IMPLEMENTATION OF AN ISO 14001 ENVIRONMENTAL MANAGEMENT PROGRAM IN A PROJECT FOR THE PRODUCTION OF ENERGY FROM URBAN SEWAGE SLUDGE

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Abstract

A procedure for utilizing urban sewage sludge to produce syngas through pyrolysis is described. Pyrolysis is carried out slowly at atmospheric pressure using a catalyst at low temperature (500 °C) in anaerobic conditions.

The syngas fuels a co-generation unit that produces thermal and electrical energy. The co-generation unit is connected to a bioreactor which produces algae that are nourished by the CO_2 that comes from the pyrolysis and from the combustion of the syngas in the co-generation unit. A biodiesel is extracted from the algae. Given its particular characteristics, the process meets with the standards for environmental quality certification set out in ISO 14001.

Riassunto

Viene descritto un procedimento che utilizza i fanghi reflui urbani per la produzione di un gas di sintesi (syngas) mediante un apparato di pirolisi.
La pirolisi viene effettuata a pressione ambiente, lenta, catalizzata, a bassa temperatura (500 °C) e in condizioni anaerobiche. Il syngas alimenta un gruppo di cogenerazione che eroga energia elettrica ed energia termica. Collegato all'impianto è previsto un bioreattore per la produzione di alghe che viene alimentato con CO_2 proveniente dalla pirolisi e dalla combustione del syngas del cogeneratore. Dalle alghe è estraibile un biodiesel. Per l'impianto è stata prevista, date le sue caratteristiche, una certificazione secondo le norme di qualità ambientale ISO 14001.

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Regulatory aspects

The current day view of production cycles and their impact on the environment no longer considers the various waste products generated in the production process as refuse to be indiscriminately released into the environment, but rather as "by-products" or "secondary raw materials" that can be used in other production cycles.

Italian legislation in this field has adopted this principle with regards to many production sectors and has adopted many European directives. For example, art. 181 of Italian Law 152/2006 says that waste materials must be utilized, where available technology allows, for the production of heat and electric energy.

This means that before any material can be considered waste, and disposed of as such, a careful consideration of whether there is modern technology available for its recuperation and reuse must be made.

In a European directive of 2008 regarding waste material, for the first time the European legislators clearly established a principle of great juridical and economic importance regarding the distinction between "waste" and "non-waste" by clearly affirming that in certain conditions the operation of recovery leads to the suspension of the category of 'waste' and at the same time to the birth, in the legal and commodity science sense, of a "new product" or of a "new goods" that enters the market with no need for recognition.

An Italian Legislative decree of December 3, 2010, n. 205 ("Disposition for the implementation of the directive of the European Community Parliament and Council of November 19, 2008 regarding waste and the abrogation of certain directives") introduced, after Art. 184 of Legislative Decree n. 152/2006, Articles 184-bis (*by-product*) and Art. 184-iter (*suspension of the category of waste*).

The first mentioned decree, among other things, says that:

1. Any substance or object that meets all of the following conditions is to be considered a by-product and not waste material in the sense intended by Art. 183, section 1, letter a […];

The second mentioned decree states, among other things, that:
1. Waste ceases to be considered as such when it has been subjected to a recovery operation, including recycling and preparation for reuse, and when it meets specific criteria to be adopted in observance of the following conditions […].

One of the sectors in which the suspension of the category of waste has been applied is that of sewage sludge from urban water treatment plants. In Italy alone it is estimated that around 15 million tons of urban sewage sludge are produced per year and it is evident that this amount will increase over time.

Legislative Decree 152/2006 specifically deals with sewage sludge. In particular Art. 127 (sewage sludge from water treatment) successively modified by Art. 12 of the Legislative Decree of January 16, 2008, n. 4, which establishes that "sewage sludge must be reused whenever its reuse is appropriate".

Moreover, Art. 6, section 1 of the Italian Legislative Decree of January 13, 2003, n. 36, in the part entitled "Implementation of EU Directive 1999/31 regarding waste landfills" states: "the following types of waste may not be disposed of in landfills […]: p) waste with a net heat value (NHV) of 13,000 kJ/kg (= 3,102 kcal/kg) starting from 1/1/2007"[1].

