Deliverable D16 B3

Report on the use of slurry derived fraction in biogas plants

Definition

Slurry: livestock faeces. Cattle slurry has average total solids around 9%.

Manure: mix of livestock faeces and straw, average total solids around 18-20%

Shredded manure: Manure subjected to cleaning (removal of stone and metals) and shredding to shorten straw length, in order to be suitable for biogas plant.

Slurry-manure derived fractions: fractions derived from slurry and manure thanks to a specific treatment. Slurry-manure derived fractions are: **Shredded manure**, **Separated Solid fraction of slurry, Cavitated slurry -manure mix.**

Separated solid fraction of slurry: fraction of slurry separated from liquid to be suitable for transport and delivery to biogas plant. An average total solid of this fraction is 16-18%.

Cavitated slurry-manure mix: mix of slurry and manure, which undergo treatment in the prototype device to be realized in the project. The objective of the treatment is to make the materials more suitable for biogas plant , i.e. produce a material with high total solids content, high homogeneity, high digestibility, and pumpability up to 16% of total solids. Foreseen average content of total solids 13-16%.

Introduction

The B3 action within LIFE DOP project has the aim to highlight if the use of slurry and manure-derived material in biogas plants is possible, effective and if has any counter effects.

The main features to monitor are the quality of feeding mix, the quality of digestate (especially TS and Nitrogen) and of course the general functioning of the plant in relation to the feeding mix.

The main questions for answers are:

- Is the substitution of silage maize with slurry and manure-derived products affecting the general functioning of the biogas plant?
- Is the plant consuming more energy for mixing, and if yes is it a cost-effective action?
- Is the increase of nitrogen and ammonia proper for the plant?
- Is the plant working in stable and balanced condition?

- Is the cost-benefit balance positive for the biogas plant?

Materials and methods

Two different anaerobic digestion plants were monitored during the substitution of silage maize with slurry and manure-derived fractions for the production of biogas.
Biogas plant 1: the plant is situated in Pegognaga and has an installed capacity to generate energy of 999kw. The plant is composed by 4 digesters, 2 primary fermenters (2500 m^3 volume each), 1 secondary digester and 1 post fermenter (2500 m^3 volume) for a total volume of 10.000m^3.
The feeding mix is generally composed of silage maize and cattle slurry produced in the farm. The input of the slurry-manure derived fraction in the plant has reached 75% of the total feeding mix. The average temperature of material in the digesters is set at 42°C.

The biogas is used in a CHP (Combined Heat and Power) unit to produce electric energy that is fed in the grid. The biogas is cooled up to 6 °C and the H_2S is removed thanks to air flowing in the digesters.
Biogas plant 2: the plant is situated in Borgo Virgilio and has an installed capacity to generate energy of 999kw. The plant is composed by 3 digesters, 2 primary fermenters (4000 m^3 volume each), 1 secondary digester (4000 m^3 volume) for a total volume of 12.000m^3.

The feeding mix is generally composed of silage maize and cattle slurry produced in the farm. The input of the slurry-manure derived fraction in the plant has reached 80% of the total feeding mix. The average temperature of material in the digesters is set at 45°C.
The biogas is used in a CHP (Combined Heat and Power) unit to produce electric energy that is fed in the grid. The biogas is cooled up to 4-8 °C and the H_2S is removed thanks to air flowing in the primary digesters.

The data were monitored on site (amount of input materials, energy production, digestate production, quality of produced biogas, energy consumption for funning the plant, i.e. mixing and feed loading) and on collected samples analysed in lab.

Samples were analysed according to the standard methods indicated in table 1

Table 1: methods used in the monitoring

Parameter	Method
pH	CNR IRSA n 64 1985
Total Solids (%)	CNR IRSA n 64 1985
Volatile Solids(%ST)	ANPA 2001
Total Kieldal Nitrogen (%ST)	G.U. 180 5 Aug. 1986
Ammonia Nitrogen (mg/l)	CNR IRSA n 64 1985
Total Phosphorus	EPA 1996.
ABP	Schievano et al. 2008

Results

Biogas plant 1

Feeding mix of the plant and characterisation of input materials

The inputs of the plant 1 are reported in table 2.

