THE ENERGY VALORIZATION OF DEJECTIONS FROM LIVESTOCK BREEDING: SUSTAINABLE PLANNING IN THE LOMBARDY REGION

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Abstract

The Italian livestock breeding sector is going through a moment of crisis that demands some innovation in its managerial strategies. A possible way is to extend traditional farming, exclusively oriented to the "food" sector, exploiting the available resources by producing also energy.

The anaerobic bio-digestion of livestock breeding dejections represents an opportunity presenting several positive effects. First of all, the production and trade of electrical energy from renewable sources that can also be remunerated with government incentives. Secondly, and aligned with Community directives, storing dejections from simple waste becomes a resource from which matter and energy can be recovered. Using a dedicated software tool it was possible to foresee a hypothesis of intervention in the most critical areas of Lombardy.

In fact, creation of medium-large consortiums allows optimization of their sustainability while having the resources required for the implementation of nitrates management technologies, thus complying with the relative EU directive.

Riassunto

La zootecnia italiana attraversa un momento di crisi che impone l'avvio di innovazioni gestionali. Un percorso possibile è legato all'evoluzione della tradizionale agricoltura, esclusivamente legata al settore "food", attraverso la

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valorizzazione delle risorse disponibili anche con finalità energetiche.

La biodigestione anaerobica degli effluenti zootecnici rappresenta una opportunità foriera di numerosi effetti positivi. In primo luogo, la produzione e commercializzazione di energia elettrica da fonte rinnovabile, remunerata anche con incentivi statali. In secondo luogo, i reflui zootecnici che, da semplice rifiuto da stoccare, diventano una risorsa da cui recuperare materia ed energia, in linea con quanto disposto dalle Direttive comunitarie.

Attraverso uno strumento di calcolo, appositamente elaborato, è stato possibile configurare un'ipotesi di intervento nelle aree maggiormente critiche della Lombardia. Infatti, la costituzione di impianti consortili medio-grandi consente di ottimizzarne la sostenibilità e anche di disporre, in prospettiva, delle risorse per affrontare l'implementazione di tecnologie per la gestione dei nitrati, nel rispetto della relativa Direttiva.

Keywords: Renewable energy, biogas, dejection, waste, sustainability, anaerobic digestion

Introduction

Overcoming the current crisis of the agricultural sector requires a radical innovation in its management decisions: there is a need to widen the scope of traditional farming, exclusively oriented to the "food" sector, moving towards integrated and advanced practices, exploiting the available resources for energy production.

To achieve the environmental compatibility of usual livestock breeding customs requires a re-assessment of the different pathways for wastewater disposal, identifying the ones that enable to recover material and energy from waste, in line with EU Directives.

Therefore, in a perspective of a sustainable agriculture, there is a growing necessity to produce and sell electricity and also a minor amount of thermal energy, produced from biogas, resulting from digestion of livestock breeding dejection.

Therefore, the present work aims to outline a possible path for the integration of traditional farming systems in the Italian region with the highest concentration of pig livestock breeding: Lombardy. In particular, it was chosen to apply the study to a sample of Lombardy farms, located in the most active counties in the sector: Brescia, Lodi, Cremona and Mantova.

To achieve that objective, the work has been articulated into three key moments: identification of the state-of-the-art of pig livestock breeding in Lombardy, development of a software tool for calculating the most important variables, evaluation of ideal locations for facilities capable of exploiting the resources available in the sector.

For the evaluations of sustainability, a software tool was implemented using electronic spreadsheets, partly already validated both by the literature and by former application to plants already operating in the sector. By using the program, we tested the minimum corporate thresholds for the implementation of a plant and evaluated the effectiveness of certain management decisions.

Picture of Pig Livestock Breeding in Lombardy

The history of livestock breeding in Italy goes together with the history of livestock breeding in the Po Valley and in particular with that of the Lombardy Region that is the undisputed leader in the sector.

Looking in more detail at the distribution of pigs' heads in Italy, it can be observed that farms are located mainly in the Po Valley and that in particular, Lombardy is the Region with the greatest concentration of units.

