AN ADVANCED EXAMPLE OF ANAEROBIC-AEROBIC INTEGRATED SYSTEM

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SUMMARY: ACEA is a modern Italian multi-utility company, which currently provides services for Municipalities, private companies and citizens. In the environment sector, ACEA manages the entire waste cycle from waste collection, street sweeping and cleaning to the development and management of different waste treatment plants (including an ISO 14001 certified landfill and an ISO 14001 and 9001 Composting plant). The Waste Treatment facilities of ACEA Pinerolese Industriale S.p.A. has been realised with the main intent of achieving an environmentally correct management of solid waste. By means of advanced technologies the plant increases the possibility to make use of renewable energy (through anaerobic digestion), and soil conditioner (through composting), with the consequently reduction of waste material in landfill. The entire process is based on the connection of four different treatment plants (anaerobic digestion, composting plant, wastewater treatment plant and a landfill), where both anaerobic and aerobic digestion take place.

1. INTRODUCTION: KEY FACTORS IN CHOOSING ANAEROBIC-AEROBIC INTEGRATED SYSTEM

The existing technologies and the high-profile know-how reached in a 30 year experience in the field of Municipal Solid Waste management are the basis and the peculiar factors which led to this technological device.

The anaerobic-aerobic integrated system represents a very advantageous solution for the organic fraction of the municipal solid waste, the key factors that have driven the initial choice are:

- production of renewable energy,
- easier control in odour emission of the integrated process compared to the simple composting process;
- less surface area needed per treated ton compared to the only compost solution;
- less ton entering the aerobic phase, as a second step of the process, compared to an only-aerobic treatment;
- high efficiency in recovering both material (compost) and energy (biogas);
- reduction of organics going to landfill (EU-directive);
- less environmental impact compared to an only-aerobic treatment.

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Figure 1. ACEA Waste treatment facilities, Pinerolo Ecologic district

2. ACEA ANAEROBIC-AEROBIC INTEGRATED SYSTEM

2.1 The anaerobic process

The two main features of the anaerobic digestion process implemented by ACEA are:

- Medium solid system: 10-20%, with TS 10 - 12%
- thermophilic and discontinuous system

The process is based on two digestion treatment lines following a first unique line, where a mechanical pre-treatment takes place. The digestion process flow-chart is shown in Figure 2.