Table 2: input materials of biogas plant 1

Date	Silage maize	Cattle slurry	Separated Solid fraction of cattle slurry	Cavitated slurry-manure mix	Total input	Slurry-manure derived fraction on total input
	Tons/month	Tons/month	Tons/month	Tons/month	Tons/month	%

Baseline only corn silage use	**1500**	**0**	**0**	**0**	**0**	**0**
10/17	1231	918	326	0	2475	50%
11/17	1157	800	133	0	2090	45%
12/17	1188	821	0	0	2009	41%
1/18	1104	793	473	0	2370	53%
2/18	953	804	562	0	2318	59%
3/18	1027	912	634	0	2573	60%
4/18	1012	690	598	0	2300	56%
5/18	1009	830	700	0	2539	60%
6/18	1006	791	565	0	2362	57%
7/18	997	802	491	0	2289	56%
8/18	1238	982	137	300	2657	53%
9/18	1062	827	0	700	2589	59%

The materials fed in the digesters where maize, cattle slurry produced nearby the farm and solid fraction of cattle slurry, coming from a longer distance.

The baseline to compare results is the plant when only corn silage is used, i.e. a supply of maize of 18.000 tons/year and a stable energy production of 8.200.000Kwh/year.

The total amount of slurry and manure-derived fraction was equal to 60% of the total feeding mix at the higher level of substitution tested in during the trial.

The addition of slurry derived fractions allows to save almost 550 tons of silage maize for a month considering the base line and the maximal maize substitution of 34% achieved last year in this plant.

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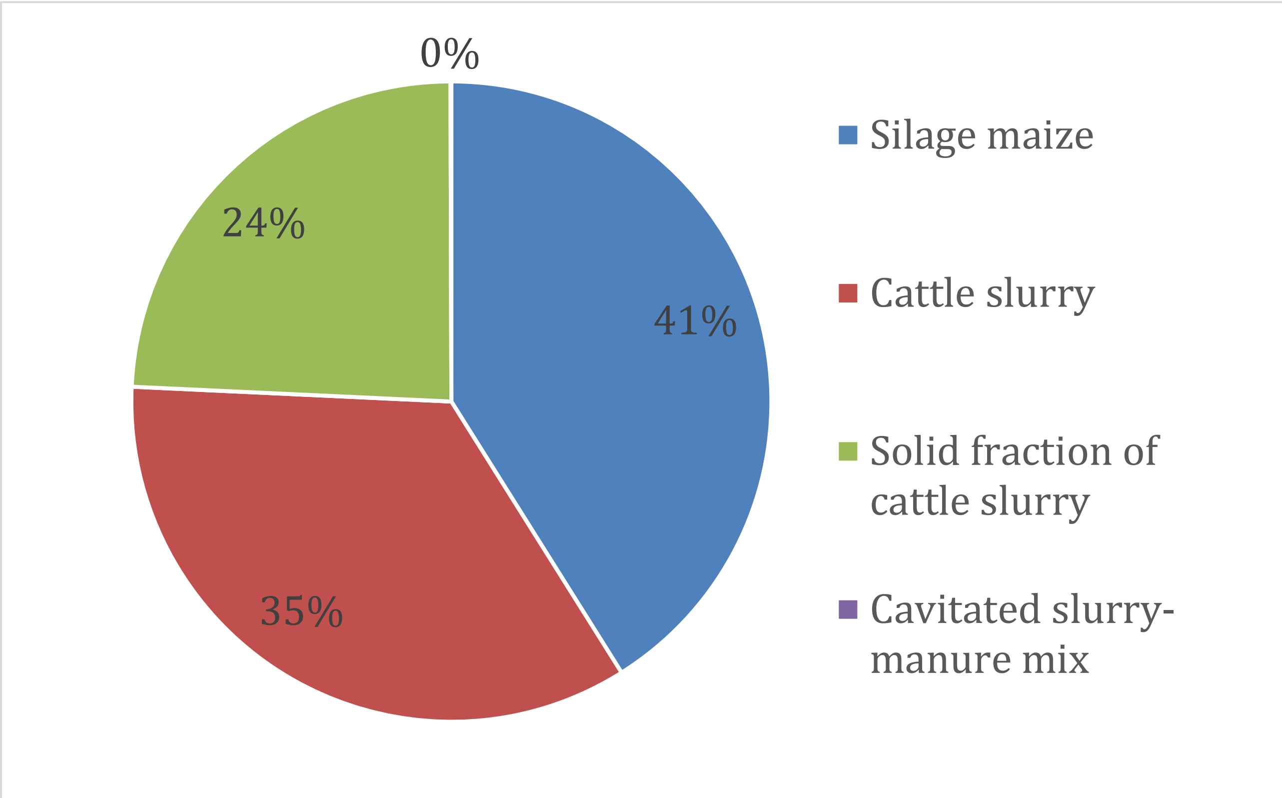

