

BIOGAS PRODUCTION AND AGRO-ENERGY DISTRICTS IN SICILY¹

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Abstract

Considering the ever growing importance of biogas production by means of the anaerobic digestion of agro-industrial biomasses, this paper sets out to survey the potential of livestock farms in Sicily. The aim is to evaluate the possibility of using them, within agro-energy districts, as collection and disposal centres for animal waste, as well as agricultural, food and household waste. This would allow a more profitable division of running costs for the plants, gaining a triple advantage from an energy, economic and environmental point of view.

Riassunto

Considerata l'importanza sempre maggiore che va assumendo la produzione di biogas per digestione anaerobica da biomasse agro-industriali, nel presente lavoro viene effettuata un'accurata ricognizione delle potenzialità offerte dagli allevamenti zootecnici della Regione Sicilia. L'obiettivo è quello di valutare la possibilità di un loro inserimento, quali centri di raccolta e smaltimento, nell'ambito di distretti agro-energetici, oltre che delle stesse deiezioni animali anche di residui agro-alimentari e di r.s.u. onde conseguire una più redditizia ripartizione dei costi di gestione degli impianti realizzando, in tal modo, un triplice vantaggio sotto il profilo energetico, economico ed ambientale.

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Introduction

Italy has been set a target by the European Commission of achieving a quota of 17% of gross final energy consumption produced from renewable sources, as one of the objectives of the “20-20-20” “Climate-Energy” package, which involves all European Union member states.

It is almost unanimously recognised in Italy that this result is at best difficult to reach, and may well be impossible to achieve. However, the objectives that have been set are not yet final and a negotiating round is getting under way, in which Italy and the other member states will discuss the Directive with the Commission and the future rotating Presidents of the EU in an attempt to soften its impact.

Currently (1), production of renewable energy in Italy accounts for just 7.1% (13.95 Mtoe) of total gross demand for energy and most of this depends on the widespread use of large hydroelectric installations, which offer no prospect of further development, as we know (Fig. 1).

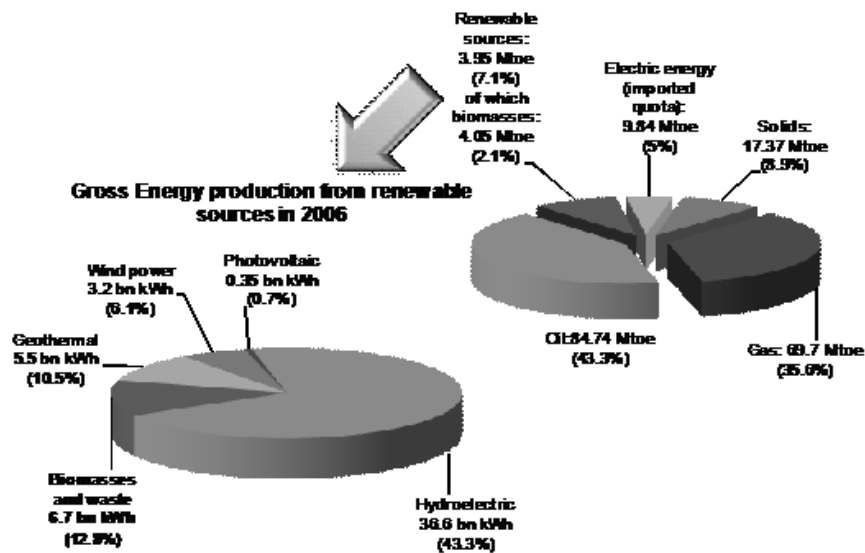


Fig. 1 – Energy requirements in Italy in 2006

Source: MEF Data 2006; INEA Observatory on EU Agricultural Policies.

In this context, biomasses represent just over 2.1% (4.05 Mtoe) of the total, a tiny amount but with enormous potential for growth. Indeed, it is widely recognised that biomasses are able to “fix”, by means of chlorophyllous photosynthesis, about 200 billion tons of carbon per year, with an energy content equivalent to 70 billion tons of oil, that is about 10 times current world energy requirements (2).