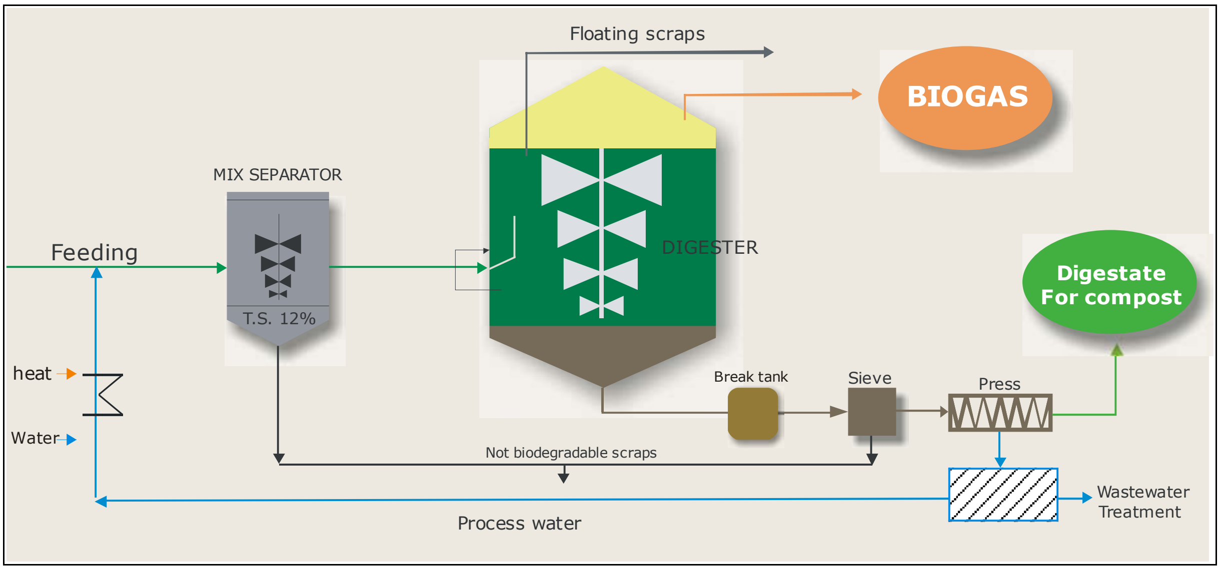

Figure 2. Anaerobic Digestion Process Flow-Chart

The organic waste entering the plant is first shredded, by means of a bag opener. This is a very light mechanical treatment, followed by a disc screen, which separates the plastic of the bags from the organic matter. After dimensional reduction, the organic material is transported further to the mix separators (180 m^3 capacity), where water and steam are added to obtain the correct dilution (TS).

Once obtained the wanted mix, in terms of temperature (about 60 – 65°C) and of solid content (TS = 12%), the matter is fed to the digester (2600 m^3 capacity). Each digester is insulated, but not heated and it is equipped with a mechanical agitation system combined to a biogas injection system. The gaseous mixture (Biogas) released from the anaerobic digestion, the biogas coming from the landfill (which is connected to the area by a 3 km long piping system) and from the wastewater treatment is first stored in a gasometer of 3300 m^3. It is then used in 2 heat engines (2,1 MWe total electrical power), after a proper thermal treatment for condensation of dangerous components (by means of a chiller).

The heat recovery system produces both diathermal oil from exhaust gas of the engine for steam production and hot water. Electrical power supplies the three plants and exceeding energy is sold to Electrical Network. The waste heat is used to warm the digesters and the sewage treatment plant and also to heat the adjacent buildings. The cogeneration plant is IAFR (authorized plant to use renewable resources) certified and obtained the Green Certificates and also the Energy efficiency title (TEE Italian mechanism). Due to the availability of excess heat, it has been planning a District Heating system for residential and commercial requirements that will be in operation for October 2008.

The digestate, the second by-product of the process, is first treated in a dewatering station and then led to composting plant for producing a soil conditioner (the compost produced by ACEA – known with the trade mark Florawiva® – obtained in 2005 the "Quality Label" of Consorzio Italiano Compostatori)**.** About 30% of the waste water is reused, while the remaining part is led to the sewage treatment plant. All the required water for the anaerobic digestion is provided by this structure.

2.2 The aerobic process

The composting process takes place essentially in two phases:

- Bio-oxidization, in which the mass is cleansed by means of a traditional "platea insufflata": this is the active phase, characterised by intensive processes of degradation of the organic components which can be broken down more easily (www.compost.it). The bio-oxidization takes place in about 28 days. The area is closed and equipped with a polluted air capturing system, connected to a biofilter.
- The maturing process, during which the product becomes stable and enriched with humic molecules. This phase is characterised by processes of transformation of the organic substance, the maximum expression of which is the formation of humic substances. (www.compost.it).

The raw materials entering the composting plant are basically three: sludge from the waste water treatment plant, digestate of the anaerobic process and the pre-selected "green waste" from the collection sites and private Citizens and company.

The compost is produced in accordance to law nr. 217/2006 and obtained the Quality Label of Consorzio Italiano Compostatori. The composting plant is ISO 9001:2000 and ISO 14001:2004 certified.

3. ENERGY EFFICIENCY OF THE ANAEROBIC DIGESTION PROCESS

3.1 Process control

The anaerobic digestion process adopted by ACEA is controlled by several technical features, there are continuous control (temperature, pressure, quality and biogas production) and not continuous (chemical analysis). Matching these different data allows a proper control of the entire process.

The samples for the chemical analysis are taken from:

- the feeding of the bioreactor for total solid and volatile contents analysis;
- the material in digestion to check the volatile fatty acid and alkalinity ratio (Rα);
- the digestate for total solid and volatile contents analysis and heavy metal check.

The continuous monitoring allows us to guarantee the heat sterilization (50-55°C) of the mass and to control the efficiency of the process.