Figure 1: average composition of feeding mix during the trial period

Characterisation of input materials

In table 3 and 4 are reported the biochemical data of the feeding materials

Table 3: average value of chemical characterisation of the biomass fed in the digesters (data from 12 samples)

	pH			TS%			VS (%TS)		
Silage maize	3.6	±	0.33	35.7	±	3.18	96.9	±	1.1
cattle slurry	8.1	±	0.98	7.58	±	2.19	85.9	±	3.3
Solid fraction of cattle slurry	8.5	±	0.71	22.4	±	5.88	83.4	±	4.13
Cavitated slurry-manure	8.31	±	3.1	11.5	±	3.1	86.2	±	8.12

Table 4: average value of chemical characterisation of the biomass fed in the digesters (data from 12 samples)

	TKN (% w.w.)			NH_3 (mg/l)			P (%w.w)			ABP* (NlkgTS-1)			ABP ($Nlkg^{-1}$)
Silage maize	0.45	±	0.05	196	±	69	0.06	±	0.01	683	±	61	244
cattle slurry	0.36	±	0.49	1846	±	497	0.05	±	0.01	349	±	29	28
Solid fraction of cattle slurry	0.43	±	0.32	1006	±	710	0.07	±	0.01	339	±	53	76
Cavitated slurry-manure	0.39	±	0.21	1492	±	210	0.06	±	0.03	ongoing			ongoing

*ABP: Anaerobic Biogas Potential, for this analysis sample were 11, sampling from September will be available for the next report

Of course the variability of total solids of all the input materials influence the biogas production and may cause different consumption in different months of functioning.

Stability of the process and data from digesters

In table 5 are reported the data measured from samples collected from the primary digesters. The data are useful to evaluate the state of the biological process.

Table 5: data from the materials collected inside the digesters. Process parameter

	pH	TS%	VS (%TS)	VFA (mg.acetic ac/l)	Total alkalinity CaCO3 (mg/l)	VFA/alk	TKN (% w.w.)	NH3 (mg/l)	N-NH_3/TKN
Digester1									
10/17	8.11	5.75	81.00	2758	15492	0.18	0.35	1365	39%
11/17	8.33	2.67	70.00	2215	14413	0.15	0.36	1186	33%
12/17	7.94	6.43	80.89	1325	15849	0.08	0.39	1252	32%
1/18	8.15	5.76	76.60	1216	15655	0.08	0.38	1533	40%
2/18	7.74	7.09	81.04	1625	15797	0.10	0.35	1404	40%
3/18	8.07	5.74	79.63	1703	16442	0.10	0.38	1370	36%
4/18	7.67	7.72	79.31	3122	14882	0.21	0.4	1415	35%