TABLE 1

NUMBER OF SWINE UNITS IN ITALY ON DECEMBER 1ST 2007

2007	**Swine** (units)	Percentage
Lombardy	4,132,342	44.56%
Piedmont	977,015	10.54%
Veneto	736,731	7.94%
Emilia-Romagna	1,630,060	17.58%
Totale of the 4 regions	7,476,148	80.62%
National Total	**9,272,935**	

Source: Revising dates ISTAT

Analyzing the data of Table 1, we can see that Lombardy is the first Italian Region, as number of bred animals: the 44.56% of the Italian swine production occurs in Lombardy (1).

The distribution of the heads amongst the various counties highlights that only four counties - Brescia, Mantova, Cremona, Lodi – concentrate more than 80% of the bred swine heads.

The primacy of the four regions, reported in table 1, in pig-breeding, is mainly due to the ham (in particular Parma ham). The number of farms number recognized for Protected Designation of Origin (PDO) for Parma ham is 5386 in 2003, located in 11 Regions of central northern Italy: in these Regions, the disciplinary specifications for the production of Parma ham, allow pig livestock breeding, which will produce fresh thighs to be processed and cured (2).

The largest concentration of livestock breeding is found in the north-west Po Valley, with 1996 livestock breeding facilities in Lombardy (37.05%), 1161 in Emilia Romagna (21.56%), 1043 in Piedmont (19.37%) and 502 in Veneto (9.32%). The other 7 areas share the remaining 12.7%. A large swine Consortium of the Po Valley (GSP) was created in February 2006, in order to valorise the traditional heavy swine, historically used for the production of PDO hams, This consortium comprises 1,116 swine breeding farms and 20 butchery enterprises.

The consortium enterprises breed almost 2,162,000 swine certified as "Big Swine of Po Valley": of these more than 50% are bred by facilities located in Lombardy (3)[1] . GSP is the first GDO for National pork fresh meat (at present, it is in a phase of transient national protection, while the Community recognition path is finalised).

The Difficulties of Livestock Breeding in the Po Valley

For the Po Valley zone, there is an obvious production decrease (of about 1.76%), as can be observed by comparing the 2002 with the 2007 production data, in opposition with the National growing trend.

This tendency is likely to be partially connected with the production of the heavy Italian swine (destined for the prestigious Parma and San Daniele ham production, with GDO label), suffering from strong competition from the importation of pig thighs (used for the production of non branded ham) characterised by lower production prices (4). Luckily, this phenomenon is decreasing thanks to the birth of Consortiums, as that of the "Big Swine of the Po Valley", which protect the quality of the local production.

[1] Production costs noticed by CRPA express an average of values coming from high efficiency breeding firms and low or smaller efficiency breeding firms.

From an analysis led by CRPA (Centro Ricerche Produzioni Animali - Centre of research for livestock breeding) during the years from 2005 to 2007, there is a large variation of profitability for the pig livestock breeding sector. Years marked by a fairly good profitability alternate with years of crisis that put at risk the survival of the breeding facilities Such variability can be partly explained by the difference between the production costs of different years, which modifies the livestock breeding profitability in a substantial way.

The cost level can exceed of about 14% the price averages (from 2005 to 2007) which shows clearly the difficult condition of the pig livestock breeding sector. It is, therefore, absolutely necessary to intervene with some type of innovative elements in the livestock breeding production process.

To keep the production continuity, indeed, it becomes necessary to raise significantly the technical performance of livestock breeding[2] (5). A low technical efficiency level, in fact, determines high production costs, which in a critical situation determined by the compliance of the "nitrate Directive" can become unsustainable.

The main causes of the increase in costs, of the agro-food industry products, are:
- the rising of the cost of energy (stables heating or illumination)
- innovations in the standards which impose structural adjustments and bureaucratic fulfilments (sometimes excessively complicated and onerous) to the breeders.

The normative tends to be complex and articulated because they did not evolve in a short time period and had to face significant changes in the scenario to regulate.

