Wastewater treatment plant residual sludge utilization as a potential unconventional energy source

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Abstract

This work is an attempt to describe the advantages, possibilities and INCD – ECOIND results in the utilization of residual organic sludge from animal breeding farms and municipal waste water treatment plants as a potential energy source.

INCD – ECOIND (former ICPEAR) started the research in this area in 1980 under the direction of dr.Craiu, manager of our Institute at that time. At the beginning, we elaborated technology design and building of an industrial biogas plant in Timisoara (1983) with a capacity of 250 m^3. After that we have developed other large industrial biogas plants with capacities up to 1500 m^3, at several industrial breeding farms such as Girov, Veresti, Bacau, Caracal, a.s.o.. After 1989, when the majority of the large industrial animal breeding farms were dismantled, our research was oriented to optimise the anaerobic digestion process of municipal wastewater treatment plants sludges (municipal WWTP's, Pitesti municipal WWTP) and to characterize the fermented sludge in order to evaluate the possibility to use them as agriculture fertiliser (Constanta and Mangalia WWTP's fermented sludge).

INCD – ECOIND's conception is that organic residual sludges will be not only a real renewable source of energy in the future but an excellent agriculture fertiliser as well. Our research efforts are now conducted in these directions.

Introduction

The decentralized approach of system and energy policy reform (sources, technologies, management, social and environmental impact) reckon with the obvious truth that the existing centralized energetic systems are inappropriate, proves (with all notable efforts of the last years) little consideration towards the environment, are not capable to ensure a constant and decent energetic comfort to a great part of the population, recurring with too much easiness to imports of energy resources and being unable to efficiently and effectively take advantage of domestic resources [1]. The obvious alternative would be the decentralized, sustainable approach, by integrating all options having proven economically potential in the local or national energy portfolio, by encouraging local initiative and by rewarding innovation and performance. The ultimate target is the achievement of a sustainable energy infrastructure using mainly renewable resources. This goes together with the development and articulation of a highly efficient energy management system that should optimize resource use and allocation [2]. The long-term result would be the awaited qualitative leap in the quality of life of everyone, yet reducing the aggression and impact on the environment. In this context, energy production and infrastructure would be surpassed in importance by the development of energy services (scenario identification, finding optimal solution, measure to increase energy yields, collecting and valuing of large data bases and information on energy, technical consultancy for customer-oriented energy services, environmental impact, waste minimization, devising strategies at the local, regional and global level, etc.) [2].

Organic sludges from municipal waste water treatment plant and animal breeding farms were considered as undesired wastes that need big storage spaces, and because of their high putrescibility capacity, that generates unpleasant odours and attracts a great number of insects and pathogen agents. In the last time (since the 1970's), consecutive with the energetic crises, these organic wastes started to be considered a potential energy source with great development perspective.[3,4.]. More over, in USA (EPA's part 503 – Biosolid rule) [5], European Union (86/278/CEE Directive) [6] and in Romania (Normative 708/2004) [7] the utilisation possibilities of organic sludges stabilized by fermentation as agriculture fertilisers have become legal matter

Why biogas?

The growing awareness of the pollution problems, like water and air pollution, associated with inadequate management of animal manure and organic waste, emphasizes the need for appropriate solutions to deal with this problem [8].

Biogas is not only a renewable energy source, but also one of the promising solution to the huge environmental problems concerning waste and manure handling, water pollution, CO_2 and CH_4 emission, etc., which is also one of the driving forces for integrating biogas production into the national energy systems. Within this frame, the development and implementation of biogas technologies is seen as a clearly better alternative for organic recycling compared to composting, incineration or land filling [8].

Energy aspects

Biogas is a renewable energy source based on various domestic organic waste resources. Since the oil crises in the early seventies, there has been general awareness that renewable energy technology must be developed. Dependency on fossil fuels must be reduced as future oil crises may occur and world-wide fossil fuel resources become scarce in the long run. Various renewable energy sources should gain increasing shares of total energy consumption. Biogas from manure, organic waste, sewage sludge comprises one of these.

Environmental and agricultural aspects

According to international commitments to reduce air pollution and greenhouse gas emissions, in the future energy consumption must partly be converted from fossil fuels to renewable energy sources. In addition, biogas plants are well-suited for recycling various types of organic waste as long as the waste does not contain elements that may restrict the end use of digested biomass as a fertiliser [9]. Finally, anaerobic treatment in a biogas plant reduces odour nuisances in times of fermented sludge application.