5/18	8.15	6.30	77.84	1465	16679	0.09	0.42	1685	40%
6/18	8.17	7.52	80.60	977	16318	0.06	0.42	1650	39%
7/18	8.21	6.36	78.40	1558	16610	0.09	0.39	1509	39%
8/18	8.03	7.42	77.59	1769	16705	0.11	0.38	1479	39%
9/18	8.17	6.54	75.24	1483	15410	0.10	0.38	1475	39%
Digester 2									
10/17	8.05	6.59	71.74	1255	11512	0.11	0.35	1436	41%
11/17	7.94	7.31	76.79	1130	9937	0.11	0.34	1450	43%
12/17	8.14	6.25	74.55	1040	15391	0.07	0.35	1659	47%
1/18	7.98	6.90	73.89	1343	15817	0.08	0.35	1480	42%
2/18	8.20	6.28	79.09	1209	13558	0.09	0.35	1476	42%
3/18	7.97	7.40	76.79	1113	15126	0.07	0.36	1472	41%
4/18	7.98	6.58	75.28	2177	13966	0.16	0.37	1507	41%
5/18	8.23	7.09	71.53	1209	13090	0.09	0.37	1658	45%
6/18	8.06	6.59	71.41	1113	16323	0.07	0.43	1604	37%
7/18	8.23	6.98	70.38	1437	13955	0.10	0.37	1646	44%
8/18	8.41	7.2	73.71	1294	15622	0.08	0.38	1545	41%
9/18	8.14	6.99	71.26	1538	13537	0.11	0.38	1519	40%

Data from the monitoring of samples from the primary digesters outline that there is no perturbation in the biological system due to the addition of slurry-derived fractions. Even if the total HRT decreased due to the use of slurry derived fraction (up to 15% in some months) the process proved to be stable and effective. Is to note that even if the increase of total nitrogen was significant (see table 8) the concentration of ammonia was never able to affect the biological process of bio-methanation negatively.

Plant Characterization of output materials: digestate

In table 6 are reported the chemical data of digestate

Table 6: digestate characterisation

Date	TS	TKN	N-NH3	NH3/TKN	P
	%	%	mgL^{-1}	%	%
10/17	5.68%	0.37%	1968	58%	0.05%

11/17	5.16%	0.37%	1731	50%	0.05%
12/17	5.16%	0.38%	1745	51%	0.07%
1/18	5.33%	0.38%	1748	51%	0.07%
2/18	5.59%	0.36%	1816	53%	0.05%
3/18	5.85%	0.36%	1789	51%	0.05%
4/18	6.11%	0.36%	1993	56%	0.06%
5/18	5.68%	0.36%	1956	54%	0.07%
6/18	5.33%	0.36%	2026	56%	0.05%
7/18	6.02%	0.39%	1970	58%	0.04%
8/18	6.02%	0.37%	1973	54%	0.08%
9/18	5.85%	0.38%	2062	57%	0.09%

Plant functioning data

In table 7 are reported some relevant data on the plant functioning, such as the amount of energy produced, the amount of energy used for running the plant (mixing and feeding) and the Hydraulic Retention Time (HRT), i.e. the average number of days that the feeding materials stay in the digesters.

Table 7: data from plant running: energy production, energy consumption, HRT.

