Promoting Small Scale Anaerobic digestion systems

Santino Di Berardino, LNEG, Alexis Chatzimpiros and Olga Bourka, EPTA

1. INTRODUCTION

Current management Organic Wastes procedures involve considerable expenses in collection, treatment and disposal, to attenuate negative and harmful impacts on the environment. Otherwise organic wastes contain considerable and valuable chemicals compounds and energetic and fertilizing properties which are lost in land filling or incineration, without any profitable use or valuable income of its potential. This management model is already recognized as inefficient and unsustainable and a change toward a better style of life and sustainable growth is under promotion. This requires a change of mentality of all the people in relation to wastes, an evolution of attitude on use of natural resources and implementation of more efficient procedures for waste separation, recovery and recycling of relevant components.

Anaerobic digestion is a recognized powerful technology for organic biodegradables waste treatment, both in liquid or dry form, generating a methane rich biogas and a stabilized digestate. Its application, if combined with digestate in land application or composting, provides several benefits in terms of Renewable energy production, waste treatment, greenhouse gas (GHG) emission and fertilizer production. This process was initially applied as single substrate technology, for sludge stabilization or animal wastes or industrial effluents pre-treatment, but quickly expanded to the concept of co-digestion, a solution that looks at profiting synergies from wastes, by the mixture and joint degradation of more substrates.

Codigestion provides chemical, biological, technical, economic and operational advantages: is less expensive than separate solutions, allows preparation of a feedstock with an equilibrate or improved composition, increases the scale of the system, can facilitate overcoming inhibition problems and may even improve degradation efficiency, resulting in a higher gas yield (Ahring *et al*.,1992). Furthermore, this process generates a large quantity of biogas which can be converted more easily in corresponding amounts of electric energy and surplus heat.

Compared to the sum of separate digestions, codigestion reduces investment and ecological footprint and can solve the treatment of seasonal discharged specific organic wastes, like olive oil mill effluents, which contain organic compounds hardly biodegradable alone (long-chain fatty acids) and phenols, some of them inhibitory of biologic processes (Di Berardino, 2006). Compared to composting reduces greenhouse effect.

Codigestion application can profit existing structures treating different basic substrate, namely: Sludge, industrial wastes, solid bio waste, manure digesters etc.. This option can make anaerobic digestion a more feasible solution, especially in decentralized regions, when not enough biogenic waste for the construction of manure or bio waste based digestion plants, is available.

In Table 1 is reported the data from exploited energy production in Europe (Biogas Barometer 2003-2008), showing the evolution of energy production from biogas. Landfill biogas has been and still remains the main source of energy from biogas, but its evolution is uncertain. In next year the biogas produced from others wastes (Industrial wastewater anaerobic Treatment plant, agricultural biogas plants, municipal waste digesters and collective co digestion facilities), will be the major source, according to the sharp increase observed in the last years.

Table 1- Exploited energy production from biogas in Europe in 2001-2007 (KTEP)

year	2001	2002	2003	2004	2005	2006	2007
Landfill gas	-	1026,8	-	2 813,8	3 172,7	2700,3	2905,2
Sludge digester gas	-	911,5	-	922,9	932,4	867,8	887,2
Others sources	-	823,7	-	540,5	854,0	1330,8	2108,0
Total	2 596	2 762	3219	4 277,2	4 959,1	4898,9	5901,2

The digested residue has good fertilizing properties. Contains most of nutrients constituent of the feedstock (phosphorous, nitrogen, sulphur, and potassium compounds, etc..) in a reduced chemical form, which is easily uptake by crops. The reuse of this effluent in selected agricultural crops is a quite valid option, when contains low level of toxic compound. The mixture of wastes, sludge and agricultural wastes can be optimized in order to provide optimal C/N ratio.