Anaerobic digestion (AD)

Biogas is the result of microbiological processes called anaerobic digestion, in which anaerobic bacteria populations decompose organic matter in the absence of air. During this process, 40-60% of the digestible matter is converted to biogas, which main component is methane [9]. The AD-process takes place in nature, in landfill sites or in biogas plants, inside specially designed digesters, under controlled conditions. When AD takes place in a biogas plant, the fresh feedstock is added to the system as the digested biomass is pumped out of the digester to a storage tank. Biogas continues to be produced in the storage tank. Collection of the biogas from the storage tank is necessary, for economical and environmental reasons, as methane is a powerful greenhouse gas.

Biogas is a CO_2 neutral and renewable energy source and is usually used to produce heat and electricity [9].

The digested biomass can be stored and spread on the fields during the growing season. This can be done without any post-treatment, or the digested biomass can be separated into a fibre-fraction and a liquid fraction. The fibre-fraction can be used as soil conditioner, or composted prior to use. The liquid fraction is a nutritionally defined fertiliser and can be used as a part of a crop management plan.

The scheme of biogas production and utilization is done below (Fig. 1) [2]

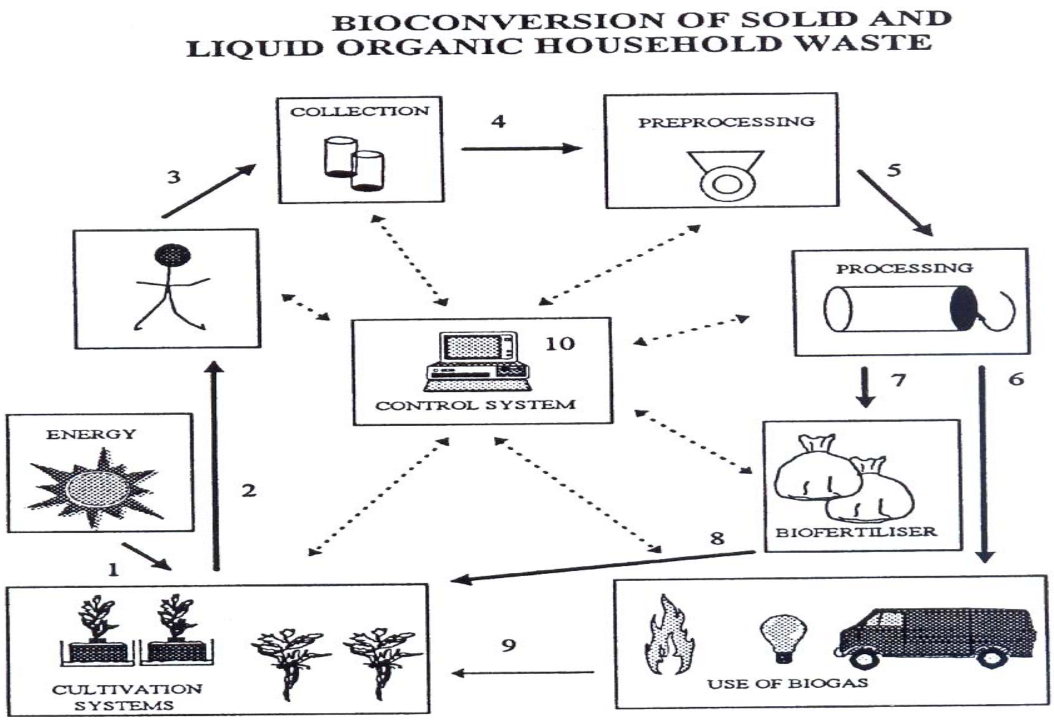

Fig. 1. Biogas production and use scheme

INCD – ECOIND results in biogas production

INCD-ECOIND (former ICPEAR) has great experience in the elaboration of the technology, designing and technical assistance for anaerobic fermentation installation of residual organic sludge from municipal wastewater treatment plant, animal breeding farms and other biodegradable solid wastes. These preoccupation dates since 1980's. Even if the main objective of the researches conducted by ECOIND wasn't bio methane production, but the stabilisation of sludge and other biodegradable organic products in order to eliminate the unpleasant odour and the easy putrescible organic substrate, the possibility to obtain large amount of bio methane was not neglected.

Based upon the technologies elaborated in laboratory and pilot phase, INCD ECOIND has designed, built and commissioned a series of industrial installation for biomethane production, such as: Timisoara (figure 2), Girov, Caracal (figure 3), Veresti, Popesti Leordeni, Oltenita. [10.]