Dehydrated sewage sludge, depending on its specific compositional characteristics, may have extremely variable net heat values ranging from 2,550 to 4,300 Kcal/kg, - values which could, in fact, impede its disposal in landfills.

Because of this situation sewage sludge comes to be treated as if it were a raw material; the energy in the organic material it contains must be recovered; it is, therefore, also source of renewable energy. Because it allows for energy recovery this kind of sewage sludge treatment is more environmentally sustainable than disposing of sewage sludge in a landfill.

Regulations apart, it is in our cultural, environmental and economic interest to recuperate energy from sewage sludge even when the calorific power it yields is lower than that established by law.

Moreover, since regulations limiting what can be disposed of in landfills are becoming more and more restrictive, it is going to become harder and harder to dispose of sewage sludge in landfills.

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[1] Law 13/2009, which converted Legislative Decree 208/2008 into law, set the definitive deadline of 31/12/2009 as the date after which waste with a net heat value above the 13,000 kJ/kg. allowed in Art. 6 of Legislative Decree 36/2003 may no longer be disposed of in a landfill.

In fact, waste disposal in landfills is going to be progressively limited to disposal of inorganic waste only, while organic waste is going to account for only a small percentage of what is disposed of in this way[2].

Characteristics of the plant for the recovery of energy from sewage sludge

For all of the reasons discussed above, a project was proposed for the recovery of energy from urban sewage sludge through the use of pyrolysis (or molecular disassociation) carried out in the absence or shortage of air, which produced energy directly[3].

Essentially, by subjecting the sewage sludge to pyrolysis a synthetic gas (syngas) which is particularly rich in hydrogen, carbon oxide and carbon dioxide, is produced.

Moreover the process produces an inert residue which is reusable in the building sector or can be disposed of after glassification.

What we are interested in analyzing here is whether the gasification of waste in general, or that of urban sewage sludge in particular, that results in the direct production of energy, can be a valid tool for the disposal of waste and for the production of energy and technical gases (hydrogen and carbon dioxide in their pure states).

Waste disposal in landfills is inadvisable since it takes more and more land away from agriculture and because it requires costly pretreatment for the storage of the sewage sludge (Dallago L. *et al*., 2001) (Fullana A. *et al*., 2003).

Incineration seems to be an efficient mode of waste disposal (Mininni G. and Di Pinto A.C., 2001) (Bemporad E., and Carassiti F., 2002) however the costs of reducing the polluting gases that are its by-products to acceptable limits must not be overlooked (Werther J. and Ogada T., 1999).

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[2] From an environmental and economic point of view, one big disadvantage of landfill disposal is that the landfill is often located at a great distance from the place where the sewage is produced. For example, sewage produced in the metropolitan area of Chieti (about 20,000 tons per year) is transported to a landfill located in Taranto (a city which is at a distance of about 400 kilometers). An industrial vehicle (lorry) with a capacity for 22 tons that travels 4 kilometers on one liter of diesel fuel, will consume 200 liters of diesel fuel to travel 800 kilometers. In order to transport 20,000 tons it takes 910 lorries a year that travel 728,000 kilometers and consume 182,000 liters of diesel fuel. The energy consumed is 2,200 MWh. The quantity of carbon dioxide that is released into the atmosphere during this transportation is 3.3 kilos per liter, multiplied by 182,000 liters = 600,000 kilos, or 600 t per year.

[3] The project planning group is part of the Esseco Research and Service Company, which has its headquarters in Chieti.

Relevant literature instead confirms that pyrolysis carried out in anaerobic conditions is useful for the treatment of urban sewage sludge because the quantity of material that ends up going to the landfill is reduced considerably and the enthalpic content of the gas mixture that is emitted can be recovered.

R. H. Perry and D.V. Green (1999) report that the enthalpy of combustion of gaseous mixtures generated by pyrolysis of sewage sludge is equal to 5,300 kcal Nm^3.

Hence pyrolysis, compared to other treatments, can be considered a valid solution since it affords the possibility of utilizing the gas produced as gaseous fuel (Conesa J.A. *et al*., 1998) (Fullana A. *et al.*, 2003) (Shen L. and Zhang D., 2003) (Adegoroye A. *et al*., 2004) (Dogru M. *et al*., 2002) (Ptasinski K.J. *et al*., 2002) (Marrero T.W. *et al*., 2004) (Midilli A. *et al*., 2002).