In recent years the applications of anaerobic digestion has been widened by addition of energy crops for biogas, in some European countries, (Germany, Austria, Sweden, Denmark etc.), where this concept has been easily accepted and put into operation (Biogas barometer 2007), promoted by benefits from overproduction of food products by the agricultural sector, high fuel price and favourable feed-in tariff. Agricultural practices are integrated nearby the digestion facility, alleviating the waste treatment problem, allowing closing the nutrient cycle, avoiding additional waste treatment and disposal of digestate and producing more biomass to increase the biogas production. This way, the treatment of animal waste slurry and energy crops in co-digestion for biogas production has become cost-effective, justifying the large increase of digesters facilities, fed with many sources of available feedstock, from municipal bio waste to energetic crops.

With respect to energy crops it can be applied as a single substrate in mono-digestion or as mixed feedstock. Numerous full-scale biogas plants are in operation and digest mainly maize silage, sorghum, whole crop cereal silage and mixtures of other energy crops.

The application of digestate to food or to rapid growth of high-yielding energy crops (maize, energy maize, sunflower, wheat), has a strongly monthly variation and requires high storage capacity. Long time storage improves sanitary conditions. This formula, associating maize production to digester system has been widely implemented in Germany but, since 2007, the strong increase in the world of price of cereals (maize) and of the capital cost of digesters has decreased substantially the rate of growth (Biogas barometer 2008).

According to the De Baere (2007) energetic crops (maize) for anaerobic digestion provide as much as 75 GJ/ha of net energy output. Anaerobic digestion provides at least 2 times higher energy yield than biofuels from wheat and rapeseed and, at least, 3 times more net energy output, making biogas a favorable option as fuel for transportation.

Another possibility is the application of digestate in multiple harvesting plants (green plant silage, grass, winter wheat, etc.). In Sweden cultivation of ley crop for energy purposes has been proposed. This crop fixates nitrogen into the ground, enhancing the structure and production ability and providing an increase in the nitrogen supply to the soil. Reduces also the need for costly fertilization, improves the physical properties and nutritional status of the soil and facilitates soil management. This crop provides less energy yield output but minimize storage requirements. One hectare of land used for ley crop produces about 16,5 Ton/year of biomass with 35% Dry solids (AGROPTI-gas, 2006). The digestion of this substrate can produce enough methane to generate ca 20 MWh·year$_{-1}$ of energy, as referred by Nordberg (2001).

Moreover, the use of ley crops for anaerobic digestion contributes in a number of ways to the development of a sustainable agricultural production system. Solve problems with plant pathogens and insects owing to the more varied crop rotation, thereby reducing the need for pesticides, as well as the environmental and economic costs associated with their use (Nordberg, 2001).

When no agricultural land is available close to the facility and it is unviable to associate agricultural crops to anaerobic digestion, a highly recommendable alternative solution can be composting. Processing the digestate by this process allows more easy storage and transportation as well as provides better safe and hygienic product. Otherwise this solution implies additional capital and operational costs and its revenue are strongly dependent from the market demand, making uncertain its cost-effectiveness.

2. SMALL SCALE IMPLEMENTATION.

Anaerobic Digestion of residues is a solution that can be favourably stand-up, once are previously defined the ways and modalities of the biogas utilization and the treatment/valorisation of digested residues, eventually to be applied in local agriculture. The financial success of a biogas plant results from the scale of operation, the biogas yield, the quality of the applied substrate and the process engineering. It is high capital cost solution and the system must be very well exploited to give rise to positive results. For this reason the system implementation must be supported on clear and established valorisation lay-out, adequately connected to the adequate existing legislation.

Anaerobic digestion is today a popular and successfully solution at average-high scale facilities. Successful implementation of small scale anaerobic digestion systems is more difficult and requires appropriate strategy and considerable changes in residues management. Its operation is heavily influenced by cost and technological requirements, associated with the construction, operation and maintenance of the facility. A number of not technical and technical barriers have to be overcome.

Anaerobic digestion technology commercially available is still expensive. Simpler and more accessible technological solution should be developed for small scale implementation. This is a serious obstacle to anaerobic digestion diffusion. But this limitation can be overcome by adequate planning strategy and measures. As focused by Spinosa L. (2008**)**, the management of sludge, bio-waste and any other organic wastes, generally carried-out by two or more different companies, which have distinct responsibilities and use different disposal solutions, should be ensured by a single company, collecting all the locally available organic wastes.