Date	Produced energy	Consumed energy for running	HRT	Methane in biogas	H2S in biogas
	kWh/month	kWh/month	Days	%	ppm
10/17	726,970	47434	81	52	122
11/17	645,020	53404	93	51	133
12/17	722,080	49416	97	52	140
1/18	718,000	51648	84	53	148
2/18	662,490	50254	89	51	155
3/18	726,090	37522	81	51	163
4/18	720,270	43980	86	51	171
5/18	703,720	40082	81	51	178
6/18	687,960	37468	86	51	186
7/18	718,790	29492	89	51	194
8/18	**703,720**	49390	**86**	51	201
9/18	709,000	55732	**95**	51	209

The biogas plant maintained the same average production (1Mw as target electric power capacity). About energy demand to run the plant, data outline that the primary cause for the increase of energy consumption for plant running is related to the ambient temperature and the cooling of the engine during summer time. Comparing annual average data on energy demand to run the plant no significant variation can be outlined. The average energy demand on an annual basis since 2015 is 8.2%±0.3 of the total energy production. In this plant, no significant variation was detected in energy demand due to the use of slurry derived fractions in the feeding mix of biogas plant.

The de-sulfuration system of the plant demonstrated to be able to keep H_2S level within a safe range in the biogas sent to the CHP unit. The biogas composition was around 52% of methane concentration, in the range of that assessed for biogas plant running on energy crop such as maize.

Finally, HRT decreased of only 10%, a value that causes no concern for the stability of process and running of the plant.

Mass balance

In table 8 is reported the mass balance of the inputs and outputs of nutrients in the biogas plants.

Table 8: mass balance of nutrients and total solids load

Date	Feeding mix TS	TKN	P	S	Digestate TS
	Tons/month	Tons/month	tons/month	Tons/month	Tons/month
10/17	558	10.39	1.62	0.054	209
11/17	482	8.73	1.34	0.044	172
12/17	465	8.36	1.27	0.042	119
1/18	537	9.99	1.58	0.051	192
2/18	506	9.80	1.57	0.053	188
3/18	555	10.87	1.74	0.059	206
4/18	525	9.74	1.55	0.048	179
5/18	557	10.76	1.73	0.057	219
6/18	523	9.98	1.59	0.052	193
7/18	505	9.66	1.54	0.051	160
8/18	507	8.46	1.28	**0.036**	**169**

9/18	516	8.96	1.36	0.041	173

Table 9: comparison of critical parameters, baseline VS trial (data at higher maize replacement)

	Baseline	test	variation
Maize	1500	953	-36%
Feeding mix TS	495	557	12%
Digestate TS	212	219	3%
TKN	6	11	71%
P	0.90	1.73	92%
HRT	90	81	-10%

The mass balance outline that:

the maximum replacement of maize by slurry derived fraction achieved in this year for the Biogas plant 1 was 36% of the baseline 1(biogas plant only fed by maize).

The input of total solids increased of 12%

Total nitrogen and phosphorus input almost doubled compared with baseline. This increase in nutrient input allows to displace these nutrients where needed, i.e. outside the breeding district.

Biogas plant 2:

Feeding mix of the plant and characterisation of input materials

The mass inputs of the plant 2 are reported in table 10.

Table 10: input materials of biogas plant 2

Date	Silage maize	Cattle slurry	Solid fraction of cattle slurry	Manure	Total input	Slurry-manure derived fraction on total input
	Tons/month	Tons/month	Tons/month	Tons/month	Tons/month	%
Baseline only corn silage use	**1500**	**0**	**0**	0	1500	%0
10/17	465	1922	0	2046	4433	90%
11/17	496	1860	0	1980	4336	89%

12/17	496	1922	0	2046	4464	89%
1/18	496	1922	0	2046	4464	89%
2/18	496	1736	0	1848	4080	88%
3/18	496	1922	0	2046	4464	89%
4/18	496	1860	0	1980	4336	89%
5/18	465	1922	0	2046	4433	90%
6/18	496	1860	0	1980	4336	89%
7/18	496	1922	0	2046	4464	89%
8/18	496	1922	0	2046	4464	89%
9/18	496	1922	0	2046	4464	89%

The material fed in the digesters where silage maize, cattle slurry, solid fraction of cattle slurry and manure.

