Mechanical-Biological Stabilisation Plant in Fusina near Venice/Italy (260,000 t/y)
– Twelve Years of Operating Experience –

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This report is to illustrate the yield and the balance of utilization of the RDF produced at the Fusina integrated pole, comparing it with what is known about the waste combustion in incineration plants. The material and energy balances resulting from a monitoring during twelve years or running are to be used in the following comparisons.

Those balances prove the convenience of the process from the energetic point of view, also considering that the privileged outlet for the co-combustion of the produced RDF will be the thermo electrical power plant of Fusina.

1. The fusina RDF production plant – a brief history

The plant was built in the early 2000s, and became fully operational in late 2001. At the beginning only section 1 was dedicated to RDF production, with a capacity of 167,000 t per year, while section 2 was a composting plant for organic fraction from separated collection with a capacity of 70,000 t per year.

After several years of testing, ended in 2008, it has been decided to also convert section to in RDF production plant, with a capacity of 100,000 t per year. The revamping was completed at the end of 2010.

Today we are running regularly the two sections, reaching a total amount of 260,000 t per year of MSW treated.

2. Section 1

This section has a technical processing capacity of up to 167,000 t per year and it disposes of fifteen bio-drying boxes working according to the Ladurner system, in which the biological inactivation of the organic residues of the waste takes place. In the following chart shows the process scheme of the plant.

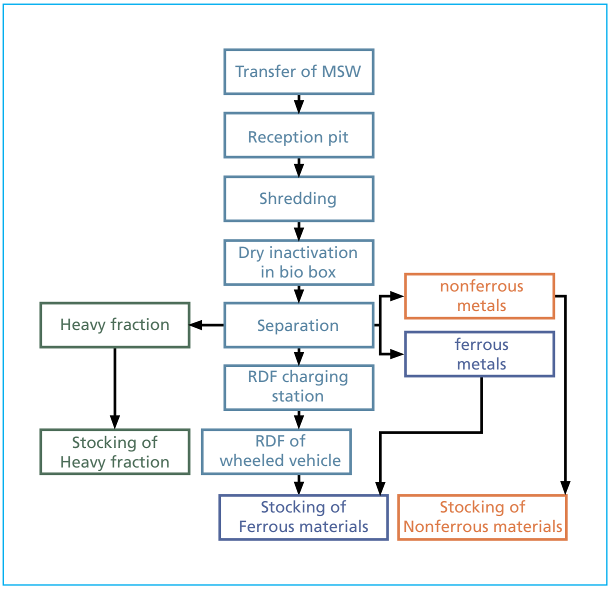

Figure 1:

Block scheme of the RDF production plant

The waste treatment process in this kind of plant is performed in a fully automated system. It can be divided into the following steps:

Material acceptance and preparation

The delivery area is divided into a deep bunker for household waste and a flat area for commercial waste. The delivery of the household-waste by waste trucks is performed via handover shafts which act as airlocks.

A fully-automated delivery crane operates in the bunker area, which ensures both the optimum utilisation of the bunker volume by moving the waste and also that the downstream crushing machines are filled. The crushing takes place via slowly running rotary shredders, which condition the residual waste to a particle size of smaller than 200 millimetres.

The crushed residual waste is freed of coarse ferrous metal fractions by a magnetic conveyor belt running above it and passes into an intermediate buffer bunker.

A second process crane, also fully automated, passes the crushed waste from this buffer bunker to composting boxes. The third generation of the Box System is equipped with an airtight lid system. To prepare the filling process, the process crane uses an ancillary lifting system to raise the lid of each empty box and then places it under assistance of a guide rail system on a neighbouring box. Each of the Boxes has an effective volume of approx. 600 m^3 and can take about 300 metric tons of waste. During the filling process, the filled level of the Box is automatically monitored by the crane system.

Once the Box has been filled, the crane lifts the lid and closes the box rendering it air tight.

Due to the fully automated operation no manual activities are required in the bunker and decomposition hall.