The co-digestion of organic wastes with sewage sludge using an existing digester can provide a number of financial and environmental advantages over conventionally operated AD plants. By this option, more organic waste will fed the anaerobic digestion system, increasing the scale of the facility. It will significantly reduce capital costs and provide also a better control condition of the biologic process, and of in land digestate application, making possible significant economic and environmental advantages. The exploitation of existing water or solid waste company asset base provides good operational and management conditions for quality control, application and reuse of the principal by-products of the process: biogas and treated residues. Combined anaerobic digestion generates more biogas for electricity generation in CHP plants. This co-treatment scheme will provide an additional waste management strategy for the achieving EC Landfill Directive targets, providing that a market is established for the digestate. Due to these potential advantages, this option should be promoted by specific and appropriate financial schemes.
The organic solid waste should be source separated, specially the “wet” fraction, in order to reduce collection and pre-treatment costs and provide better quality of digestate for agricultural purposes. The Directive 1999/31/EC defines target concerning the reduction of biodegradable waste in land filling. Priorities for waste recycling are defined in the revised Waste Framework Directive.

However source separation target can be hardly fulfilled in countries with low solid waste material recovery in short time, unless a number of EU legal instruments are available, stimulating this practice. This prerequisite constitutes an important technical and not technical barrier.

In case where source separation is not implemented, anaerobic digestion of solid wastes imply the installation of a mechanical treatment for sorting the different SW fractions. This solution is expensive, difficult to be feasible at small scale and separates a bio waste with poor quality for agricultural purposes. In small scale community should be easier to implement a source separation collection, by involving local population by adequate information and educational campaign.

The digested residues valorisation and it integration in surrounding territory for food or energetic crops is a key factor for a successful co-digestion, requiring incentives for revitalizing agriculture application. Residues from food crops and the energetic crops are usable digester feedstock, increase the scale of the facility and the entire system can be tailored in order to obtain higher biogas production and more valuable fertilizing products.

In any case, depending on the co-substrate properties, an available digestion system can be equipped with adequate pre-treatment facilities and modified, in order to accommodate the additional substrate. The food or energy crops associated to waste treatment can difficult generalization of system adaptation. The inherent technical hitches must be solved case by case, due to the great diversity of substrates.

In table 2 are listed the additional pre-treatment or the modifications which can be necessary in co-digestion units, accommodating additional substrates. In some specific case can be justifiable the change of digester technology, from liquid to solid state digestion or vice versa.

Table 2: Pre-treatment and modifications necessary for co-digestion of waste

Type of Co substrate	Pre-treatment necessary	Eventual Modification of Digestion system if available
Solid Waste	Removal of big components (stones, metals, wood etc..), sieving, Maceration, removal of inerts, mixing and Homogeneization	Hydrolisation-acidification step Prevention of foaming and scume layer formation, Removal of sediments, hygienisation. Termophilic operation
Manure, liquid waste and sludge	No pre-treatment,	Increase of mixing capacity, hygienisation
Bio-waste source separated	Sieving, Maceration, removal of inerts, mixture and homogenization	Hydrolysis-acidification step Prevention of foaming and scume layer formation, Removal of sediments, hygienisation. Termophilic operation
Energetic crop	Sieving, Maceration, removal of inerts, mixture, homogenization	Hydrolisys-acidification step, additional post treatment of digestate. Termophilic operation
Industrial waste	Specific pre-treatment to prevent toxicity	Prevention of foaming and scume layer formation. Hydrolisys-acidification step.

Unless concept of co digestion plant is fully understood, there are a number of different reasons that this simple and efficient solution is not more frequently implemented at small scale. Some drawbacks of anaerobic co-digestion make difficult larger implementation. It is a high capital cost investment, requires a collecting system and cooperation between several entities. It also concentrates large quantities of residues that have to be treated and disposed properly or have to be inserted in a nutrient recovery system. The whole system must be very well designed and operated in order to generate some economic return.