The total amount of slurry and manure-derived fraction was equal to 90% of the total feeding mix at the higher level of substitution tested in the first year of trials. The addition of slurry derived fractions allowed to save up to 1000 tons of silage maize for a month, i.e. a maize substitution close to 70%.

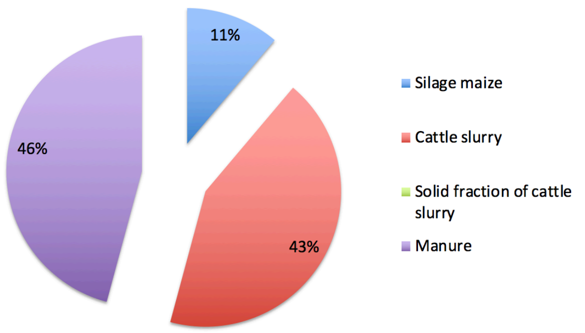

Figure 2: composition of feeding mix in biogas plant 2

Characterisation of input materials

In table 11 and 12 are reported the biochemical data of the feeding materials during the testing period.

Table 11: average value of chemical characterisation of the biomass fed in the digesters (data from 12 samples)

	pH			TS%			VS (%TS)		
Silage maize	4.0	±	0.15	32.8	±	2.12	96.8	±	0.4
cattle slurry	8.02	±	0.09	6.88	±	1.14	84.2	±	3.3
Solid fraction of cattle slurry	8.22	±	0.20	20.2	±	3.92	83.5	±	2.1

Manure	8.00	±	0.18	23.1	±	4.06	85.0	±	2.2

Table 12: average value of chemical characterisation of the biomass fed in the digesters (data from 12 samples)

	TKN (% w.w.)			NH3 (mg/l)			P (%)			BMP (NlkgTS^{-1})		
Silage maize	0.51	±	0.12	98	±	58	0.06	±	0.01	709	±	18
Cattle slurry	0.38	±	0.09	1689	±	106	0.07	±	0.01	321	±	69
Solid fraction of cattle slurry	0.44	±	0.07	1496	±	359	0.09	±	0.01	355	±	48
Manure	0.45		0.06	1759	±	188	0.08	±	0.02	370	±	59

Stability of the process and data from digesters

In table 13 are reported the data measured from samples collected from the primary digesters. The data are useful to evaluate the state of the biological process.

Table 13: data from the materials collected inside the digesters of plant 2. Process parameter

	pH	TS%	VS (%TS)	VFA (mg.acetic acid/l)	Total alkalinity CaCO3 (mg/l)	VFA/alk	TKN (% w.w.)	NH3 (mg/l)	N-NH3/TKN
Digester 1									
10/17	8.1	8.20	75.91	2153	10953	0.20	0.48%	2012	42%
11/17	7.9	9.38	76.14	1138	8532	0.13	0.54%	2703	50%
12/17	8.2	9.18	78.10	1234	15764	0.08	0.53%	2676	50%
1/18	7.9	8.20	67.91	1485	13881	0.11	0.54%	2938	55%
2/18	8.1	9.38	65.78	1215	14303	0.08	0.53%	2929	55%
3/18	8.0	8.61	70.34	1087	15284	0.07	0.54%	2419	45%
4/18	8.08	7.91	73.49	1453	12371	0.12	0.53%	2392	45%
5/18	7.98	9.38	66.32	1189	15110	0.08	0.52%	2512	48%
6/18	6.93	8.38	74.28	1164	14617	0.08	0.53%	2858	53%
7/18	8.10	9.18	74.50	1041	8348	0.12	0.54%	2962	55%
8/18	8.09	8.98	76.42	1198	15425	0.08	0.53%	2716	51%
9/18	8.12	8.02	66.45	1815	13583	0.13	0.54%	2595	48%