3.2 Process data

ACEA treats a municipal organic waste (OFMSW) coming from separated collection, for a capacity of 900 ton/week (Table. 1). Through composition analysis we check the quality of the waste changes. The unwanted material reaches a 20 % on weight (Figure.3), affecting deeply the mechanical pre-treatment.

Table 1. Data about the process 2007

Description	Values
Average of OW treated	870 ton/week
Waste to landfill from the pre treatment	26 %
Average total solid content in the OS, TS	30 – 35%
Average total solid content fed to the digestor, TS	10 +/- 10%

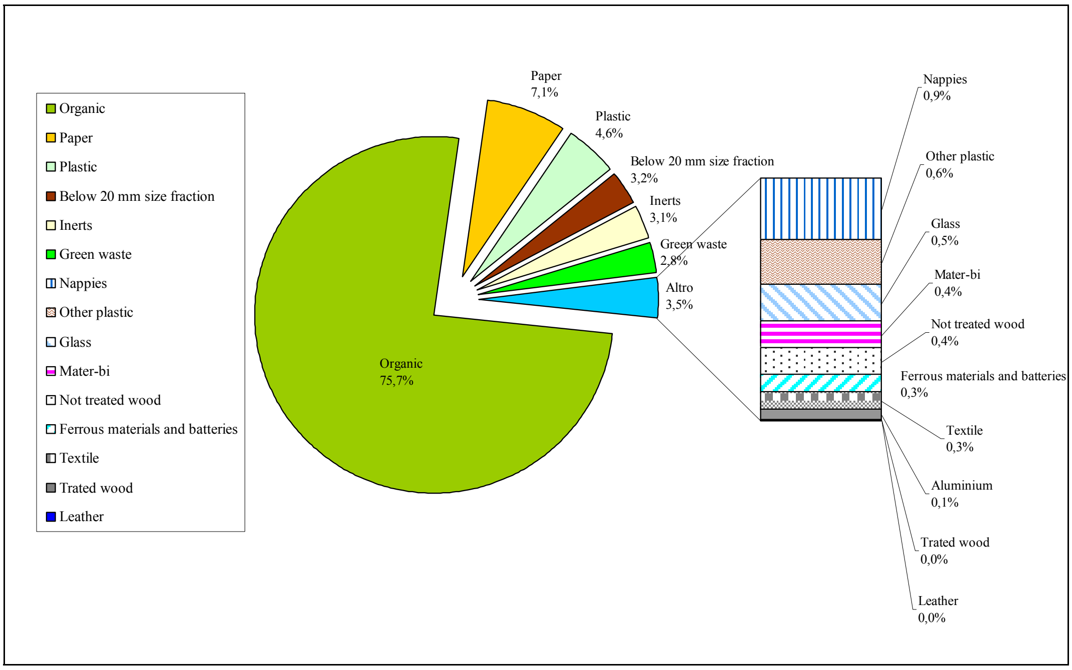

Figure 3. Typical composition analysis on 2007 campaign

As a not continuous control is done taking samples, a continuous one is obtained through a network of fixed instruments (more than 150 instruments are in place). The changes in methane to carbon dioxide ratio allows ACEA, in parallel to the value of Rα (acid/alkali ratio, coming from samples on the material in digestion), to preview unwanted changes in the process (Figure 4).