Another difficulty may be found in the fact that co digestion presents also non technical hitches, concerning administrative, regulatory and market barriers, requiring that different parties, such as municipalities, constructors, people of administration, farmers, waste producers and waste collectors, population involved, etc., have to talk to each other and to work together. For this reason, successful implementation of small scale system requires appropriate strategy, planning and actions as well as considerable changes in residues management and local community involvement.

3. BIORES PROJECT DESCRIPTION

The environmental and energetic benefits of small scale biogas plants associated to nutrient recovery and reuse management scheme are so evident and attractive that E. C. programs are promoting seriously demonstration projects to increase dissemination.

The BIORES project (www.biores.eu) "Reinforcing Investments in biogas technologies for small-scale RES applications in islands", is co-financed by the Intelligent Energy - Europe programme of the European Commission, aiming at promoting the implementation of technologies for energy polygeneration, based on biogas derived from waste in European islands, which usually have insufficient energy resources. It also links with the energy needs of end-users of island communities and promotes small-scale decentralized energy production from renewable energy sources and sustainable waste management. As practical result, the volume of disposed waste in islands is expected to decrease.

The project addresses two important issues faced by islands: energy dependency from the mainland, and waste management.

The project aims to facilitate investments in energy production from biogas derived from waste by providing technical and administrative means, including a Decision Support System (DSS) tools to potential investors and local authorities, to contribute to increase the decentralised energy production, the green electricity's market share and to decrease the islands' energy dependency on fossil fuels and on the mainland.

The work is focused on 6 European islands, namely Samos (Greece), Samsø (Denmark), Sardinia and Tremiti islands (Italy), Porto Santo (Portugal) and the Outer Hebrides of Scotland.

During the first phase of the project, the existing potential of European islands for exploiting biogas derived from waste, as well as their energy end-use needs, have been assessed. In addition, all the technologies based on biogas derived from waste already successfully implemented in European islands were identified. Finally, the benefits from the implementation of these small-scale RES technologies are under analyzed and dissemination to local communities.

The program of the second phase was directed to the identification and analyse of non-technical administrative, regulatory and market barriers, regarding the penetration of biogas technologies in the market, as well as best practices for overcoming non-technical barriers. On this purpose, it was identified that the biogas market, has small and big actors, not linked together, requiring more involvement of the commercial actors. Biogas is a mature technology but it requires the necessary critical mass in order to penetrate the market. There is a need for stability of the legal, institutional and policy framework for the creation of a positive environmental investment. There is a need for packaged solutions in order to improve plant reliability and acceptance by the key actors and the public at large and decrease costs. Key market players of the biogas industry in Europe need to join forces in order to develop a strong position and send out a clear message about the importance of biogas.

Finally, during the third phase, an evaluation methodology for the detection of the most preferable technology will be developed and the perspective financial mechanisms and tariffs will be assessed taking into account a number of parameters and special characteristics of each specific area. The DSS tool for selecting the most preferred technological investment in RES, prepared on behalf of this project, and the respective Training on its use will be offered to local authorities, so that they would be capable of using it after the end of the project.

Project activities are being accompanied by dissemination actions for the diffusion of the project's objectives and results, as well as for raising awareness on environmental issues at local level.

In this research project SWOT analysis was applied to detect and define NTB's regarding small scale future biogas investments in islands. The analysis and deliberation were designed to identify ways in order to take advantage from factors that are considered as strengths, to exploit and optimize factors that appear as opportunities, to minimize the impacts of weaknesses and to protect against threats.