It is possible to produce electrical energy using high yield thermic motors that have a low environmental impact or by first producing and separating the hydrogen (with the appropriate reforming process) and then directly converting it into fuel cells.

The composition of gaseous wastewater obtained from the thermochemical conversion of sewage sludge through the simulation of equilibrium, demonstrates that the gaseous species present in significant percentages are hydrogen (H_2), carbon monoxide (CO), water vapor (H_2O), carbon dioxide (CO_2) methane (CH_4) and nitrogen (N).

The composition varies depending on the quantities of air and water present, the temperature, the pressure and the catalysts used in the process.

Under normal pressure, high concentrations of hydrogen and carbon monoxide and low concentrations of methane and carbon dioxide are found.

The formation of methane and carbon dioxide is favored by low temperatures, while at higher temperatures hydrogen and carbon monoxide predominate.

The formation of char decreases as a function of temperature, therefore the efficiency of the reagent conversion in the syngas increases as the temperature increases.

The characteristics of the pilot plant proposed for the pyrolysis are summarized below and a diagram of the plant showing the quantities of substances at the various stages of the process appears in Figure 1.

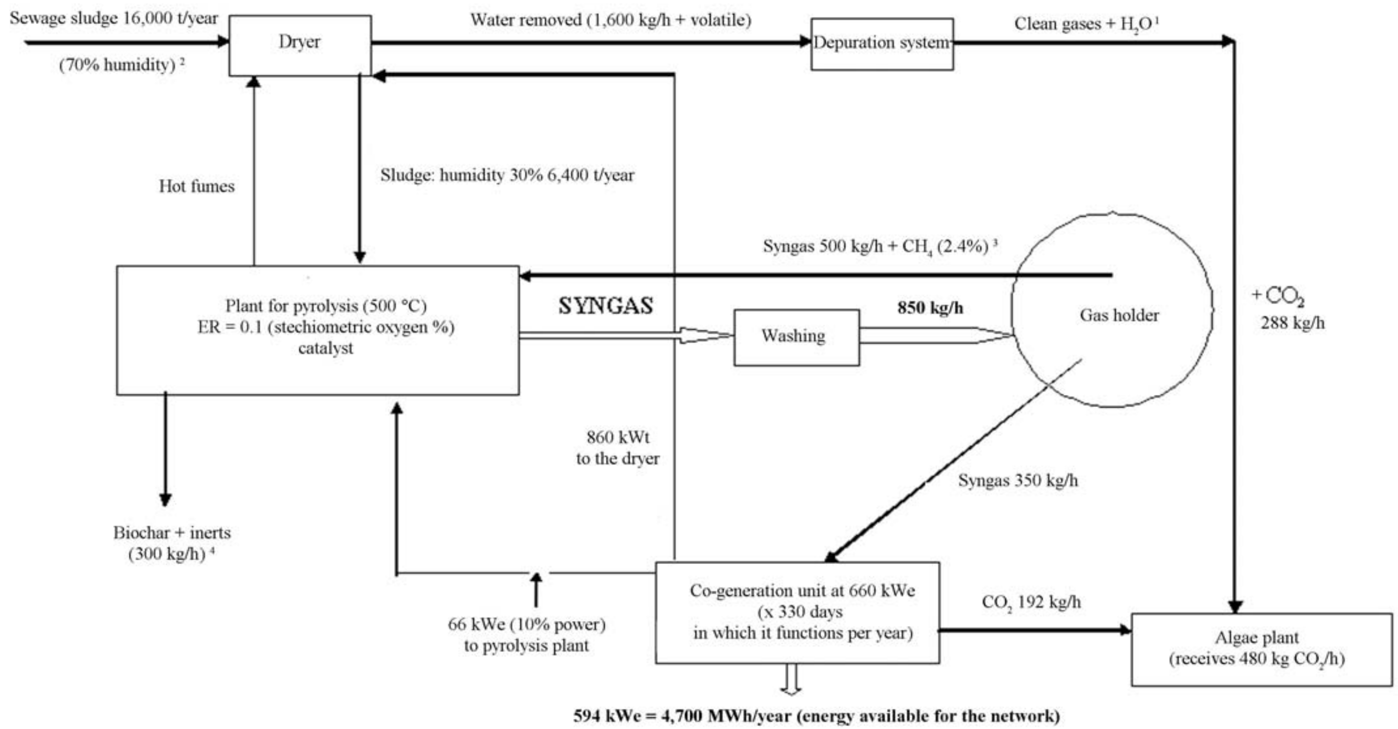

Fig. 1 - Diagram of the plant for pyrolysis (1 = The characteristics of the wastewater allows for its inlet in surface water or, at the most, in sewers (see Legislative decree 11/5/99 n. 152, attachment. 5. 2 = The sludge has 6.6% carbon wet weight. 3 = Small quantity of methane for the pyrolysis, equal to 2.4% of the energy required. 4 = the amount of sludge inerts are 6% (experimental data) and so the production is 960 t/year and 120 kg/h).

1. Electrical energy (4,700 MWh/year) and thermal energy (6,124 MWh/year) are produced using a co-generation unit that is mainly fueled by syngas (with NHV of 17,600 kJ/kg) obtained from pyrolysis of urban sewage sludge (16,000 t/year) that has been carried out slowly at atmospheric pressure, in anaerobic conditions, with catalysts and at a low temperature (500 °C);

2. A patented process is used (patent held by ENEA and Mazzanti[4]) which allows for a greater purification of fumes, of Syngas and of the products that result from its combustion, even though these substances do not exceed regulatory limits;

3. The inorganic residues of the pyrolysis can be used for the production of cement-based concrete, blacktop, filler material, etc. thanks to a special process that was developed by Contento Trade, a research company located in Terenzano in the Udine province of Italy which is specialized in this field; where possible, after having undergone analysis, these residues may also be used in agriculture as an amendment;