The regulation that had the greatest impact upon the breeding sector is the "Nitrate Directive", which disciplines the use dejections on the agricultural soils. Since adopting the Directive 91/676/CE (first at National and then at Regional level, with various regional laws), the livestock breeding facilities had to re-organize their management.

The Nitrates Issue

In the last decades, and especially starting from the 1960s, the development of intensive livestock breeding modified the long-established

[2] If the average number of 20.6 weaned pigs for sow by year raised to 23 weaned pigs for sow by year, the production cost would diminish by 7.75%

relationship between produced food, swine heads and dejections (6).

The prevalence of the "disposal" concept over that of “organic fertilisation”, together with the economic demands of cost reduction for storage, transport and distribution of breeding dejections, produced inappropriate management strategies (dejection downloading in waters surface) or random spreading on fields in very high doses (up to 1000 m^3/ha) (7).

In general, it's necessary to think that the distribution of the animal dejections on the ground represents the most logical end for the natural cycle of the main nutritive elements that had been removed from soils by crops. It represents therefore, from a technical and economical point of view, the more effective way to remove the dejections from livestock breeding.

Other methods, as for instance the purification, did not generate positive economic results and, furthermore, did not allow reaching the limits imposed by the legislation regulating the download of waste in waters surface.

The most fragile aspect sewage distribution on agricultural soils is the environmental protection, obviously not excluding other themes such as for instance, the agronomic valorisation of dejections.

The most critical point about the agronomic use of sewage remains the leaching of nutritional elements, like nitrates, with the consequent possible pollution of groundwater.

The “Nitrate Directive”: Economic Effects and Possible Solutions

With the adoption of the “Nitrate Directive”, the bulk of livestock breeding in Italy, located in areas with high breeding load, must conform to the new law prescriptions.

For this purpose, two strategies can be assumed: the first consists on the increase of the surface on which sewages can be spread (by means of purchasing, renting or new grounds concession for spreading). The second strategy consists in the reduction of the nitrogen content of sewage with a resulting cutback of the surface required for its spreading.

The issue of costs increase on the products of the livestock breeding exists anyway, and for pig meat it ranges from a minimum of 9.18% to 13.70%. These increases are difficult to be supported in a moment when the breeding sector is already in crisis.

The modification of the Community structure will probably increase transfers for the agriculture of incoming new Countries, to the detriment of Countries with consolidated markets, as Italy.

So it's necessary to revise the weight of the traditional incentives on the breeding economical balance.

The possible ways to improve the stock farm profitability are mainly three:

- the efficiency increase for the productivity of breeding farms, as already described above;
- the creation of circuits for products of Protected origin, recognized at Community level, characterized by a particular added value, that could support the price increase at the stable, obtained by the intermediaries;
- the establishment of innovative sources of income through the exploitation of biogas, resulting from the anaerobic digestion of dejection in dedicated facilities.

Even if not solving the problem of the nitrates, which are not removed using the anaerobic treatment, this last solution is able to produce electrical energy.

Despite the possibility of realizing very simplified facilities, in most cases the economic engagement isn't lower than the € 200,000[3] (4). Therefore, it becomes interesting to evaluate the chances of a consortium activity that would collect dejections for all livestock breeding farms not able to sustain the necessary investments for reducing also the amount of nitrates.

CODEP S.c.a.r.l. is an example of cooperative for the management of dejections breeding, located in the county of Perugia: it accepts about 1000-1200 m^3/day of sewages coming from about 80,000 swine units of the livestock breeding facilities located in this geographical area.

The system is formed by two bio-digesters, working at medium temperature conditions, for a volume of 10,000 m^3. The plant produces about 9,600-12,000 m^3 of biogas per day, necessary to feed three electrical generators for an installed total power of 1,105 kW (two 410 kW engines plus a 285 kW one). The transport of the incoming sewage and the outgoing digested material is made through an underground pipe network.