Biothermal drying

An aerobic degradation process is started after closing the Ladurner Box System, which is in principle an *In Vessel Composting System* with computer control and forced aeration. But the process is specifically not designed as a traditional composting process, where the maximum amount of organic material has to be degraded. The target is here to remove as much water from the waste as possible in a short time by generating biothermal energy. That means, the biological heat produced during this process is used to remove the moisture from the material using the ventilation system of the Box. The material to be biodegraded, is the easily degradable organic matter, which is the reactive part in the organic fraction.

The main reasons for drying the waste are as follows:

a) Dry waste (smaller than twelve percent moisture) with a minimized content of reactive organics is stable.

b) Only a dry waste can be effectively separated into the different fractions of recyclable materials. Historically all attempts to separate wet waste have not achieved adequate results.

Due to an automatic control system adjusted to the requirements of the biological conversion process, the easily degradable organic substances in the composting boxes are converted into heat during a brief six-day aerobic biodegradation process. This heat is used to evaporate the humidity and thus to dry the residual waste. No external heat is required for the drying process. The water is removed from the moisture saturated air by means of a heat exchanger system, and this condensate is subsequently cleaned in a water treatment unit.

Due to the individual control of each composting box and the segmental air supply, it is possible to guarantee even and efficient drying. The relevant data such as heat quantity, temperature curve, and CO_2 discharge are entered into the process control as is the air permeability of the waste.

In an optimum bioconversion process, the mass is reduced by up to thirty percent in only six days. The dried waste then has only a residual moisture content of less than twelve percent and thus very good properties for the subsequent mechanical separation treatment.

Following the biological drying process, the pre-treated waste is moved by a process crane to a buffer bunker equipped with a *walking floor* conveyor. From here the waste is automatically transferred in batches to the separation machinery.

Intensive decomposition in the Box System

Intensive decomposition occurs in the air and liquid tight, closed Ladurner Box. This Box is made of concrete and is insulated. Hence, the degradation processes in the interior of the box can proceed regardless of the climatic conditions outside the box.

During intensive decomposition, the easily decomposable organic substances are microbiologically transformed within the shortest period of time using a process-controlled air supply that is adjusted to the biological requirements. The control system of the Box is adjusted to CO_2 production and temperature.

The space underneath the perforated floor plate is subdivided into segments. Every 2.5 metre segment is constructed in form of a pressure chamber. This enables the air supply to be controlled separately for each 2.5 metre section and the material to be ventilated and dried homogeneously.

To produce optimum climatic conditions for the degradation process, there are a total of four different air flows possible. These are automatically regulated by the computer according to the oxygen requirement, based on CO_2 production, and the temperature of the material to be decomposed.

The four air flows are divided into:

- fresh air (from the air extraction in the halls)
- pre-heated fresh air
- uncooled circulating air
- cooled circulating air

By the circulating airflow , there is a homogeneous ventilation flow within the material which averages about 100 to 125 $m^3/h/m^2$. With this, the pore volume of the material can be maintained to an optimum and the drying process is accelerated.

The exhaust air, arising from this stage of decomposition contains significant quantities of steam, CO_2 and odorous substances. This air is extracted and either directly mixed back into the additional air (uncooled air) or directed over the air-water-heat exchanger. Here it can either be added additionally into the air circuit as cooled air or it is sent to the Exhaust Air Treatment System in proportion to the fresh air. The fresh air needed for the composting boxes is taken from the interior of the process hall and reception area.

The main air/water-heat exchanger transfers the process heat from the exhaust air to the cooling water circuit. Here it can be optionally used for low temperature heating devices. Excess heat is released into the atmosphere by means of an open evaporation cooler.

The odour, that is distinguishable by the human sense of smell is water-soluble. That is why this part of the smells can be eliminated from the exhaust air by condensation. Tests have shown that appr. sixty percent of the total odour can be trapped this way.

When it is cold or the delivered material is very cold, the air circulation ensures that the heating up phase is shortened until the operation temperature has been achieved.

The computer control also makes a *mixed air operation* possible. This enables the optimum temperature adjustment and CO_2 content during various composting periods. The reason is always, to minimize the amount of exhaust air whilst keeping the aerobic condition in the system at an optimum.