4. A co-generation unit fueled by vegetable oil obtained from algae was built to complete the system so that there is a sort of closed cycle system. In fact, the algae will be fertilized with the carbon dioxide from the pyrolysis and from the co-generation unit as well as from the condensation coming from the sewage sludge dehydration plant.

Pyrolysis *does not* produce dioxins since the reactions take place in the absence of (or in scarce presence of) oxygen; the temperature exceeds 450 °C; the carbon is present in the amorphous state; the presence of organic chlorides is negligible and furthermore there is not correlation between the presence of chlorine and the production of dioxins; the presence of sulphides inhibits the catalytic action of metals like copper and iron.

Given its characteristics, the plant meets the requirements for certification under both the ISO 14001 regulations on environmental quality and the EMAS eco-management audit scheme.

The sewage sludge which is used has a net heat value of 17,400 kJ/kg and is classified as special but non-toxic waste, and so it cannot be disposed of in landfills (Art. 127 Legislative Decree 152/06) unless there

[4] European Patent n. 1238679 issued on March 4, 2002: "Process for the deodorization and abatement of odorous organic substances from fumes and/or gases", on behalf of ENEA and Uranio Mazzanti.

is a legal waiver, since it exceeds the 13,000 kJ/kg[5]. The same is true for the DOC (Dissolved Organic Carbon), the sludge exceeds the legal parameters and can only be disposed of in a landfill if there is a legal waiver.

On the basis of the information contained in diagrams 1 and 2 (Figures 2 and 3) the lack of air conditions that would create a positive enthalpy were chosen: ER is the relationship between the amount of oxygen supplied and the amount required by the material: ER = 0 in anaerobic conditions, ER = 1 is the stechiometric requirement. The lowering of cycle temperature in conjunction with the same production of energy, was made possible through the use of a catalyzer. For example: a $ZnCl_2$ based catalyzer can increase hydrogen production up to 30% (Demirbaş A., 2002).

The plant for the production of biodiesel from algae

The CO_2 extracted from the combustion residues of syngas that come from the pyrolysis plant are used to feed the algae bioreactors. The cultivation of the algae requires large amounts of CO_2 (nearly two kilograms of CO_2 for each kilogram of algae biomass produced) in other words, in order to produce 100 tons of algae biomass 183 tons of carbon dioxide are fixed.

For further considerations regarding the available technology for cultivating these microorganisms, the extraction of biofuel and the economic- environmental aspects arising from its use, in the interests of brevity, the reader is referred to the report of Aveni and Rana (2008) which includes 51 notes in its bibliography.