The expected results are the ranking of awareness at local level in order that local communities support biogas technologies, the achievement of environmental, energetic, socio-economic and market benefits, the preparation of on-line decision support system for local and national authorities and investors to identify the technologies and financing mechanisms and feasibility and the identification of appropriate technologies for each region

4. PORTO SANTO FEASIBILITY STUDY

4.1 Introduction

The islands are isolated systems with, usually, limited land availability, insufficient energy resources, and variable touristic populations, which cause a dependency from mainland and increased costs. In this framework small scale biogas systems can find a more favourable ground for its implementation. Within this the objective the Porto Santo island was chosen as a case study for evaluating the feasibility of implementation of biogas system derived from waste, detect the non technical barrier and validate the DSS tool.

The feasibility study concerning the possibility of implementing an anaerobic digestion system and biogas production and use in Porto Santo Island, was based on all the locally available organic wastes, and identified several environmental, economic and social benefits, as well as some technical and not technical hindrances.

4.2. Organic wastes available in the Porto Santo Island

Porto Santo is a small Island accounting with a resident population of 4500 habitants and a touristic population of about 10 000 habitants, in summertime. The main sources of organic wastes available in Porto Santo, as depicted in Table 3. are the municipal solid wastes, the sludge from the WWTP and the green wastes from gardens green areas.

Table 3: Porto Santo organic wastes availability

Kind of Residues	Minimum monthly amount tonnes/month)	Maximum montly amount (tonnes/month)	Yearly amount (tonnes /year)
Organic solid wastes (Biowaste)	70	150	1080
Sludge from the WWTP	45	110	740
Organic material from gardens	32	60	550

All the collected municipal solid wastes are shipped to the incineration plant of Madeira. The other relevant waste available is the sludge from the local WWTP which, due to its high humidity, is putrescible and not suitable for incineration. The green residues from gardens also have not a locally profitable use, being sent to incineration. The chemical, biologic, energetic and fertilizing potential of the residues are not recovered and valued. In this context, has been identified some feature which are in favour of implementing a Biogas production facility to solve existing environmental problems.

The island waste and sludge treatment and disposal are today under the responsibility of only one company, which facilitate an integrated and optimized management approach and can avoid overlapping.

The available sludge for the anaerobic digester is produced in the local Wastewater Treatment Plant (WWTP), which is based on biologic nutrient removal and is not provided with primary sedimentation. The excess sludge from this treatment is partially stabilized by the aerobic/anoxic processes and is chemically conditioned and dewatered. An adequate disposal solution for this sludge is still unavailable, being dumped in land filling and generates nuisance and bad odours. The company in charge for the management of the wastes is looking to apply a favourable solution, by mean of solar drying or gasification. Anaerobic digestion with biogas production based on this sludge can be an alternative in this case, but the expected biogas production can be smaller, compared to anaerobic digestion of conventional mixed sludge, making less profitable the biogas exploitation.

Joint treatment of sludge with the island bio waste increases the scale and can fulfil the necessary critical mass, but source separation of municipal solid waste is still scarce, and corresponds at about 11 % of the total amount and the quantities of available biowaste are scarce. In this context source separation of bio wastes is a necessary prerequisite for the biogas project implementation. This procedure is also a recommendable option, allowing preventing sanitary problems during, handling, storage and transportation of the municipal solid wastes, by marine ship, to the incinerator in Madeira Island. The segregation of “wet” bio waste improves incineration and reduced the quantity of land filled cinder.

By joining all the available waste, the resulting total quantity is, still, relatively small and does not provide adequate scale economy for the digester facility.

4.3. Fertilizer production and application

The digestate from AD facility must be disposed in the island territory in order to avoid the additional costs in transportation and further treatment in Madeira. The digested product has very good agricultural fertilizing properties and the most convenient solution is the direct application in forestry or agricultural land, for fertilization, or in degraded land areas, for soil restoration and biomass production, thus avoiding any additional final treatment (composting or drying). This way, a correct, good and safe in land application of the sludge, minimizing pollutant impact, can be implemented, after defining the areas where the application does not provoke any environmental problems.

Land territory of Porto Santo (figure), is mainly occupied by forest trees (350 ha). Agriculture represents a small activity in the island. Irrigated land corresponds to 62 ha (14,4%) and dry land to 20 ha (4,6 %). A portion of the territory of the island, mainly in the central part, is constituted by arid limestone based soil, which have not a profitable use and is degraded. A part of this territory, about 50 ha, can be eventually used for sludge disposal and new crop activity.