Biomass is widely available everywhere and, if it is used cyclically for energy purposes, it becomes an important local resource, renewable and environmentally friendly.

It is certain, however, that the most interesting strategic investment for zootechnical firms among the possible conversion processes (Table 1), under strategic point of view, is the one regarding anaerobic digestion (A.D.), since it does not require the growing of an “ad hoc” biomass; it avoids “food/fuel” competition; it is a very useful method for the disposal of cost-free sludge, a material that in any case needs to be eliminated; the production of energy is a “valuable” by-product, not to be wasted.

The biogas production: the experience of European Countries

A.D., or “biomethanisation”, brings about the gradual separation of the chemical bonds of the organic compounds, releasing their energy in the complex biological process of fermentation and accumulating it in molecules of methane, which are the main components of “biogas” (50-80%). The capture of biogas is an energy benefit that has considerable environmental advantages, including the reduction in emissions of: methane; NH_3 ; other greenhouse gases, by indirect means; non-methane volatile organic compounds (VOCs) and smells. The experience of European countries in which plants operate has been highly positive (Fig. 2).

TABLE 1

TYPES OF BIOMASS, CONVERSION PROCESSES AND ENERGY USES

Biomass	Properties	Conversion processes	Products	Final uses
Firewood and lignocellulose solids	H ₂ O = 35% C/N > 30	Combustion, pyrolysis and gasification	Heat, oils, gas	Thermal energy and/or electricity
Putrescible agricultural by-products	H ₂ O > 35% 20 < C/N < 30	Anaerobic digestion	Biogas	Thermal energy and/or electricity
Animal sludge	70% < H ₂ O < 90% 20 < C/N < 30	Anaerobic digestion	Biogas	Thermal energy and/or electricity
Sugary plants	15% < H ₂ O < 90% C/N any	Alcoholic fermentation	Ethanol and derivatives	Mixtures with petrol
Crops with high cellulose content	H ₂ O > 35% C/N any	Hydrolysis and alcoholic fermentation	Ethanol and derivatives	Mixtures with petrol
Oily crops	H ₂ O > 35% C/N any	Oil extraction esterification	Biodiesel	Motoring and heating uses (with diesel)

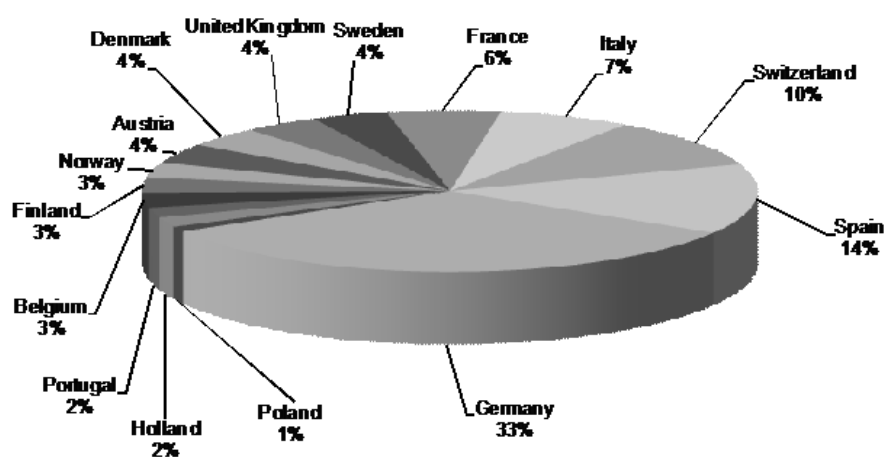


Fig. 2 – Percentage distribution of biogas plants in Europe

Source: University of Insubria - DASS, (2008)

The German experience, in particular, based on 3,800 biogas production centres, demonstrates that there can also be indirect economic advantages; indeed, Germany is the European country in which anaerobic digestion for biogas production has had the greatest boost, as a result of a strong policy of incentives from the government in Berlin, with considerable state support for investments (3) (Fig. 3).

