Alternative energy production in anaerobic digestion plant used as disposal technology for poultry and swine manure with a particular attention to the soil sanitization

Reference H2020 call:
WASTE 7 - 15

Project abstract

The growth of poultry and livestock production over the last years has resulted in the problem of disposing of waste, in turn responsible for several environmental troubles (Sakar et al., 2009). Inadequate disposal of animal waste causes severe consequences, such as odor problems, release of animal pathogen agent and impairment of many freshwater and coastal marine ecosystems in the world (Nelson and Lamb, 2002). Due to the fact that the regulatory compliance regarding environmental safety has become more stringent, there is a need to install more effective waste treatment facilities. Composting is the most traditional way in disposal livestock manure. It is characterized by the aerobic degradation of organic waste, taking usually 4-6 weeks to obtain stabilized material. Loss of nitrogen and other nutrients, environmental odors and necessity of available land are the possible disadvantages that may be experienced during composting (Sweeten, 1988).

Another alternative in disposal waste is represented by direct combustion of it providing heating in farm with power generation or combined heat and power. Efficient combustion facilities, such as gas cleanup, able to reduce the waste to an inert residue with a minimum of pollution, are today available (Kelleher et al., 2002). A third way to process manure is the anaerobic digestion played by bacteria able to degrade organic matter from poultry and livestock waste. The anaerobic digestion is used worldwide as possible treatment for industrial, agricultural and municipal wastes. It involves two stages in which the degradation and stabilization of organic material by anaerobic organisms lead to the formation of methane and inorganic products including carbon dioxide (Kelleher et al., 2002). More in detail, anaerobic fermentation is the well experienced process of converting organic waste into biogas energy. Biogas is primarily composed of methane (CH₄) and is typically used in boilers and electric generators to generate heat and power. Biogas can also be refined into biomethane or renewable natural gas (RNG) for injection into natural gas networks. Biogas typically refers to a gas produced by the biological breakdown of organic matter in absence of oxygen and it is composed primarily of methane, carbon dioxide and various other gases. Poultry and livestock manure fit in this process, since it consists of excreta, feathers, and bedding (e.g. sand, sawdust, wood shaving). However its properties may depend on several factors, such as animal age, housing environment, nutrition and category of production (Lorimor et al.2000). Jones et al. (2003) reported that anaerobic digestion does not reduce the phosphorus content of manure, and thus the sludge must be treated in a proper manner. Anaerobic digestion plays a dual role by converting organic waste into stable organic soil conditioners or liquid fertilizers and reducing the environmental impact (Sung and Santha, 2001). Anaerobic digestion could represent a source of renewable energy as methane. In this context, the project proposal will aim at defining a new biogas plant layout to be EU transferred, able to provide an effective technology for the production of biogas from little farms. A particular focus will be reserved to the social acceptability of the technology, highlighting some relevant soil sanitization aspects.

Since the installation of anaerobic digestion plant (ADP), treating animal manures and slurries from farms and increasing use of co-digestion of manures, have raised the need for hygiene and sanitation during operation of ADP.
To this aim, CIRIAF/CRB experience in the biogas energy field, will be used for the project success. 

CIRIAF is an inter-university research which was founded in 1997 by the University of Perugia and University of Roma Tre. University of Florence, Pisa, L’Aquila, Rome “La Sapienza” and Polytechnic of Bari have later joined the agreement. More recently, it has been approved for afference of the University of Pavia, Cassino and Salento. The administrative seat of the Centre is at the University of Perugia. 

CIRIAF’s laboratories at the University of Perugia are one of the main scientific and technical resources of the Faculty of Engineering. CIRIAF scientific board is composed of a number of major academic experts in all areas of interest to the Centre; scientific and cultural areas covered range from Engineering, Architecture, Economics and Agriculture to Medicine and Veterinary Medicine. 

In 2013, CIRIAF incorporated the scientific knowledge and experience of CRB, the Biomass Research Centre. CRB is a National (IT) Biomass Research Centre, founded by the Italian Ministry for the Environment, and it is the result of a project set up by the Division of Energy Systems and Thermodynamics and Heat Transfer, Department of Industrial Engineering of Perugia University. 

The Centre aims at developing and organising national and local initiatives on the use of biomass for energy purposes. The Centre promotes research and experimentation to optimise biomass production, processing and energy conversion in terms of efficiency, profitability and environment. 

