energy will be used for the experimental farm's needs and the heating of the living houses. Usually cogeneration equipment manufacturers produce them with heat exchangers and a hot water temperature measurement system; therefore it is not necessary to design them separately. If the necessary pressure (identified by cogeneration manufacturer) is not created in the biogas system, it is needed to make a proper flow and pressure blower. Some manufacturers complement them together with the control devices of the biogas power plant.

The biomass recycled in biogas reactors is removed through the openings installed in the upper part. The design solutions of the equipment for fresh raw material supplying and recycled biomass removing depend on the type of the chosen reactors type and their construction. To start biogas reactors recycled biomass can be used pumped from one to another by pumps 4. The pump-unit can also be used to pump the recycled biomass pumping to transport means 13. The pump-unit can also pump liquid manure from the barns to manure reservoirs, when it is not used for biogas production (in case of the power plant failure).

Recycled biomass will be contained in closed reservoirs that are established in the biogas power plant's territory. The recycled biomass will be kept up to 8 months; therefore, their working capacity has to reach 11000 m^3, depending on the possibilities to drive biomass to the fields. Reservoir coating is planned to be flexible, because their upper part will be used for keeping biogas reserve. In addition to that biogas that is produced from fresh recycled biomass is collected in the closed reservoirs. The closed reservoirs will also eliminate harmful gas and unpleasant smell emissions from the recycled biomass. Mixers have to be installed in the reservoirs needed to homogenize biomass, take its samples for analyses and before driving it to the fields. The recycled biomass kept in the right way has good fertilizing features and can be used for fertilization of energy plants, reducing their growing expenses at the same time.

Table 3: Summary of technological equipment and constructions

No.	Technological equipment	quantity unit	Characteristics Measurement	Indicator
1	Biomass dosage equipment	1	t/d	25
2	Biogas reactor (current capacity)	2	m^3	1500
3	Silage storage	1	t	3000
4	Liquid raw material and recycled substrate pump-unit	1	t/d	20
5	Biogas torch	1	m^3/h	150
6	Cogenerator	1	kW_{el}	250
7	Gas hot water boiler	1	$kW_{šil}$	100
8	Recycled biomass reservoir	2	m^3	5500
9	Transportation means of recycled biomass	1	t	20
10	Distribution-incorporation means for recycled biomass	1	t	20
12	Process control and visualization equipmen of biogas power plant	1	-	-
13	Control console and domestic premisess	1	m^3	30

A preliminary plan of biogas power plant's equipment and building location in the cow farm territory is given in the attached paper.

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4: Analysis of investment need, income and costs

Preliminary investment need is based on the technological scheme drawn earlier (illustration3.1.) according to the prices of the analogical equipment sold on Lithuania and EU markets. It will be possible to find more presice prices in the process of making a technical project and by getting commercial offers. The prices of the main equipment for the biogal power plant and the total price for the biogas power plant are given in Table 4.1.

Table 4.1. Price of main technological equipment for biogas power plant

Name	Quantity	Characteristics	Price, thousand Lt
Biogas power plant (including installation work): - bioreactors, - dispensers, - cogenerator, - heat unit, - control equipment, - pump-unit, - recycled biomass separator, - console and domestic premises	1	250 kW_{el}	3500,00
Silage storage	1	3000 t	150,00
Recycling substrate reservoirs (covered, with mixers and pumps)	2	5500 m^3	1400,00
Composting site (open)	1	2000 t	100,00
Engineering network: - slurry, - recycled substrate, - biogas, - electricity, - heating. Roads	-	-	400,00
Raw material loader	1	1 t	100,00
Mobile equipment for recycled biomass broadcasting – incorporation	1	20 t	300,00
Total			5950,00

The preliminary building price of the biogas power plant with the indicated equiopment is around 6 m lt.

Two employees are envisaged for the power plant service, whose work salary is estimated at 40 thousand Lt per year. Considering that the production and transportation price of 1 ton of maize silage is 100 lt, a yearly silage production cost would be 300 thousand lt. If 2,5 % of investments were allocated for the repair and maintenance of the biogas power plant equipment, the yearly expenses for these activities would make 15 thousand lt. 60 thousand lt are provided for other unexpected costs.

A part of the biogas power plant's electric energy (190 thousand kWh) and heating energy (500 thousand kWh) would be used for its own needs. The rest of it would be used for the experimental farm needs, sold to the inhabitants and to the electricity grid (LESTO). Considering the price for heating energy is 0,2 lt/kWh, yearly income for it would be 300 thousand lt. It would be used for the production objects of the cow farm (300 thousand kWh), supplied to the inhabitants (130 thousand kWh) and used for wood and grain drying (1070 thousand kWh). The summary of biogas power plant production costs and income is given in Table 4.2.

Table 4.2. Summary of biogas power plant production costs and income.

Material, costs and income title	Unit of measurement	Price (standard), Lt	Quantity	Amount, thousand Lt/year
Expenses				
Equipment repairs and maintenance	%	2,5	6000,0	150,000
Work payment (with SODRA)	Unit	20000	2	40,000
Silage production	t	100	3000	300,000
Other expenses	%	1,0	6000,0	60,000
Total:				550,000
Income				
Electric energy, of which:	Thousand kWh	0,30	1500	540,000
- farm production facilities	Thousand kWh	-	300	178,000
- inhabitants	Thousand kWh	0,40	30	12,000
- LESTO	Thousand kWh	0,30	1170	350,000
Heating energy, of which:	Thousand kWh	0,20	1500	300,000
- farm production facilities	Thousand kWh	-	300	60,000
- inhabitants	Thousand kWh	0,20	130	26,000
	Thousand kWh	0,20	1070	300,000
Total:				840,000
Untaxed profits				290,00

Having sustained the yearly costs and achieved the planned income, the untaxed profits of the biogas power plat would make 290 thousand Lt.

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Baltic Compass

Baltic COMPASS promotes sustainable agriculture in the Baltic Sea region. The region's 90 million inhabitants anticipate both high quality food produced in the region and a healthy environment, including a cleaner Baltic Sea. Baltic Compass looks for innovative solutions needed for the future of the region and its agriculture, environment and business.

Baltic Compass has a wide approach to the agri-environmental challenges, covering agricultural best practices, investment support and technologies, water assessment and scenarios, and policy and governance issues.

Baltic Compass is financed by the European Union as a strategic project for its support to investments and policy adaptation. The 22 partners represent national authorities, interest organizations, scientific institutes and innovation centres from the Baltic Sea Region countries. Baltic Compass is a three year project running until December 2012.

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Programme 2007-2013

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