94% of biogas plants operate using co-digestion (animal sludge + energy crops + organic waste) and this brings about a significant decrease in the costs of organic, agro-industrial and municipal waste disposal (4).

The biogas production: the experience of Italy

In Italy, after the first experiments in the mid-1970s, interest in plants for the production of biogas by means of anaerobic fermentation of organic material from agriculture had gradually declined. Recently, government policies in favour of agro-energy have revitalised the use of biomasses for energy purposes (Fig. 4).

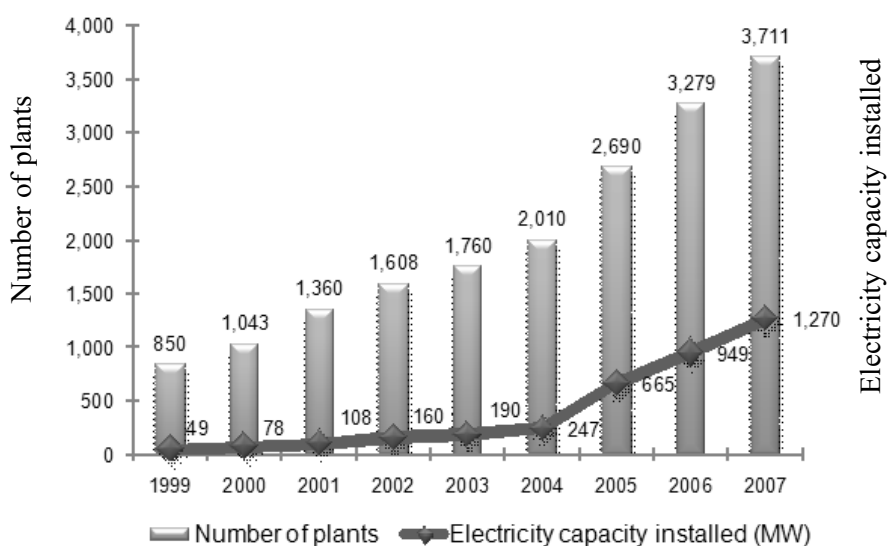


Fig. 3 – Biogas plants trend in Germany

Source: Doheler 2008 - KTBL

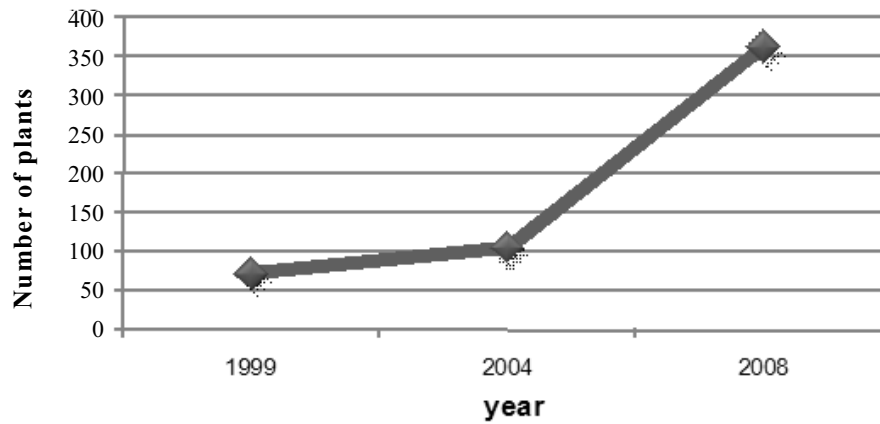


Fig. 4 – Growth trend of biogas plants in Italy

Source: our elaboration of GSE data (2008)

According to a census taken by Gestore dei Servizi Elettrici (GSE), as of 30/06/2008, 362 plants producing biogas by means of anaerobic digestion were operating in Italy: 202 fuelled by animal effluent (of which 88 are simplified plants using only pig and cattle sludge), 121 fuelled by sewage sludge, 10 fuelled by the organic fraction of municipal solid waste, 22 fuelled by agro-industrial waste and, finally, 7 fuelled by other types of substrate (Fig. 5).