The Nitrates Problem in Lombardy: the Region Having the Highest Livestock Breeding Load of Italy

Regarding soils, in the year 2000 the Lombardy Region made a study (8), highlighting (Table 2) that the total nitrogen amount from bovine and swine livestock breeding dejections is superior in Lombardy than in the

[3] To obtain this approximate value, costs paid by the livestock breeding were considered, for systems with installed power of 50kW or lower.

other Regions (Piedmont, Lombardy, Veneto and Emilia-Romagna) with high breeding load. There are not recent studies about S.A.U. (superficie agricola utilizzabile - usable agricultural surface), because the last available data refer to the general agriculture census, made by ISTAT in 2000 (9).

TABLE 2

AVERAGE TOTAL OF NITROGEN/HECTARE/ YEAR OF REGIONAL EXPLOITABLE AGRICULTURAL SURFACE

Regions	N from bovine kg /ha/year	N from swine kg /ha/year	N Total kg /ha/year
Piedmont	30.4	6.9	37.3
Lombardy	62.3	30.,6	92.9
Veneto	4	0.7	4.7
Emilia – Romagna	25	16.8	41.8
Total	121.7	55	176.7

Source: Pedrazzi et al., 2000

Making a calculation on regional basis of the breeding load and of the total nitrogen amount produced, it's possible to observe that the Lombardy soil should receive 92.9 of total N, for every hectare of S.A.U. for year, with the largest fraction coming from bovine heads.

The average value appears reasonable since it is lower than the one established by good agricultural practices and by current laws. It is however necessary to consider that data are average values and that a few Lombardy provinces (the four provinces examined in this paper too) do not possess the required spreading surface for all dejections[4] (Tables 3 and 4) (10).

TABLE 3

VULNERABLE ZONES BASED ON THE ACT OF THE LOMBARDY REGION COUNCIL

County	N tot (kg)	S.A.U. (ha)	N (kg/ha)	Surface (ha)
Mantova	26,380,393	127,280	207	–27,899
Cremona	18,765,259	75,864	247	–34,520
Brescia	41,350,977	115,187	359	–128,054
Lodi	3,539,257	16,806	211	–4,013

Source: Sommariva, 2008

[4] European Union imposes the waste disposal to take place inside the production area, as one of the management goals for its waste policy.

TABLE 4

NOT VULNERABLE ZONES BASED ON THE ACT OF THE LOMBARDY REGION COUNCIL

County	N tot (kg)	S.A.U. (ha)	N (kg/ha)	Surface (ha)
Mantova	5,479,884	41,526	132	25,408
Cremona	8,405,930	59,469	141	34,745
Brescia	2,706,665	20,524	132	12,563
Lodi	7,316,132	40,563	180	19,045

Source: Sommaria, 2008

It is therefore necessary that agricultural firms comprehend the concession problem[5], necessary in the case that the property ground is not sufficient to spread the produced dejections. Numerous soils, which could be given in concession for spreading, belong to agricultural farms, who must not compile PUA (piano utilizzazione agricola - agricultural utilization plan) because they use an amount of nitrogen lower than 3,000 kg/year in vulnerable zone or 6,000 kg/year in a non vulnerable zone[6].

This obstructs the signing of concession contracts for spreading, because they impose the compilation of PUA, with its relative bureaucratic burden and periodical check-ups on the legitimacy of the declaration.

Since 2006, following the infringement proceeding opened against Italy about nitrates, such situation became worse because the Lombardy Region had to proceed to a remarkable widening of the areas classified as vulnerable zones, where the spreading nitrogen is reduced from the normal 340 kg/ha/year to 170 kg/ha/year.

Such difficulties are related to the various regional policies which generally underestimated the nitrogen production to the field[7] and the alignment to the values fixed by the Community originated considerable

5 Concessions are contracts between breeders and farmers, who, against remuneration, assume the obligation to spread dejections on their grounds, according to current laws for nitrogen spreading limits both in vulnerable and not vulnerable zones.