Each box is equipped with an independent control unit. The process is permanently supervised and controlled by the computer during the six days process. At adjustable time intervals, the nominal and actual values of the different measuring parameters are compared. The PLC automatically resets the course of composting of each box. The modular construction of the Ladurner plant also permits different *nominals* for each single Box and load. All data is logged in a central processor and evaluated. The data output is possible either using a display unit or printer/plotter. In case of a failure of the PC the individual batch parameters are stored until the completion of a complete process period and can be downloaded when the PC is reactivated.

All disturbances in the process that may arise at any one of the Boxes and with each single load are logged and can thus give information about the effects on the course drying.

The data in the PLC is stored for ten days. In case of failure of the central computer they can be recovered.

Creating a fuel from waste

The biological drying to a residual water content of smaller than twelve percent decisively improves the ease with which the waste is mechanically separated. This is the essential prerequisite for the efficiency of the automated waste separation and for the sorted quality of the fractions extracted.

The material separation separates the dry waste flow into three basic fractions:

- Fuel
- Ferrous and non-ferrous metals
- Inerts (stones, sand, glass)

An important characteristic of the material separation, especially the separation of the light-weight fraction, is that due to the well positioned use of several air classification and sieving processes matched to each other, a very precise separation between light (combustible) and heavy waste components (metals, inert materials) is achieved and thus a high fuel quality is guaranteed.

The remaining Ferrous and non-ferrous constituents (lids, aluminium foils, etc.) are removed from the dry, light weight material using magnet and fluidised bed separators. This treated light-weight fraction, the, now consists of virtually hundred percent combustible materials such as wood, paper, plastics, textiles and organic matter. The renewable energy fraction contained in the (wood, paper cardboard, organics) is around two/three, thus enabling the provision of CO_2-neutral energy.

The quantity of the light fraction obtained through the separation of the inert material is only about fifty percent by weight of the initial quantity of the MSW input.

A clear two-stage increase in the heating value is achieved through the *biological drying* and *inert material separation* process steps, to a level of 15 20 MJ/kg (6,900 to 9,100 Btu/lbs). The calorific value of the lies within the range of and thus represents the energy equivalent of treated, dried lignite coal.

Due to its dry consistency, is very easy to store and can thus be used as a secondary fuel in industrial processes when it is required and independent of the amount of waste generated.

In order to achieve high fuel qualities for Stabilat, a nearly quantitative separation of the lumpy ferrous and non-ferrous metals and batteries is carried out, in addition to the separation of minerals. This is because the metal fraction in particular contains a high percentage of the heavy metals. Many ferrous metals are finished or protected with corrosion-inhibiting surfaces (chrome, nickel, zinc). Batteries have casings of steel, or a large share of the metal fraction itself consists of the heavy metals copper, lead or other alloys. It has been established that up to ninety percent of the heavy metals in waste are to be found in the metal fraction. An optimal separation of the metal fraction therefore leads unavoidably to a significant reduction in the heavy metal content of the fuel and thus to a significant improvement in quality in regard to use as a secondary fuel. The removal of heavy metals associated with the removal of metal parts and batteries is of decisive importance for the use of as a secondary fuel. This reduces the heavy metal load by up to ninety percent compared to that of residual waste.

Heavy fraction

The heavy fraction gained from the initial density sorting process is subjected to further treatment stages.

With the separation of the combustible residues (organic matter, plastics), the overall organic content (expressed as ignition losses) are reduced and a material quality is achieved that can for example be used for the construction of landfill sites. The combustible fractions separated out are added to the .

The separation of electronic scrap, iron and non-ferrous metals using magnetic and Eddie current separators produces a marketable product, the income from which helps to reduce the overall treatment costs..

3. Section 2

This section has a technical processing capacity of up to 100,000 t per year and it disposes of eighteen bio-drying boxes working according to the Ladurner system, ten from the former composting plant, and eight new construction.

These boxes are not filled with an automatic crane, but with traditional front loader, and are smaller than section 1 ones (up to 450 m^3 instead 600). The control of the process is the same.