The area with the highest number of plants is Lombardy (72), followed by Trentino-Alto Adige (34), Emilia Romagna (28), Veneto (23) and Piemonte (16). As can clearly be seen, southern Italy has very few biogas production centres and, in Sicily in particular, there are no plants at all, even though there are numerous livestock farms, as shown in Table 2. The corresponding numbers of head of livestock are shown in Fig. 6.



Fig. 5 – Distribution of biogas plants in Italy
 Source: GSE data as of 30/06/2008

TABLE 2

DISTRIBUTION OF LIVESTOCK FARMS IN SICILY DIVIDED BY PROVINCE

<i>Province</i>	<i>Cattle</i>	<i>Sheep</i>	<i>Pigs</i>	<i>Others</i>	<i>Total</i>	<i>%</i>
Palermo	387	238	19	191	643	15%
Catania	245	238	34	275	529	12%
Messina	705	474	55	284	1,131	25%
Siracusa	395	64	17	154	532	12%
Ragusa	307	46	31	163	427	10%
Agrigento	81	261	8	99	366	8%
Trapani	69	226	10	154	376	9%
Caltanissetta	16	85	3	54	128	3%
Enna	109	118	8	120	250	6%
TOTAL	2,314	1,750	185	1,494	4,382	100%

Source: our elaboration of data from Messina Chamber of Commerce Industry and Agriculture (2009)

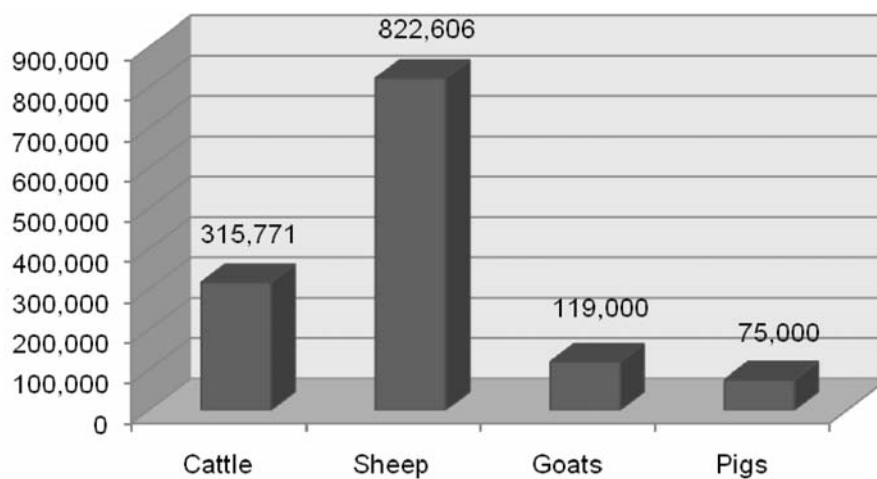


Fig. 6 – Regional livestock numbers (n° head)

Source: ISTAT 2007

Analysis of the livestock farms: situation in Sicily and potential development of agro-energy districts

Unfortunately, there has been a rapid decline in both the number of livestock farms and in the overall number of head of livestock, reflecting a trend to be seen at a national level, but which has been particularly serious in Sicily, as shown by Figure 7, in which we can see the trend for the number of cattle, sheep and pig farms over the period 1991-2008.