6 According to the law, in fact, who uses livestock breeding dejection is obliged to compile PUA, even if in simplified way, from 1,001 kg/N/year for vulnerable zones and from 3,001 kg/N/year for not vulnerable zones. These limits would raise up to 3,001 kg/N/year for vulnerable zones and 6,001 kg/N/year for not vulnerable zones, if sources different from the livestock breeding dejection will be used. That means the need to spread 2,000 more kg/N/year for vulnerable zones and 3,000 more kg/N/year more for not vulnerable zones, without having to compile PUA.

7 Constituted by the nitrogen contained in the dejection, without losses, like emissions in atmosphere, in the stables and in the storage.

nitrogen increases, in particular for the Lombardy Region. The differences of nitrogen to the field between the Act of the Regional Council n. 37 of December 15th, 1993 and the Act of the Regional Council n. 8/3439 of November 7th, 2006, are shown in the Table 5.

TABLE 5

VALUES OF NITROGEN TO THE FIELD FOR SWINE

Heads units	Dgr 3439/2006 (kg/t)	Dgr 37/1993 (kg/t)	Change in %
Fattening pigs	110	70	157.14%
Sows with sucking pigs	101	70	144.29%

Source: Dgr 3439/2006 – Dgr 37/1993

Thus, in absence of strategies oriented to the reduction of nitrogenous load, Lombardy risks of compromising not only the development, but also the maintenance of the livestock breeding sector at the current levels.

Solutions

Because it is not possible to increment the area of crops (available for spreading breeding dejections), there are two main strategies that complement each other:

- to optimise the feeding allowance in order to reduce excreted nitrogen;
- to treat sewage in order to reduce nitrogen content.

During the following discussion, is the second option that will be particularly analyzed.

The sewage treatment is a method that needs to be calibrated on the specific requirements of every farm, or group of farms, in order to optimise the performance and to guarantee their economic sustainability.

Because of the complexity and the costs of the de-nitrification technologies, the solution of a consortium management should be very interesting, in particular if it is part of a more important strategy for the reduction of energy consumption.

It is possible to use two kinds of treatments:

- The simple nitrogen reduction (chemical-physical and physical-mechanical treatments);
- The transformation of sewage in fertilizers, suitable to be conveniently transported (even for long distances) and sold.

Biogas: an Extra of Sustainability for Livestock Breeding

From the economic point of view, anaerobic digestion plants should represent a new type of profitable income useful to compensate the increased management costs of breeding facilities that derive from structural changes imposed by the “Nitrogen Directive”. From an environmentally compatible standpoint, the valorisation of materials and energy from waste is in line with the EU environmental strategies.

Green “Agriculture” Certificate and “Whole Fixed Rate”

On November 28th 2007 the new Green “Agriculture” certificates have been approved by the Italian Government after conversion into law of the legislative Decree D.lgs 159/2007 (11). It is a type of incentive for electricity production from plants using biomass and biogas as feedstock. Two categories of incentives are anticipated: one if the plate power of the plant is under 1 MW/year and another if the plate power is greater than 1 MW/year.

For plants having a plate power producing more than 1 MW/year, an amount of green certificates will be released equal to electrical energy produced the previous year multiplied for the coefficient 1.8.

For plants with plate power lower than 1 MW/year, it is possible, as an alternative to green certificates, to request a whole fixed rate equal to 0.30 €/kWh. This system is simpler: in this case, in fact, the producer does not need to sell the green certificates on the market.

In both cases, the green certificates will have a fixed validity period of 15 years. Every 3 years, with a specific Ministerial decree, both the multiplication coefficient and the whole fixed rate could be updated.

A Software Tool for Sustainability Evaluation

In order to validate the hypothesis about the economic-environmental sustainability of the biogas plants implementation, is has been necessary to develop a software tool in order to determine the most important values, based on conversion factors either calculated or found in the literature.

The program is made with Microsoft™Excel™, using formulas and some macros that allow the automatic update of the entire program, between different spreadsheets, starting from the filling of a mask with the most significant data of the breeding plant.

The goal was to configure all the characteristics of a plant.