Digester 2									
	pH	TS%	VS (%TS)	VFA (mg.acetic acid/l)	Total alkalinity CaCO3 (mg/l)	VFA/alk	TKN (% w.w.)	NH_3 (mg/l)	N-NH3/TKN
10/17	8.6	9.94	65.823	1492	11525	0.13	0.48%	2467	51%
11/17	8.0	7.39	74.746	1479	9857	0.15	0.54%	2524	47%
12/17	8.4	7.82	67.652	1150	11574	0.10	0.52%	2605	50%
1/18	8.7	7.81	70.557	1139	16927	0.07	0.54%	2820	52%
2/18	8.5	8.77	72.838	1273	11902	0.11	0.53%	2698	51%
3/18	8.2	7.84	70.239	1624	16770	0.10	0.54%	2662	50%
4/18	8.5	8.63	74.990	1329	12408	0.11	0.53%	2547	48%
5/18	8.3	7.08	74.327	1523	10854	0.14	0.52%	2605	50%
6/18	8.3	9.65	67.798	1184	11871	0.10	0.53%	2720	51%
7/18	8.8	7.18	76.988	1173	12259	0.10	0.49%	2698	55%
8/18	8.3	7.59	72.682	1291	17273	0.07	0.48%	2407	50%
9/18	8.7	9.03	73.769	1176	15664	0.08	0.53%	2722	51%

Data from the monitoring of the material inside the primary digesters outline that there is no perturbation in the biological system due to the higher addition of slurry-derived fractions. Even if the use of slurry derived fraction decreases the total HRT (up to 32% see table 15) the process proved to be stable and effective.

Plant Characterization of output materials: digestate

In table 14 are reported the chemical data of digestate

Table 14: digestate characterisation

Date	TS	TKN	N-NH3	NH_3/TKN	P
	%	%	mgL^{-1}	%	%
10/17	9.3%	0.54%	3007	56%	0.54%
11/17	9.2%	0.54%	2815	53%	0.54%
12/17	8.5%	0.54%	3379	63%	0.54%
1/18	8.6%	0.54%	3345	62%	0.54%
2/18	7.9%	0.53%	3673	69%	0.53%
3/18	9.2%	0.54%	3661	68%	0.54%

4/18	9.2%	0.53%	3024	57%	0.53%
5/18	9.3%	0.54%	3289	61%	0.54%
6/18	9.0%	0.53%	3140	59%	0.53%
7/18	9.2%	0.54%	3144	59%	0.54%
8/18	9.2%	0.53%	3184	60%	0.53%
9/18	7.6%	0.54%	3395	62%	0.54%

Plant functioning data

In table 12 are reported some relevant data on the plant functioning, such as the amount of energy produced, the amount of energy used for running the plant (mixing and feeding) and the Hydraulic Retention Time (HRT), i.e. the average number of days that the feeding materials stay in the digesters.

Table 15: data from plant running: energy production, energy consumption, HRT.

Date	Produced energy	Consumed energy for running	HRT	Methane in biogas	H2S in biogas
	kWh/month	kWh/month	Days	%	ppm
10/16	684,664	43,304	79	53	171
11/16	686,967	42,795	80	52	223
12/16	701,100	44,529	78	52	341
1/17	701,100	43,681	78	51	247
2/17	658,700	39,032	84	53	177
3/17	701,100	42,986	78	52	266
4/17	686,967	41,757	80	51	144
5/17	684,664	42,518	79	52	216
6/17	686,967	41,549	80	53	133
7/17	701,100	48,482	78	53	136
8/17	701,100	41,291	**78**	53	122
9/17	701,100	41,835	**78**	51	171

The biogas plant maintained the same average production (1Mw as target electric power capacity). About energy demand to run the plant, this year we can detect a sligty increase, that is consistent with the high level of maize substitution (higher amount of material to be mixed and pumped). The de-sulfuration system of the plant demonstrated to be able to keep H_2S level within a safe range in the biogas sent to the CHP unit. The biogas composition was in the general range (51±2) assessed for biogas plant running on energy crop such as maize.