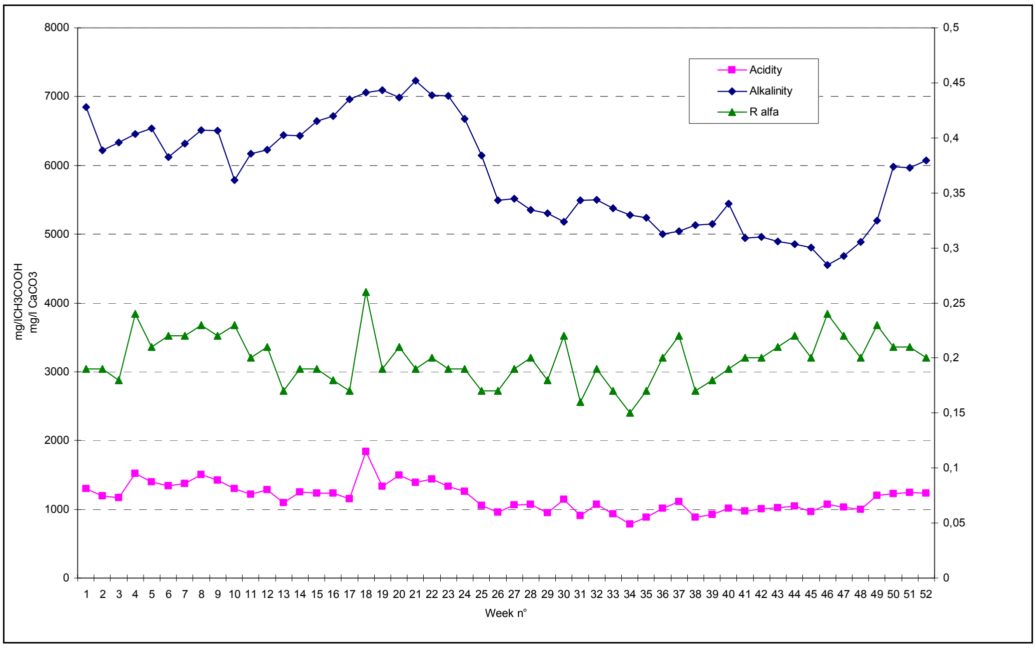

Figure 4. Line A Process control data, Acidity, alkalinity and Ralfa 2007

Temperature level into the digestor is another typical element that follows the way the process behaves and guarantees the proper heat sterilization of the material.

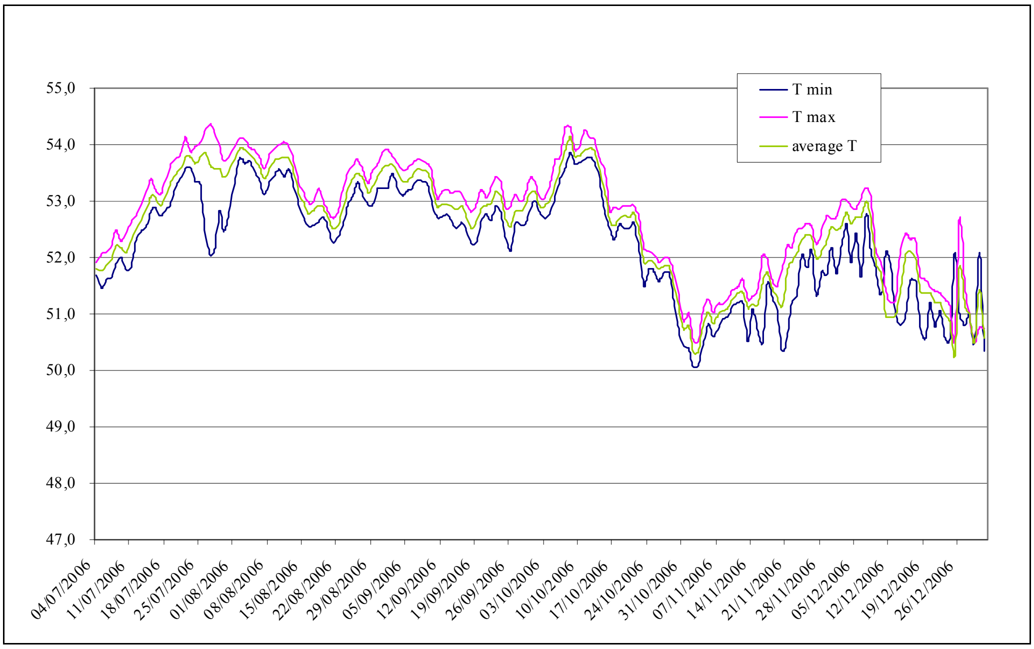

Figure 5. Line A temperature level during the second half of 2006

The biogas capacity control is equivalent to our energy efficiency. On Figure. 6, we can match the efficiency of the production per specific volatile solid tonne treated during 2006 and 2007.