The software system consists of five calculation spreadsheets:

1) *Operational parameters*: this sheet allows the user to insert all the parameters needed to calculate the plant dimension according to livestock heads, the type of biomass used, the number of employees of the plant, the hours a day and the days of the year that the plant should function, the quantity of land to be spread, the different techniques to reduce the nitrogen and a mask in which the user could input the updated values of the green certificates (GC).

2) *Operational calculations*: this spreadsheet calculates the plant operational values such as the quantity of biogas produced the electrical power that should be installed, the amount of breeding dejections to dispose and the extension of soil for disposal with the relative calculation of Nitrogen concentration, before and after the treatments for its abatement.

3) *Economic parameters*: the spreadsheet allows the user to insert some parameters to calculate the taxes of the organization. These parameters are: the legal type of organization and how many stocks options are owned.

4) *Debit*: this spreadsheet allows calculating the rate of an eventual credit of the plant by a loan with constant rates. The user can modify the total amount of the loan that is automatically set on a default value constituted by the entire amount of the plant cost.

5) *Economic calculations*: this spreadsheet resumes, by some key indicators, the economic sustainability of the project. Here some values can be found like activity income (gross and net), investment return time, the ROI, and the BEP[8] (calculated as kWh that have to be produced to complete the return of the investment).

The software tool is therefore divided in two parts: one regarding the environmental sustainability (first two spreadsheets), and the second regarding the economic sustainability (the last two spreadsheets).

It is important to note that the quantification of the conversion factors is set on a cautionary method.

Software Masks Description

In the following paragraph, some particularly significant and parameters amongst the variety used for the operational and economic calculations, will be described. The software masks were structured in order to be adapted both to bovine and swine breeding plants. This paper takes into consideration only the latter category.

[8] Break Even Point

Operating parameters

Heads/units number: in this mask it is necessary to insert the number of fattening pigs bred in the plant. For the purposes of this work, the possibility to have a choice between various types of pigs at different breeding phases (weaning, fattening, …) was not considered as significant.

Type and amount of biomass used: this mask allows the choice between eight different types of biomass (corn silage, grass silage, hay, clover, straw, vegetable corn-stalks, serum and vegetable waste)[9] by a suitable menu. The software tool allows inserting three different kinds of biomass inside the bio-digester. The system recognizes the selected biomass and inserts them in the subsequent calculations (biogas and Nitrogen produced).

Hectares (ha) available to spread the digested material: this card allows differentiating the available-to-spread surfaces, between property surfaces and surfaces in concession. The last ones are divided into vulnerable zones (ZV) and not vulnerable zones (ZNV).

Techniques for the nitrogen removal: in this mask there are three menus from which it is possible to choose the various treatments that could be implemented in the farm for nitrogen removal.

Price of CV and of electrical energy €/MWh: the last mask was inserted to make the automatic calculation of the value of CV for the current year, according to the parameters defined by the Italian law number 244 of December 24th, 2007.

Operational calculations

Average weight of live units present in a stable, expressed in tons (a.w's t.): for swine livestock breeding, a value of 100 kg of live weight was assumed related to fattening pigs.

Biogas produced (m^3/year): quantities of biogas, concerning the swine dejections, are equal to 1,100.5 m^3/ a.w's t /year (12).

CH4 produced: the conversion factor used to calculate the methane quantity that could be produced is assumed equal to 50%. This is a particularly cautionary value with respect to the literature data, which is included between 50 and 80%. The choice of the cautionary criterion is justified because if the system results profitable with this value, it would certainly be convenient also with a higher methane production.

[9] For the choice of the various types of biomass used, it was considered appropriate to consider both dedicated biomass and waste biomass, to handle the volatility characterizing the market at the present moment.

Fitting power: in order to allow the software tool to calculate the various powers, the conversion factors were extracted from theoretical existing data, with a yield of 0.014 kW/pig unit.

Spreading surface required: this mask compares the necessary spreading surface before the treatments for nitrogen reduction with the one required after treatment of the digested material.

Economic parameters

Annual energy production: the produced electric energy is given by the power installed multiplied for the hours of engine work.

Thermal energy: Economic returns, coming from any sale of the thermal energy, are estimated to be about 10% of the total returns deriving from the sale of electrical energy[10].