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[5] The characteristics of the sewage sludge used in the plant are as follows: dry residue at 105 °C = 30% (±2%); dry residue at 600 °C = 6% (±1%); pH = 7.1-8.1; total nitrogen (N) = 1.7%; total phosphorus (P) = 0.7%; total organic carbon = 22%; metals (mg/kg d.w.) within the limits (aluminum, antimony, arsenic, barium, beryllium, bismuth, boron, cadmium, cobalt, hexavalent chromium and total, iron, magnesium, mercury, nickel, lead, copper, selenium, tin, thallium, tellurium, vanadium, zinc); total mineral oils ≤ 5 mg/kg; solvents (mg/kg) ≤ 0.1; within the limits: benzene, toluene, ethylbenzene, xylene, isomers, styrene, dichloromethane, trichloroethane, 1.2-dichloroethane, 1.2-dichloropropane, 1,1,1 – trichloroethane, trichloroethylene, tetrachloroethylene, pentachloroethane; PCB, dioxins and furans = absent. Transfer test in acetic acid 0.5M within the limits (mg/L): antimony, arsenic, barium, cadmium, total chromium, mercury, molybdenum, nickel, lead, copper, selenium, zinc, chlorides, sulphates, fluorides, cyanides, aromatic organic solvents, nitrogenous organic solvents, chlorinated organic solvents, total pesticides phosphorated and not phosphorated. The DOC level of the eluate exceeded the limit: 175 mg/L rather than 80mg/L.

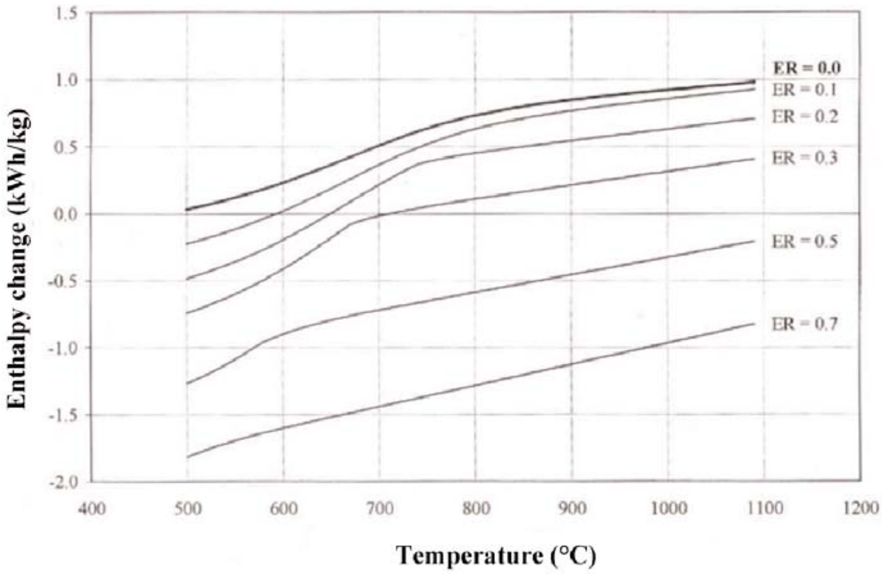

Fig. 2 – Variation of net enthalpy, as a function of pyrolysis temperature, for the ER various values (Baggio P., Bartieri M., Grigiante M, Ragazzi M., "Gassificazione di fanghi da depurazione", in Quaderni del Dipartimento di Ingegneria Civile e Ambientale, Università di Trento, 2006, 19-44).