Using a simplified sludge management tool, in terms of residues land application and quantities of macronutrients added, a preliminary selection of areas where the digestate can be safely applied, established that the limiting nutrient compound for application is nitrogen, which is present at high level in the sludge, requiring about 270 ha of agricultural land to receive safely the nitrogen load. Phosphate and potassium contents are also quite high, but require less area for application. The market value of these fertilizers is quite high (Specially Potassium compounds), representing an interesting economic return, if applied to adequate local crops.

The locally available agricultural and forestry area are enough to receive the digested waste. The digestate can be spread to grape fruit and others food crops and in forestry. It is also possible to develop energetic crop in the degraded and eroded territory, which can improved by nutrient application. Based on preliminary evaluation seems to be possible to use 50 ha of this degraded soil land area, to produce endogenous grass for energy purposes and soil stabilization.

Table 4: Land area necessary for digestate application

Nutrient contained in the sludge	Annual Production (kg/Year)	Land area necessary for application (hectars)
Nitrogen (N)	21600	270
Phophate (P_2O_5)	3300	130
Potassium (K_2O)	3000	30

The availability of nutrients and application in adequate crops, can contribute to revitalize the local agriculture and to stimulate new initiatives.

4.4. Expected Energy production.

The average composition of the Porto Santo wastes allows the production of the energy reported in the following table 5. Moreover, if the fertilizing digestate would be applied to the degraded soil land area, to produce endogenous grass, with equivalent properties of the ley crops, it is possible to increase the producible energy and the scale of the digester, according to the values of referred in column 2 of table 5. The biogas can be used in a cogeneration unit for the combined production of electric energy end heat.

Table 5: expected energy production by anaerobic digestion

Energetic Product	Anual production From waste	Annual production from grass energy crop
Biogas (m^3/year)	200 000	400 000
Methane (m^3/year)	130 000	260 000
Electric Energy (MWh)	450	750
Heat (MJ)	2400	5000

Based only on the available wastes the plant can satisfy about 1,2 % of electric energy demand of the Porto Santo island (34,5 GWh, em 2005), or 3,5 % if energy crop are produced and used.

The electric energy can be produced in a cogeneration plant equipped with two motor-generators with 80-150 kW of electric power, connected in peak electric energy demand, in order to contribute to improvement of the island electric energy balance. The heat obtained from the engine can have several uses, according to the localization of the central biogas plant (heating/cooling of hotels, houses, swimming pools or greenhouses).

4.5. Economic balance

The economic benefits obtainable from the biogas plant are summarized in table 6. The more relevant revenue is obtained from avoiding the transportation, treatment and disposal cost of the organic waste to Madeira. Based on price of electric energy from biogas fixed by the national legislation, the electric energy plays a secondary role. The values from heat recovery and fertilizers have been evaluated at 20 % of the marked price, once are products strongly dependent on local demand.

Table 6: Preliminary economic balance of anaerobic digestion

Product	Income (€/year) Waste treatment	income (€/year) energy Crop
electric Energy	42 500	85 000
Heat	13 500	27 000
Fertilizers	20 000	-
Reduction of transportation and incineration costs	105 000	-
Total	181 000	112 000

The energetic crop can provide an additional annual income of 112 000 euro from the electric energy and heat selling, which seems enough to finance the cultivation of 50 ha of land area for energy crops production.

The necessary capital to invest is evaluated about 1 million of euro, but avoids investments in the additional sludge treatment (drying) evaluated about 500 000 €. In this context the economic incomes seems allowing a payback period evaluated in less than 5 years, according to agricultural options and opportunities. From a macroeconomic pointy of view, the Project will contribute to create added regional value and reduce the use of imported fossil fuels.