Engine amortization: the introduction of the paying back (amortization) parameter constitutes an innovative aspect of this software tool, which allows to quantify the costs emerging from the wearing out of instruments and plants and to expect their replacement or updating at the end of the considered period. The fact that the system profitability is not compromised by the cost of this specification (which considerably weights upon the investment return percentage - 20% lowest) shows the economic sustainability of the process and its significant added value.

For the engine amortization case, the resulting cost refers to the purchasing expenses for the co-generation group (1,000 €/kWh of installed power), divided by the number of years of its useful life.

The Consortium Hypothesis

The consortium hypothesis is based on the fundamental assumption that almost exclusively livestock breeding dejections are used for biogas production. It is a choice linked to the need to avoid conflicts that would arise if food crops were used as feedstock for the bio-digester.

The consortia comprise Counties belonging to one province to reduce the possible administrative burden associated with the local authority. The Counties selected where those where the presence of swine breeding was more significant. Moreover, it was decided to select counties where the average facility contains more than 2,000 heads. The few tolerated exceptions were due to the impossibility to form consortia having the characteristics listed above.

[10] Cautionary value (12)

Consortia have been identified based on the following parameters:
- The geographical proximity to the livestock breeding, in order to avoid long journeys of material, which is characterized by a low added value;
- The optimal size for each facility has been identified as not exceeding 1 MW.
- Economic opportunities related to government economic incentives for electrical energy produced by renewable sources for facilities up to 1 MW of installed power;
- Administrative simplification, regarding plants of this size.

A variable for which it was not possible to assume a default value is the number of companies that compose the consortium. However former experiences in the field have shown the ability to successfully manage businesses with a high number of associates.

By applying the dedicated software tool previously described, it was possible to quantify a number around 75,000 as indicative of the heads required to achieve the goal. Within the limits imposed by the state-of-the-art for breeding facilities, this dimension is based on cautionary criteria that take into account the variability of heads present the plants, in terms of numbers and of fattening phases.

Table 6 summarizes the number and features of the identified plants for each province. An interesting aspect of this consortium hypothesis consists in the fact that with a limited number of plants (3 to 9, depending on the size of the sector in different realities) it is possible to intercept the dejection from more than 60% of swine breeding in the area.

TABLE 6

ASSUMPTION OF THE DISTRIBUTION FOR THE CONSORTIA EXAMINED IN 4 PROVINCES

Number of plants	*LOMBARDY'S COUNTIES*	*SWINE BREEDING*	
		Firm (number)	*Heads (units)*
1	**LODI**	27	83,400
2		34	88,934
3		40	98,901
1	**MANTOVA**	23	79,337
2		27	80,823
3		37	81,121
4		21	72,610
5		18	91,686
6		30	73,137
7		29	72,190
1	**CREMONA**	21	83,597
2		44	80,293
3		22	78,968
4		26	81,219
5		23	88,509
1	**BRESCIA**	27	70,024
2		25	69,950
3		20	81,071
4		31	73,503
5		28	80,766
6		45	82,685
7		32	98,287
8		32	85,018
9		33	77,683

Source: Our elaboration on ISTAT data

Using the software tool for a plant with a power plate equal of about 1 MW, it was possible to identify the relevant parameters from the point of view of environmental and economic sustainability.

The produced biogas is slightly less than 8,000,000 m^3/year and taking into account the particularly cautionary value adopted, it is estimated that not less than 4,000,000 m^3/year of methane can be produced, for each plant 1 MW.

It is important to emphasize the positive effect methane recovery for energy production, instead of the normal dispersion in the atmosphere of a gas that, according to the Kyoto Protocol, is one of those responsible of global warming.

In fact, it is possible to imagine a hypothesis of certification for such plants in order to allocate certificates on a voluntary basis for CO_2 reduction (13) (one ton of methane is approximately equivalent to 20 tons of CO_2 equivalent).

These certificates are freely tradable on the international market and can offer a supplementary income for the concerned companies.