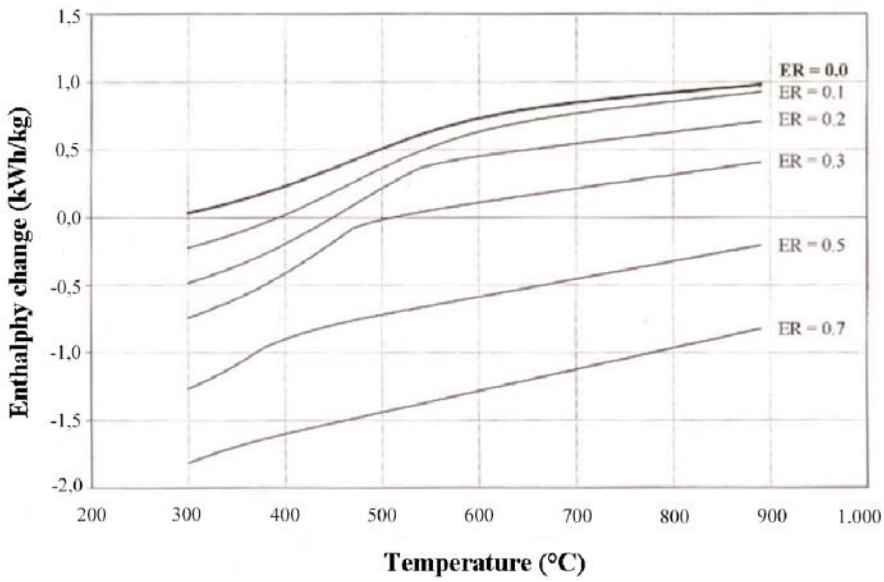

Fig. 3 – Hypothetical variation of net enthalpy with the use of catalyst.

Each reactor of 300 liters of water (with algae) absorbs about 1 gram of CO_2 per minute, or 720 grams per day (for an average of 12 hours of insolation). The CO_2 concentration in the atmosphere of the reactor is 8%. The pyrolysis plant produces 0.48 tons per hour of CO_2; for an average of 12 hours of insolation the bioreactor absorbs 5.76 tons of CO_2 per day. With this quantity it is possible to produce 3 tons of algae per day. The oil content dry weight in some species may be as high as 40 to 45%. In order to ensure constancy, the daily extraction of biomass is around 15%. Theoretically the CO_2 not absorbed during the night but in any case produced by the pyrolysis plant, could be accumulated and utilized during the day which would double the plant's cultivation capacity, increasing it to 6 tons of algae per day.

ISO 14001 Environmental Management System

The environmental policy is the guideline for implementing and improving a System and it should tend to either keep environmental performance at a constant level, or improve it. It must establish the objectives and the goals to be reached. It is essential that it be clear enough to be easily understood by all of the interested parties, both inside and outside of the project. Policy is defined by top management and then communicated to all of the people who work within the organization or on its behalf.

The implementation of an Environmental Management System has the scope of improving the environmental performance of an organization. ISO 14001 (Environmental Management System requisites and directives for their application) provides the ground rules for implementation and the diagram below provides a synthetic description of how the ISO14001 rules work. (Figure 4):

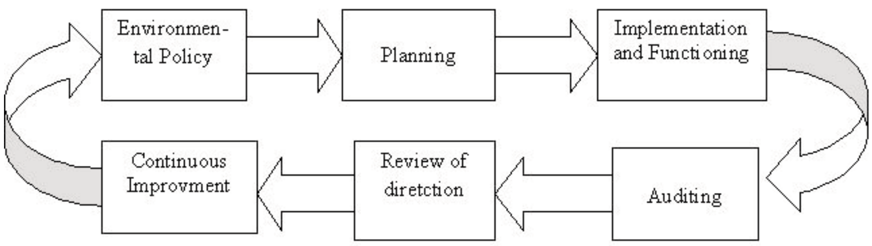

Fig. 4 – Diagram of ISO 14001.

In line with the rules set out in UNI ISO 14004 that stipulate the general principles which govern Environmental Managements Systems and the various techniques for their implementation, an initial environmental analysis was carried out for the project described above. This analysis was conducted according to the following plan:

- a detailed description of the business and its location was made;
- all relevant legislative prescriptions and regulations were identified, beyond those with which the company had already agreed to comply;
- all aspects of the company's operations, including energy use and waste produced, that have, or could have, a significant impact on the environment, were identified. In identifying these aspects, normal as well as anomalous operating conditions were considered, as were start-up conditions and pauses in operations, emergency situations and accidents;
- the practices and procedures for environmental management then in force, including those associated with the drafting of supply contracts (for example, contracts for the supply of sludge or other biomasses) were identified;
- an evaluations was made of emergency situations and accidents that had occurred in the past;
- a study was made of the activities of other organizations that could help or hinder the environmental performance of the company;
- measurable environmental objectives and goals, including commitments for the prevention of air pollution emissions, respect for established limits and continuous improvement, were defined;

To ensure that the Environmental Management System works effectively the project provides for: highly trained and qualified personnel, organizational infrastructure and the most advanced technology available.