Finally, HRT decreased of only 32%, but no adverse effects were detected in the digesters and in the biological parameters of samples.

Mass balance

In table 13 is reported the mass balance of the inputs and outputs of nutrients in the biogas plants.

Table 16: mass balance of nutrients and total solids load

Date	Feeding mix TS	TKN	P input	S input in the digester (from biomass)	Digestate TS produced in 1 month
	tons/month	tons/month	tons/month	tons/month	tons
10/16	682	18.86	3.02	0.089	377
11/16	675	18.45	2.95	0.086	368
12/16	692	18.99	3.04	0.089	373
1/17	692	18.99	3.04	0.089	379
2/17	640	17.35	2.77	0.080	361
3/17	692	18.99	3.04	0.089	384
4/17	675	18.45	2.95	0.086	376
5/17	682	18.86	3.02	0.089	378
6/17	675	18.45	2.95	0.086	377
7/17	692	18.99	3.04	0.089	392
8/17	692	18.99	3.04	**0.089**	**396**
9/17	692	18.99	3.04	0.089	335

Table 17: comparison of critical parameters, baseline VS trial (data at higher maize replacement)

	Baseline	test	Variation
Maize	1500	496	-67%
Feeding mix TS	495	725	46%
Digestate TS	190	393	107%
TKN	6.30	18.99	201%
P	0.90	3.04	237%
HRT	114	78	-32%

The mass balance provides some useful information:

The replacement of maize by slurry derived fraction achieved is almost 70%

The total input of solids increased of 46%

Digestate production increased of about 55% and total solid of digestate doubled

Total nitrogen input increased of 3 times the amount that is introduced without any slurry fractions, the same for phosphorus. This increase in nutrient input can be an advantage if there is the possibility to displace these nutrients where needed, i.e. outside the breeding district.

Economic evaluation

The substitution of maize has generated for biogas 1 and 2 this economics:

Table 18: economic data for plant 1

Average maize demand (baseline)	tons/years	18000
actual maize used	tons/years	13489
Saved maize	tons/month	**484**
Produced energy by slurry derived fractions	Kwh/month	238253
Money saved from maize	euros/month	21762
Money spent for slurry transport, treatment and farmer reward	euros/month	11607
Total saving for biogas plant	euros/month	10156
Total money for farmers selling manure	euros/month	4352
Money for slurry treatment and transport	euros/month	7254

Table 19: economic data for plant 2

Saved maize	tons/month	**1004**
Produced energy by slurry derived fractions	Kwh/month	494631
Money saved from maize	euros/month	45180
Money spent for slurrry transport, treatment and farmer reward	euros/month	24096
Total money for farmers selling manure	euros/month	9036
Money for slurry treatment and trasport	euros/month	15060

By the point of view of technical evaluation, process parameter and production, the synthesis of relevant criteria to be taken into account is reported in table 15

Table 20: technical criteria to evaluate the use of slurry derived fraction in digesters

Parameter	Criteria for positive assessment	Biogas plant 1	Biogas plant 2
Energy demand increase	<5-7% of baseline	Not detectable	Not detectable due to upgrade in plant equipment
Stability of process	Yes	yes	yes
Increase in digestate volume	<30%	17%	40%
Increase in the amount of nitrogen	To be evaluated	Almost 2 fold increase	3 fold increase
Concentration of ammonia in digesters	< 3000 mg/l	<3000	Sometimes >3000
Stop of running due to maize substitution with slurry and manure-derived fraction	No	No	No
Savings compared with maize	<5-7% of baseline	Not detectable	Not detectable

The substitution of silage maize with slurry derived fractions in the two biogas plants was (According to the outlined numbers) :

Feasible by the point of view of the technical parameters in plant running (table 15)

Economically valuable for biogas plants and farmers, as the expenses for slurry treatment and transport allowed in any case significant savings for biogas plants and new income for farmers.