Given the expansion of vulnerable zones in 2006, as already discussed, it was considered appropriate to calculate the hectares needed for waste spreading, as if they were working only in vulnerable areas. In this case the area needed for each 1 MW plant is about 4,700 ha. If we look at the number of identified plants in the various counties and compare the need for spreading surface for the waste produced in the consortium with the surface for agricultural use (Tables 3 and 4), there is a substantial compatibility, but with caution because of the increase in vulnerable surface.

It should be noticed that if facilities could adopt systems of dejection treatment, the required land could be reduced to one fourth of that assumed. This is a managerial choice that must be assessed taking into account the investment required for its implementation.

Regarding the economic parameters for a power plant of 1 MW, the capital investment for its construction is estimated at € 3,200,000, while the cost for treatments is less than € 400,000. Depending on the presence or absence of treatments for dejections, the share of investment return will vary from two to three years. At the same time, the ROI varies from 39% to 50%.

Conclusions

The current situation involves a change in perspective about the evolution pathways for the livestock breeding sector, the future of which cannot be linked to the incentives of the European community and of the State and Regions.

The traditional income sources of the sector have not yet gained benefits from certified quality brands: the severe laws in the food area established by the consortiums for production of Italian typical products (Parma ham, Parmigiano Reggiano, etc) implies higher costs for Italian breeders. Unfortunately, not all interested consortiums have been able to finalise the certification of origin at European level. Due to these delays, the price paid to breeders for kilogramme of meat or litre of milk, does not reflect the substantial difference between Italian and imported products.

As previously discussed, the anaerobic digestion of breeding dejections can provide numerous and rapid advantages on the profitability of the livestock breeding sector.

The process has a multipurpose valence able to start real sustainability pathways for the breeding sector. First of all, dejections are re-considered and from refusal become a resource, with positive influences, not only at economic but also at environmental level. Therefore, besides generating benefits to the environment, the whole process reveals itself as fundamental for the economic sustainability of a sector in crisis for a few years.

The anaerobic digestion represents a valid alternative to simple storage and it ensures an increased environmental sustainability to livestock breeding firms. During the process, in fact, a reduction of the emissions of CO_2 and CH_4 (considered among the gases responsible for global warming) is realized. The nitrogen in the digested material is not removed, but it is subject to substantial modifications that produce an ammonia derived form: this chemical state is more efficiently absorbed by the radical plants system and as such is less leachable than the Nitrogen contained in untreated dejections.

The returns, concerning the energy sale (and possibly CO_2 reduction) and the savings due to internal consumption, constitute a new opportunity, in parallel with the traditional livestock breeding activity. At the moment, the new return potentials become determinant because they would allow breeding firms to offset the highest costs deriving from obligations of the "Nitrate Directive".

The biogas plant dimension becomes a strategic element to support the management with an advanced technological characterization. Therefore, a consortium hypothesis was envisaged, based on medium-large dimension plants that could be able to implement new technologies and also aiming at reducing nitrogen in the digested material.

In the case that co-digestion (livestock breeding dejections and vegetable biomass) is implemented, it could be possible to reduce significantly the number of swine heads that produce useful dejections, and at the same time, the surface necessary for spreading.

In the present hypothesis, we chose to valorise breeding dejections, without expecting to add virgin vegetable biomass, in a continuative or massive way, to avoid a series of problems existing in the biomass energy production sector. First of all, it was taken into consideration to avoid the well-known risk of conflict with the biomass "food", linked to the use of soils for agro-energy instead of food crops. We also chose to minimize costs concerning the raw material to be put in the bio-digester, increasing the value of the waste way that becomes a resource.

Finally, the open sustainability problems were considered regarding the vegetable biomass shifting to be destined to energy recovery, with the negative effects in terms of sustainable mobility.

The results highlight a substantial sustainability of the presented hypothesis, and it is necessary to point out the importance of a coordinated intervention by local governments, in synergy with the Regional support, in order to inform, to form and to increase the awareness of the sector operators. The objective is to exploit a resource, without losing the economic and cultural heritage linked to traditional livestock breeding activities.

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