Regular functioning of the System is ensured by re-examination and improvement of performance; the people who carry out the tasks regarding ascertainment of environmental impact have the necessary competence.

A determination was made as to the type of training needed and the methods for training/recruitment of personnel inside and outside of the company.

The project also provides for personnel who conduct the training inside of the company and handle external recruitment communications.

Description of the Company and its Location

- The pyro-gasification plant occupies and area of 3,000 m^2 and has the capacity to transform 20,000 tons of biomass per year, which are mostly urban sewage sludge. The entire area involved in the project (headquarters, service facilities, roads, car parks, green spaces, the algae plant, etc.) is about ten times larger.
- The plant borders for the most part on the urban waste water treatment facility from which it receives the sludge that is to undergo pyrolysis.
- The production area includes: the water and air layouts; the pyrolysis reactor; the area for the collection and storage of sludge and other biomasses; the storage area for syngas; the storage area for ashes; the co-generation unit; water waste treatment; other service plants.
- The plant uses the water network of the industrial park.
- Emissions are made into the atmosphere by the pyrolysis reactor, the exhaust fumes from the motors of the co-generation unit, occasionally there is a release of syngas for safety purposes when the production has exceeded the capacity of the storage tank.
- The annual consumption for the pyrolysis of 16,000 tons of biomass is 530 MWh of electric energy, 95 tons of methane gas, 11,7 tons of sodium carbonate and 240 kg of activated charcoal for the filters.
- The hydrological, geological and morphological features of the area can be found in the records at office of the Industrial –Scientific Park.
- Climatic conditions do not have an important effect on the company's environmental performance since the essential parts of the productive cycle take place in a closed reactor.
- The area in which the company is located has no protected landscape sites or sites of historical or cultural interest since it is an area in which there has been an intensive presence of industry for some time.
- The environmental characteristics of the area are those of and industrial park which hosts a variety of activities.

Legislative prescriptions and regulations regarding the plant and the activity carried out there

The company has equipped itself with copies of all of the laws which are related to its activity: laws regarding its specific activity; those which specifically regard the products and services it offers; the specific laws for its sector of operation; the general laws on the environment; authorizations, licenses and permissions.

In particular, it has copies of the following materials regarding environmental protection:

- Legislative decree 152/06, and successive modifications, on gaseous, liquid and solid emissions;
- Law 447/95, and successive modifications, regarding noise pollution.

A procedure for periodic evaluations of the legal limits applicable to the activity is carried out. Activities in which the regulatory limits have actually been improved upon are also periodically evaluated. The fume depuration plant patented by ENEA is an example of a procedure used that actually improves on the legally required limits. Moreover, a procedure has been established that deals with instances of non-conformity, corrects them and takes the necessary action to prevent future occurrences of non-conformity.

Production process

The production process was subdivided into two principle phases. The energy flux and the ingoing and outgoing materials in each phase were calculated in order to determine the environmental aspects of each of the two phases. The support and production service activities were also identified and the environmental aspects connected with these activities were also noted. The following is an outline of the systems involved in production process:

- Reception and storage area for sludge and other biomasses;
- Biomass dryer unit;
- Storage area for dried biomass;
- Unit for mixing and pelleting of the biomass and for fueling the pyrolysis reactor;
- Pyrolysis reactor
- System for cooling and cleaning the syngas produced;
- Vessel for storing the overproduction of syngas
- Co-generation unit
- Apparatus for connecting with the national electric grid in order to sell electric energy;

- Direct heating line;
- Unit for the depuration of gaseous, liquid and solid effluents. It carries out depuration on effluents from syngas production and effluents from engine combustion.
- Auxiliary installations.

Using a check list prepared for this purpose, the interactions between various parts of the plant and the environment were evaluated as follows:

Emissions into the Atmosphere. These were reduced to the minimum. They included carbon dioxide, water vapor, dust, etc., all of which were below the limits established by the legislation in force. The potential for damage is insignificant.