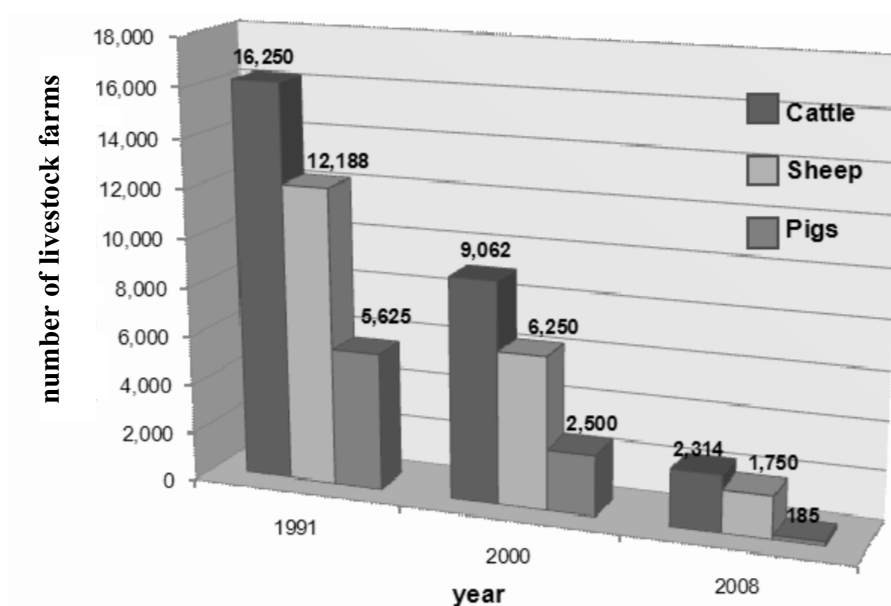


Fig. 7 – Trend in number of livestock farms in Sicily from 1991 to 2008

Source: our elaboration of ISTAT data.

We can see that, over the period taken into consideration, there has been an overall decline of 85.8 % for cattle, of 85.6 % for sheep and of 96.7% for pigs, that is to say an average annual reduction of 5% for cattle and sheep and of 5.7% for pigs. In order to calculate the “theoretical potential” of energy production from biogas produced from animal waste we have considered only those effluents that can be defined as “sludge”, that is to say, those with a dry substance content of <10 12%. Thus, we have taken into consideration only data relating the categories of cattle, sheep

and pigs. On the basis of the number of livestock farms in the region, the potential has been calculated as amounting to a total of 54,716 TOE per year (Table 3).

TABLE 3
THEORETICAL ENERGY POTENTIAL (TOE/YEAR)

	n° head	Biogas produced m3/year	Energy Potential TOE/year
Cattle	315,771	94,296,668	34,000
Sheep	822,606	44,659,503	19,680
Pigs	75,000	2,956,513	1,037
Total	1,213,377	141,912,684	54,716

Considering the correspondence between TOE and kWh, we would obtain a theoretical potential of energy production from biogas of 248,708,842.2 kWh, corresponding to a quantity of energy ten times greater than present total annual energy production in Sicily (24,606,000 kWh in 2007) and thirteen times greater than the energy consumed by the entire Sicilian population in a year (19,081,000 kWh). Of course, this data is purely theoretical as it clashes with the reality of a highly fragmented livestock sector in Sicily, in which each farm has a small average number of just a few hundred animals. This is the fundamental reason for which Sicily lags well behind other regions in Italy in recovering energy from biogas. Indeed, a study conducted (5) in 2002, based on strictly economic criteria, shows that only the larger farms, with several thousand animals, are in a suitable position to set up a feasible project for energy recovery. In Sicily, in reality, there are not more than an about ten farms of these dimensions and so the potential production of biogas can realistically be calculated as being around 1-2 % of the theoretical figure (6); nonetheless, this would still represent an important contribution of around 2.5 million kWh, equivalent to 15-25 % of Sicily's total energy consumption.

In this context and considering the current economic crisis, it is easy to understand why there have been few initiatives in this field in Sicily so far.

There could be a significant shakeup of the situation with the creation of agro-energy districts, which are organised systems involving a large number of firms from the same geographical area, which use the A.D.

system of the livestock farm, by creating co-digestion systems, in order to treat waste from agro-food firms, wood cellulose residues and the OFMSW (Organic Fraction of Municipal Solid Waste), from separated waste collection.