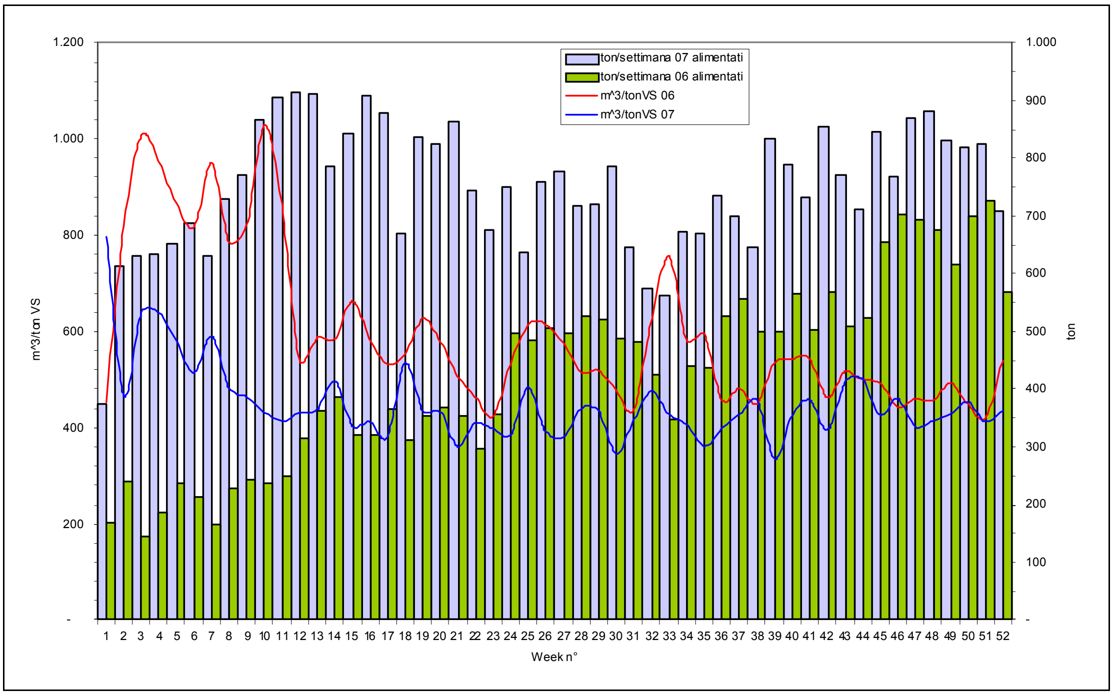

Figure. 6. Biogas weekly specific production 2006 and 2007 compared to the waste fed to the digestor.

On table 2 are presented data about the process matching 2006, 2007 and the project features.

Table 2. Process index of the plant based on ANPA, ONR (2002)

Control parameter	Line A and B medium (2007)	Line A and B medium (2006)	Project data
Average organic load [m^3/d]	210	115	180
Hydraulic retention time HRT [days]	12	14	14
TS feeded material [%]	9	10	12
Organic Load Rate OLR [Kg organic/m^3bioreactor*day]	7	3	4,5 – 5,2 (7,0 max)
Specific biogas production at 60% CH4 [m^3/KgVs feeded]	0,44	0,59	0,300
Substrate removal effectiveness Vs% [%]	69%	74%	53%
Biogas production rate [m^3biogas/m^3bioreactor *day]	4,6	3,3	-
Electric energy specific production [KWhe/ton feeded]	263	330	-

Data presented on table 2 shows how the system has already reached the project data and show that, even if 2007 has had better complete performance (see Figure. 6) by a specific point of view it has been worst than 2006. We can see also that the OLR reached is the maximum previewed on the project and mostly of the parameter previewed are been reached or even passed. This is also confirmed by the high efficiency reached by the substrate conversion and data on specific biogas production are higher of what was expected.

From figure 7, we can see how the electric production is a clear positive effect allowing us to sell half of the production on the market. Data are referred to a single month (11/2007) to have a clearer image.