Waste water. It comes from the steam produced from the drying of sludge. Furthermore it takes account of rainwater. These do not involve significant environmental impacts. They were likely to be disposed of in surface waters or, at least, in the sewer system.

Waste production. The principle waste materials produced are ashes coming from pyrolysis (1,000 tons per year) until some use for them is found; filters from fume abatement (4.8 tons from sodium carbonate and 240 kg from activated charcoal per year); the usual residues from lubrication of machines and normal urban waste.

Pollution of the soil and substratum. The danger of contamination of the soil or its substratum is very low since what we are dealing with here is urban and not industrial waste.

Vibrations. Scarce

Noise. Noise is continuously measured through the use of a sound level meter. Readings are compared and action to reduce noise levels is taken when the allowed levels have been exceeded (> 85dB in the plant).

Odors. Sensors able to detect anomalous odors are used so that action can be taken immediately for their abatement.

Electromagnetic emissions. There are no detectable electromagnetic emissions.

Dangerous substances. The production cycle does not include any dangerous substances.

Other activities connected with the production cycle. A list was made of all of those activities which, although strictly speaking not a part of the production cycle, are in some way related to it. These activities include in-plant storage and warehousing operations, equipment maintenance and management of energy resources.

In particular, the following activities were considered:
- receipt and storage of sludge and combustibles;
- warehousing of combustible products and glassy residue;
- venting the excess syngas produced;
- general services and maintenance of equipment;
- depuration and treatment of fumes, water and solid residues;

A registry of all of the machinery in use in the plant was drawn up.

Overall, the activities carried out in the plant are considered to have a low risk of danger, a consideration which is also supported by low quantity of material worked in a day: about 30,000 tons.

Monitoring

The activity of monitoring was planned so that it scrutinizes the production process and carries out the necessary checks on compliance with environmental parameters/objectives under normal working conditions, when the production cycle is in start-up or pause phase.

Moreover, it takes into account the real or potential impact from both foreseeable situations and emergencies.

It works as follows:

- the composition of the sludge is analyzed weekly to determine its conformity with specifications in art. 127 of the legislative decree 152/2006;

- as they are coming out of the depuration unit, the quality of the fumes from the dryer, together with the fumes from the pyrolysis unit, is continually registered. It has been shown that the quality of these fumes is better than that required by law;

- the quality of the fumes form the co-generation unit is continuously monitored;

- in case of an accumulation that exceeds the capacity of the gas holder, the pressure release valve automatically vents the excess syngas and then it is combusted in the depuration unit for exhaust gas.

The waste water from the dryer can be disposed of in surface waters.

The instruments for surveillance and measurement are periodically calibrated and checked for accuracy.

Documentation

Thorough documentation of the EMS is required, including a statement of its environmental policy, its goals and objectives, a description of its field of application, as well as all of the registrations required by law and those considered opportune for the correct functioning and effective checks on all of the processes that have significant environmental aspects.

Plant management establishes, activates and maintains a procedure for identifying situations that could cause emergencies or accidents that would have an impact of the environment. Once such situations have been identified, management defines the response to them.

Provision has been made for internal audits of the EMS at regular intervals for the purposes of determining whether the system is in conformity with the original plan and with the relevant norms (ISO 14001) and if the system has been correctly implemented and maintained.

Moreover, provision has been made for an information communication system which will keep company management informed of the results of audits. It goes without saying that the selection of auditors and the auditing process itself must guarantee objectivity and impartiality.

Conclusion

The recovery of energy from urban sewage sludge has different advantages when seen from the economic, social and environmental points of view:

- from the economic point of view, the costs of disposing of sewage sludge which are expected to increase considerably in the coming years, would be drastically reduced and totally recuperated by the production of electrical and thermal energy;

- from the social point of view, this project envisions the recruitment of a highly specialized research group, offering ever-increasing employment opportunities to qualified personnel, not only from the technology sector but also from agriculture;

- from the environmental point of view, the disposal of waste in landfills will be reduced, the vehicle traffic connected with transportation of sewage sludge will begin to be eliminated, air emissions of various types will be reduced and the recovery of carbon dioxide will make a substantial contribution towards achieving the reduction of CO_2 that Italy has promised to both the European and the international communities.

- Given its characteristics, the system can be certified according to the norms of environmental quality set forth in ISO 14001.

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