The “short process chain” approach within a district, within a range of 70 km, favours the achievement of a higher level of efficiency due to the greater and continual use of the anaerobic digestion plants, ensures a more equitable redistribution of benefits among the various firms belonging to the same area of production and, at the same time, makes it easier for them to gain access to the incentives provided for in the regulations governing the production of agricultural biomasses, including:

- law 222 of 29/11/2007 which provides incentives exclusively for biomass, such as: “green certificates” guaranteed for a period of 15 years and which, for biogas obtained from agricultural activity, either regarding animals or forestry, applies the highest coefficient (1.8) for plants fuelled by RES (Renewable Energy Sources) with electric power >1 MW, or, for plants that do not reach this power level, a fixed all-inclusive tariff, worth 30 €cent/kWh for biogas production;
- Process chain contracts for projects in which the total permissible investment sum is between 5 and 50 million Euros;
- Regional Funds allocated annually by the regional government;
- Regional Rural Development Plans 2007-2013 measures for plants of <1 MW power: in Sicily these plans provide contributions of up to 50% of total investment costs;
- 2008 Budget, law 244 of 24/12/2007.

Conclusions

Sicily is also now ready to start up agro-energy production, which could prove to be an essential element for the development of the island. Indeed, a certain number of studies have already been undertaken with the launch of the “Fisica” project (Filiera Siciliana per l’agroenergia), with the participation of 28 firms, which has mainly concerned the possibility of identifying energy crops of the “Brassica Carinata” variety, which can be rotated with durum wheat in order to produce seeds suitable for the extraction of oils for use in the production of renewable biofuels.

The creation of agro-energy districts in the biogas sector would be a very significant change of direction because the participating firms would be

able to dispose of their organic waste while making themselves independent from an energy point of view, or indeed becoming producers of renewable energy themselves. In this way, they would enjoy considerable benefits, such as the chance of having access to incentives granted for the production of energy from biomasses.

It is necessary, however, to have a clear and attractive package of incentives in order to encourage those who are interested in investing in this sector, so as to attain a more profitable sharing of running costs for the plants and achieve benefits from an energy, economic and environmental point of view. Above all, there is a need to clarify unambiguously the borderline between agricultural activity and waste disposal activity, for those who wish to build co-digestion plants.

REFERENCES

- (1) S. GIUCA, "Le biomasse nella politica energetica, comunitaria e nazionale", *Agriregioneeuropa* 2007, 3/9, 4-9.
- (2) <http://www.itabia.it>
- (3) S. PICCININI, L. TOSI, "Esperienze di gestione di impianti di biogas", *Informatore Agrario* 2006, 62/1, 37-40.
- (4) S. PICCININI, "Le tecnologie di produzione del biogas", http://www.crpa.it/media/documents/crpa_www/Convegni/Biogas30-05-07/Le_Tecnologie_Produzione_Biogas.pdf.
- (5) G. FLORIO, R. GIORDANO, R. GRECO, "Modello Tecnico-economico per la determinazione delle potenzialità energetiche del recupero di biomasse da reflui zootecnici. Parte II: applicazione alla Regione Calabria", *RS Rifiuti Solidi* 2002, 16/4, 210-217.
- (6) C. LA MALFA, G. IOPPOLO, G. SAIJA, S. CHIRICOSTA, "Biogas from zootechnical refluents: potentialities and productive realities in Italy and Sicily", in *Biomass for Energy, Industry and Climate Protection*, vol. I, ETA-Florence and WIP-Munich, Florence/Munich, 2004, 702-706.
- (7) S. PICCININI, "Biogas: Produzione e prospettive in Italia", in *Proceedings of the "Convegno Nazionale sulla Bioenergia"*, ETA-Energie Rinnovabili, Roma, 2004, http://www.crpa.it/media/documents/crpa_www/Settori/Ambiente/Download/15.pdf.