The Biomass Research Centre, financially supported by the Italian Ministry of Agriculture and Forestry, has developed in the central Italy an innovative batch prototype plant (Cotana et al., 2013) with a nominal electricity power rating of about 30 kW. Innovation consists in reactors for biogas digestion realized by big polyethylene bags, commonly used for herbaceous storage, reconverted as digesters to reduce costs and simplifying technology, and filled with biomass such as olive husk, pruning, slurry and straw. By the anaerobic fermentation of biomass, activated by slurry from manure, biological processes starts to produce biogas, burnt by an engine for combined production of electric and thermal energy.

**Energy objectives**

- Identification of the optimal characteristics of manure to be exploited in an anaerobic digestion plant (nitrogen, humidity, etc.)
- Definition of the optimal manure characteristics in relation to the management factors (food, water consumption, environmental parameters, animal density)
- Definition of the mass flows of solid residual biomass to be added as complementary to effluents
- Optimization of the collection phases of the residual marginal biomass
- Definition of the more effective co-digestion conditions of both pig and poultry manures for the biogas production.
- Optimization of the anaerobic digestion technology, to be used for energy enhancement of animal effluents
- Investigation of the possibility to upgrade the obtained biogas to biomethane
- Disclosure of the more proper upgrading technologies to be used as a function of the investigated case studies
- Economic assessment of the incentives achievable from electricity and biomethane at European level

**Social and health objectives**
Expected

Detection of possible pathogen organisms, relevant for the Public Health, in the incoming waste and in the digested final product in particular: *Salmonella typhimurium*, enteropathogenic *E.coli*, *Clostridium perfringens* type C, faecal enterococci

- Decimation time of possible pathogenic bacteria in biogas plant during storage in manure holding and in thermophilic and mesophilic digesters, since *Clostridium perfringens* and faecal enterococci display long survival time and great thermostability (Bendixen et al., 1999; Boohm et al., 1999)

- Development of hygiene and sanitation procedures in order to reduce risk related to farm digestion of organic waste mixtures

- Improvement “impact acoustic impact “ mainly due to cogeneration modules and equipment used to minimize noise

- Evaluation of environmental impact (odors) in:
  a) receipt and storage of organic biomass awaiting loading in the system;
  b) treatment and storage of digest product

- Economical evaluation of the common gains in preserving public health

**Relation to the work program**

Our program seems to respond to Societal Challenge 'Climate action, environment, resource efficiency and raw materials' (7-2015 waste). It proposes to assess vantages and disadvantages of techniques in the disposal of wastes of animal origin from industrial production, being a pressing problem. Production of alternative energy following anaerobic digestion of biomass and impact to public health will be considered from different point of view. Even though anaerobic digestion is a century-old process, the adaptation of this process successfully on the commercial scale for producing energy is still evolving especially with regard to the overcoming of problems related to public health. In this regard the detection of pathogens organisms (EU Regulation 142/2011, Annex V, Chapter III Section 3 : standards for digestion residues and compost) in the incoming waste and in the digested final product and emission of environmental odors will be considered. The emission of odor, that frequently occurs in consequence of a poor design or /and construction of plant, or in consequence of inadequate management will be examined together with the evaluation of “noise pollution” according to the *END Environmental Noise Directive* (2002/49/EC).

It cannot be also neglected an economical survey to determine benefits and critical aspects considering a multidimensional approach for efficient use of biomass (electricity, green gas, heat).

**Expected impacts**

- Increased dialogue with European partners and industry in order to compare the method of disposal, from different animals and from different technical disposal

- Transferability of the major outputs of the project at TRANS-continental level, possibly in Asia.

- Increased opportunities for valorization of waste and enhanced competitiveness with new types of source. Our biogas plant was also selected since the farm produces both hog and poultry waste, known able to increase the production of methane *(Magbanua et al. 2001)*

- Improvement livestock management condition to influence the manure characteristics

- Sensitization of population to the utility that animal manure may have not only as a fertilizer but also as a source of alternative energy

- Improved water and air quality: possible solutions to minimize the levels of ammonia in the manure and eutrophication in water

- Multidimensional approach for efficient use of biomass
Project budget
7 M€, as recommended in the call text.
R&I action, funding rate is up to 70%

Project consortium (partner search)
- CIRIAF/CRB University of Perugia (Coordinator)
- Italian Biogas supplier (SME)
- Fraunhofer UMSITCH Unit (to be confirmed)

Searching for:
- EU Energy Agencies
- EU Agencies for the Protection of the Environment
- EU National Authorities e.g. Ministries of the Public Health
- EU SMEs biogas suppliers
- Chinese Third Countries partner, in the role of observer, (to exploit the project results also out of Europe)

Deadline for partner search: July, 15th

Bibliography