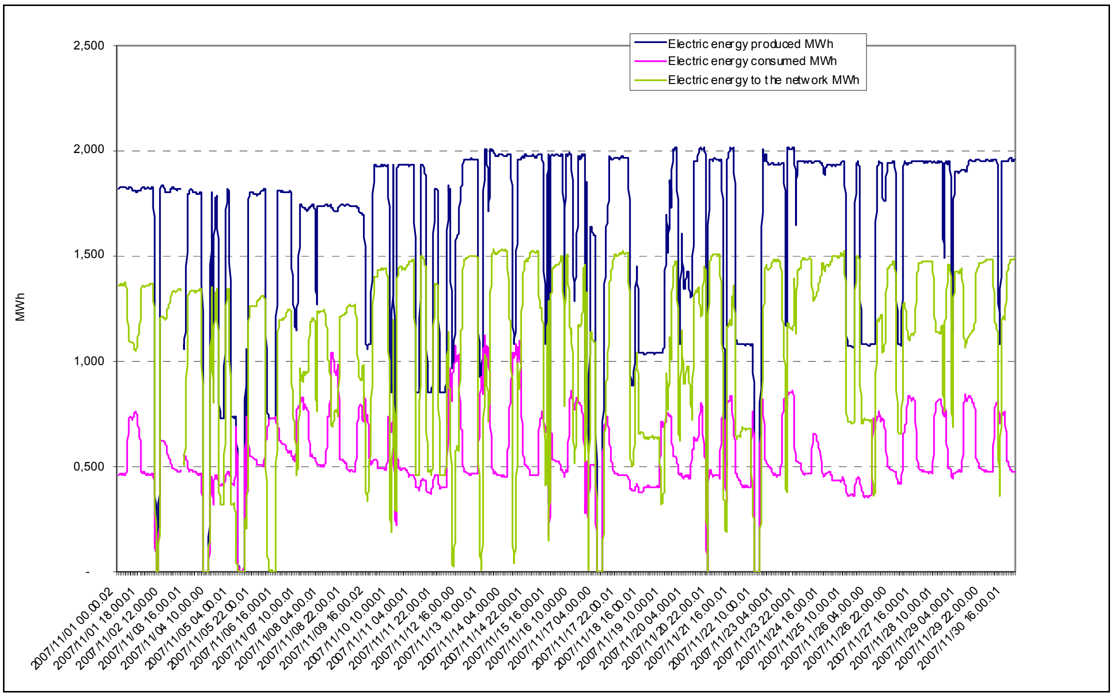

Figure 7. daily production and consumption of electric energy for 11/2007

To clarify better the efficiency of the project we summarize on table 3 and 4 some consumption data about 2007.

Table 3. Consumption 2007 data

Specific electric consumption	75 KWhe/ton
Specific thermal consumption	45 KWht/m^3
Percentage of the electric energy consumed on the one generated by biogas	28 %
Percentage of the thermal energy consumed on the one generated by biogas	16 %

Table 4. Energy 2007

Potential energy (biogas)	39,1 GWh
Produced electric energy	13,2 GWh
Internal electric consumption (primarily in daily time)	8,3 GWh
Heat energy consumption	6,5 GWh
Electric efficiency	35 %
Heat efficiency	17 %
Woking engine hours	14.293 h
Amount of non working hours per year	17%

4. FINAL CONSIDERATIONS

Good results obtained by our integrated anaerobic/aerobic system and the know how acquired give us the opportunity to draw a brief set of considerations on our experience.

Principal system index shows us a very stable process (pH, Rα, T).

Biogas quality product is coherent with other well known anaerobic process (60 % CH4), and this is also true for biogas production. This means a high efficiency of the adopted anaerobic system, both in electrical (50% of the electrical production is available for the market) and in thermic term (less than 20% of the production is consumed) and offers interesting opportunities for the future.

Energy recovery of the organic waste through anaerobic digestion offers advantages in economic terms, matching the new issues of the energy market (green energy and energy efficiency title).

Sludge coming from the digestate allows a good compost production easily respecting the law limit for the final product (Italian law act 217/06).

The strong volume reductions through anaerobic digestion and the homogeneity of the sludge help the aerobic process.

Anaerobic and aerobic integrated process avoids pollution due to organic fraction and the high temperature reached in both processes causes the destruction of pathogen organism.

Managing a complex system need professionals and only much more accurate control will allow a better management of the entire system, giving instrument to improve efficiency and controlled results.

A better and more efficient thermal energy recovery is the next challenge, data show us this important opportunity.

On the base of acquired know-how we can confirm the obvious advantages that the integrated system offers and that anaerobic digestion option is a clear industrial option.

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