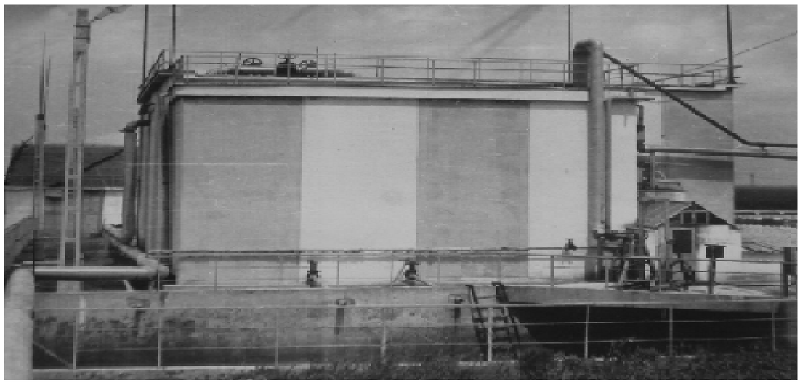

Fig. 2. Timisoara anaerobic treatment plant made of concrete with biogas production, capacity $800m^3$ [10.]

Fig 3. Caracal anaerobic treatment plant made of metal with biogas production, capacity $4x1200m^3$ [10.]

After 1989, industrial animal breeding farms proved to be unprofitable and gradually were closed down. Anaerobic fermentation installations designed and built by ICPEAR were put out of action.

A possible reuse of these installations could be by feeding them from local sources; wastewater manure and sludges from little animal breeding farms developed nowadays, food industry (slaughter houses, brewery, alcohol, milk, canned meat, etc.) residual sludge from municipal wastewater treatment plants.

Industrial biogas plants which have been realised by ICPEAR used the residual wastes and manure from pig, cattle and chicken industrial farms. The main characteristics of this plant's operation parameters are described in Table 1. [10].

Table nr. 1. Characteristics and investment values for industrial installation

Farms Cow Pigs Chicken	M.U.	85 1000 20000	100 1500 22000	175 3000 44000	400 75000 110000	600 10000 150000	1000 18000 250000
Dry matter	kg/day	300	450	900	2250	3000	4500
Volatile matter	kg/day	240	351	700	1750	2340	3500
Work volume	m^3	150	180	360	720	1100	1500
Work temperature	^oC	32	32-37	32-37	32-37	32-37	32-37
Gas volume/day	m^3/day	140	180	360	750	1100	1500
Caloric power	kcal/day	770000	990000	1950000	4125000	5845000	85550000
Self - consumption	kcal/day	154000	190000	310000	825000	1150000	1700000
Daily self consumption	m^3/day	35	36	71	150	200	300
Available gas volume	m^3/day	105	144	285	600	900	1300
Gasometer volume	m^3	70	70	140	200	500	500
Informative price	US$	45.000	55.000	70.000	110.000	160.000	260.000

Therefore, INCD-ECOIND wishes to develop a project, under CEEx Programme, to involve local/regional authorities in the resuscitation of biogas producing installations built by ICPEAR in the former industrial animal breeding farms.

This project proposes the next objectives:

- Evaluation of the working state of the existing installations;
- Evaluation of the collection and transport possibilities of the feeding material (inventory of the possible biodegradable organic matter sources from the adjacent area);
- Elaboration and dissemination to local authorities and media of a feasibility study concerning the possibility of using organic biomass as a renewable energy source (biogas);
- Commissioning and operation parameter studies of the biogas installations.

Conclusions:

Identification and valuing of all renewable energy sources, in the perspective of a future EU member should become top priority in the Romanian infrastructure policy.

The contribution of renewables in Romania's energy portfolio should align to the EU one in a matter of several years.

This can be done by taking advantage of the existing experience in the field, of which the present paper is a good argument and ECOIND an important depository. There is important know-how and background information to set up a sound renewable energy sector, based, among others on waste.

Existing facilities should be re-engineered and new investment in the field should be encouraged in order to accelerate the implementing of new technologies in biogas generation.

As the final objective of every new industrial development should be "zero-waste", bio-methane generation in municipal wastewater treatment facilities should be accompanied by a more comprehensive approach that may include the use of different wastes in fermentation (industrial, agricultural, domestic) and composting of the residual solid in order to deliver it as a valuable fertilizer.

Our appeal goes to all interested parts (industrial companies, farms, local administration) that should start work together immediately in order to establish a coherent policy in the field of wastewater sludge use as a valuable energy source.

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