

Biogas purification and use as vehicle fuel in rural areas

Ruiz, B.^a, Gómez, P.^a, Giralda, R.^a, Carreras, N.^b, Rodríguez, M.^b, Ramos, J.L.^b, Morales, J.^c, Muñoz, S.^c, Torrente, M.^c, Pascual, A.^a
^aAinia Technology Centre. Technology Park Valencia. Benjamin Franklin5-11. 46980 Paterna (Valencia). Spain.
^bCentre for research of Energy, Environment and Technology (CIEMAT). Av Complutense 40. 28040 Madrid. Spain.
^cHera Amasa, S.A., Technology Park Vallés. Ed.A2 Paletes 6. 08290 Cerdanyola del Vallés (Barcelona). Spain.

Introduction

There is a lack of availability of agro-industrial co-substrates in certain regions of Spain that hinder the implementation of anaerobic digestion due to the limited economic profit of the monofermentation of manure. **Alternative biomasses** available in rural areas would foster the application of anaerobic digestion for treatment of organic waste and obtention of biogas.

At the same time, there is very little experience in the use of **biomethane as a vehicle fuel** in Spain. New uses of biogas are sought at the moment due to the moratorium to the feed-in tariff from renewable energy sources.

The objective of this work is to demonstrate a sustainable system of biomethane production and use in vehicles from farm waste and alternative biomasses.

Materials and Methods



Biogas potential (batch tests)

2L glass digesters, placed in ovens at 38°C and connected to Ritter Milligascounters ® MGC-1 and Awite gas analyzer.

Inoculum: digested sludge from a running agro-industrial biogas plant.



Semi-continuous anaerobic digestion tests

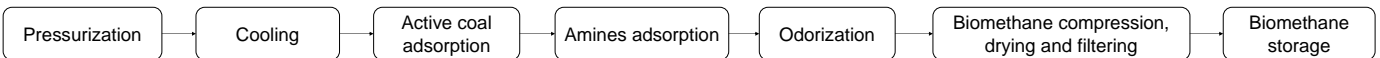
36L inox digesters, jacketed (38°C), mixed and connected to Ritter Milligascounters ® MGC-10.

Daily feed of the co-substrates. Weekly sampling for chemical analysis.

Substrates:

three species of microalgae, cereals (different varieties of barley, oat, wheat, triticale, rye, sorghum, maize and sunflower), harvest residues (straw, horticultural waste), industrial vegetable processing waste (bagasses, husks, filtration cakes), and farm wastes (pig slurry, sheep manure, poultry manure).

Biogas purification pilot plant



Mixtures:

	Cow Manure (%)	Substrate (%)	Substrate	OLR (kg _{VS} ·m ⁻³ ·d ⁻¹)
M1	66	34	Wheat straw	3
M2	73	27	Oat hay	3
M3	67	33	Barley straw	3
M4	72	28	Rye straw	3

Results

Alternative biomasses:

As a consequence of deficit of co-substrates in numerous Spanish areas, different alternative biomasses have been identified, quantified and localized at a "comarca" level, with special interest in crop residues.

Crop group	Residue (tons year ⁻¹)	%
Cereals	2,638,750	55.2
Vegetables	1,579,249	33.1
Industrial crops	438,512	9.2
Tubers	108,292	2.3
Legumes	13,433	0.3

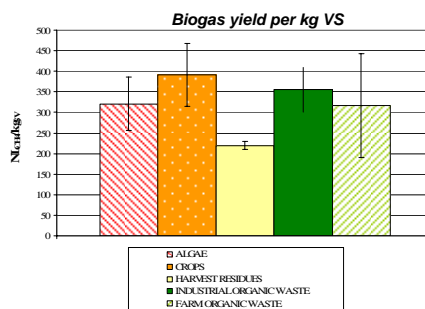
Crop residues production in Spain

Different "comarcas", mainly located in Castilla y León, Aragón, Castilla-La Mancha, Extremadura, or Cataluña, show a deficit of organic agro-industrial waste, with estimated amounts of crop residues, (in tons per year), of 1,182,918, 949,882, 554,580, 324,107 and 207,224, respectively.

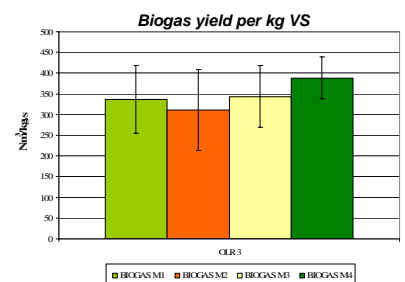
Biogas purification tests



Biogas potential tests



Semi-continuous anaerobic digestion tests



Parameters to measure the performance of the demonstration vehicle:

- Fuel efficiency: biomethane consumed (Nm³)/dist. covered (km)
- CO₂ emissions: CO₂ emission (gCO₂)/distance covered (km)
- Vehicle autonomy: distance covered (km) with one refuelling

Yields to be calculated for the biogas purification process:

- H₂S removal: $([H_2S]_{in} - [H_2S]_{out}) / [H_2S]_{in}$
- CO₂ removal: $([CO_2]_{in} - [CO_2]_{out}) / [CO_2]_{in}$
- CH₄ enrichment: $([CH_4]_{out} - [CH_4]_{in}) / [H_2S]_{in}$
- Active coal consumption: AC(kg)/biomethane obtained (Nm³) and AC(kg)/H₂S removed (g)
- Amine consumption: amine(L)/biomethane obtained (Nm³) and amine(L)/CO₂ removed (kg)
- Energy consumption: energy consumed (kWh)/biomethane obtained (Nm³)
- Energy balance: energy consumed (kWh)/energy content of the biomethane produced (kWh)

Conclusions

- Alternative biomasses, as harvest residues from vegetables, cereals and other crops, could be considered as potential co-substrates for biogas production in numerous areas of Spain with lack of co-substrates. Mainly, "comarcas" located in Castilla y León, Aragón or Castilla-La Mancha could have a higher benefit from such alternative biomasses sources as main co-substrates.
- Among the alternative biomasses tested at batch level, industrial organic waste showed the highest methane yield and the highest degradation speed
- At pilot scale, digesters under semi-continuous feeding conditions were running stable at an OLR of 3 kg_{VS}·m⁻³·d⁻¹ and percentage of co-substrates under 30% to avoid loss of alkalinity.
- The biogas composition of both digesters was around 44-47% of CH₄ and 351-435 ppm H₂S. Necessary a step of purification and upgrading for its use as vehicle fuel.

References

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