4.6. Environmental benefits

The environmental benefits can be resumed as follows:

- Reduction of emission of CO_2, NOx, SOx e CH_4 to atmosphere due to substitution of fossil fuel by biogas, for the production of electric energy end heat.
- Attenuation or elimination of smells.
- Improvement of the hygienic and sanitary conditions during residue handling and transport to the final disposal.
- Reductions of storage and of the number of trips between islands. Improvement of incineration plant burning performance. Reduction of 360 ton/year of land filled cinder from biowaste.
- Resolution of disposal of the sludge from the WWTP.
- Promotion of an improved environmental figure of the Porto Santo Island.

4.7. Social benefits

Implementation of a sustainable system, which utilize the local wastes as renewable endogenous resource for energy production, promotes an environmental conscience and awareness in the island population and visitors.

The project also increases local employment, improves touristic attraction and encourages the agricultural and territory defence practices. It also stimulates participation of the local community in the solution of the problems of his wastes, contributes to implementation of selective collection of the urban solid wastes and uses of the market for green energy to obtain carbon credits, constituting an opportunity to set-up a new and more profitable socio-environmental structure in the Porto Santo Island.

5- CONCLUSIONS

Small scale application of anaerobic digestion and waste valorisation on agricultural crops can be a feasible solution can since technical and not technical barriers are overcome and favourable conditions are presents. Waste management must be optimized in order to collect all the locally available organic sources, to increase the scale of the system and enhance the economic revenue.

Biowaste must be preferably source separated, thus avoiding expensive mechanical pre-treatment and improving the quality of the substrate. This prerequisite can be difficult to implement.

Existing digester should be used for co digestion, in order to save on capital costs, minimize operational requirement and improve economic balance, unless can require additional pre-treatment operations and processes and modifications of the digester system, to accommodate more wastes.

The companies in charge for water and waste treatment and disposal should be integrate its waste activity in order to maximize results, ensure coordinated management and operation, profit existing structure and avoid overlapping. Digestate application and recycle in agricultural energy crops, increases the scale of installation and can stimulate local agriculture practice and employment.

This strategy can provide the necessary critical mass, but its feasibility depends from a number of technical and not technical factors which can enhance its applicability. On this regard, the Biores project pretends evaluate technical and not technical barriers and prepare a decision support system tool, to facilitate small system biogas implementation, in European islands.

The feasibility study carried-out in Porto Santo Island showed that by implementing a Biogás production facility from residues and a sustainable waste recovery and reuse in agriculture, can be feasible, and can help to fulfil interesting socio-environmental targets and social benefits. Economic incomes are significant, allowing a pay back period evaluated in 5-8 years. But successful operation requires source separation of organic solid waste, the involvement of population and strict cooperation between different parties, as well as willingness of the people in charge for waste management.

References

Agropti gas (2006). *Vaxcraft project in Vasteras*. Report of EU demonstration project within the 5th framework program.

Ahring, B., Angelidaki, I. and Johansen, K. (1992). *Anaerobic treatment of manure together with industrial waste*. Wat. Sci. Tech., 25(7), 311–318.

De Baere, L. (2007). *Start-up of continuous dry digestion plant of energy crops*. International Conference: Renewable resources and biorefineries. Ghent, Belgium, June 4-6, 2007.

Santino Di Berardino (2007): *Implementation of Codigestion and sludge management system in Portugal*. Water Practice & Technology © IWA Publishing 2007 - doi10.2166/wpt.2007.017

Nordberg, A., Edström M. (2001). *Co-digestion of ley crop silage, straw and manure*, homepage2.nifty.com/biogas/cnt/refdoc/whrefdoc/d1codig.pdf.

Systèmes solaires – *Barometer of Renewable Energy 2003* . 2003

Systèmes solaires - *Biogas Barometer*. Le Journal Des Énergies Renouvelables n° 162– Aug. 2004, n° 167– Jun. 2005, n° 173– May 2006, n° 179– May 2007 and n° 186. – Jun 2008

Spinosa L. (2008): *Co-management of sludge with solid waste: Towards more efficient processing*. Water 21 –IWA Magazine, Dec. 2008 pp21.