Other difference is a simplified material selection line after the biological treatment, thus to reduce maintenance costs, and focusing the process in

4. Mass balance

The average mass balances of the plant is shown in the following chart. There is a substantial correspondence between the data of the project and the forecast, with a percentage of process loss higher than thirty percent in form of condensate with low organic rate, with an RDF yield slightly higher than expected, and with a percentage of separated inerts slightly lower.

Table 1: Mass balance of the RDF production plant

Fraction	Section 1	Section 2
	%	
RDF	56.17	53.57
Inerts	9.58	10.50
Ferrous metals	2.29	1.70
Nonferrous metals	0.38	0.26
Process loss	31.59	29.46

Source: Vesta Spa

Those data are of utmost importance, especially considering they are associated to a complete recovery of the sorted fractions, except the inert materials.

5. RDF characteristics

The RDF resulting from the sorting process is made up in three different ways, as fluff, as it comes out of the plant, pellettized and in bales.

Table 2: Chart: average characteristics of the RDF produced at the Fusina plant

Reference parameters	Values provided for by DM. 2/2/98	VESTA S.p.A. plant for the RDF production at Fusina (VE)
P.C.I	min 15.000 KJ/kg	18000 KJ/kg
Humidity	max 25 % (in mass)	9,33 % (in mass)
Chlorine	max 0,9 % (in mass)	0,48 % (in mass)
Sulphur	max 0,6 % (in mass)	0,21 % (in mass)
Ashes	max 20 % (of dry material in mass)	17,5 % (in mass)
Pb (volatile compounds)	max 200 mg/kg (of dry material in mass)	Pb volatile = 96 mg/kg (of dry material)
Cr	max 100 mg/kg (of dry material in mass)	34,9 mg/kg (of dry material)
Cu (Soluble compound)	max 300 mg/kg (of dry material in mass)	Soluble compound = 53,9 mg/kg (of dry material)
Mn	max 400 mg/kg (of dry material in mass)	116 mg/kg (of dry material)
Ni	max 40 mg/kg (of dry material in mass)	15 mg/kg (of dry material)
As	max 9 mg/kg (of dry material in mass)	2,8 mg/kg (of dry material)
Cd + Hg	max 7 mg/kg (of dry material in mass)	< 2,6 mg/kg (of dry material)
T softening ashes	only indication	> 1160 °C

Source: Vesta Spa

This differentiation became necessary after a valuation of the requirements of the destination plants and of the problems of stocking, movement and transport of the product.

As far as the quality of the obtained fuel is concerned, the chart below shows the average of the product analysis carried out until now. Please note the high calorific power (there have been peaks major than 20,000 kJ/kg), and the fact that all heavy metals are present with a far lower concentration than allowed by the D.M. 5th February 1998 which defines the characteristics of RDF according to authorizations. A further important aspect is the humidity of the material, which is very low, proving thus the efficacy of the inactivation process to which the waste underlies.

6. Use of the RDF

The RDF produced at Fusina has been used in four kinds of plants, during the past twelve years:

- Incineration plants with a grid furnace with water-cooling system, requiring fuels with a high calorific value. These plants are constructed to burn waste fuel in a percentage of up to hundred percent with the same process parameters (smoke temperature, steam pressure) of conventional incineration plants. Such plant can burn fluff as well as pellets.
- Bubbling or circulating fluidised bed boilers. These can also process up to hundred percent of RDF with process parameters corresponding to the ones of incinerators. The circulating fluidised bed boilers can process both fluff and pellets, whereas bubbling boilers can only process pellets.
- Biomass furnaces. These are furnaces which usually use a special grid to burn refuse of processed olives or tendrils, etc. They can accept only limited amounts of RDF (around forty percent). They can process fluff or pellets.
- Cement factories. These are rotating furnaces that achieve temperatures around 1,400 °C in which the RDF is fuelled in a limited percentage in addition to the main fuel which is coal.
- Thermo electric power plants. An experimentation which is being carried out plans the injection of pulverized RDF together with slack. The percentage of used RDF is very low (five ~ ten percent), however it is significant considering the high potentiality of the plants.

Currently we are conveying to the thermoelectric plant in Fusina up to 70,000 t/y of RDF with the possibility, now that Enel has implemented some changes in the cooling system of thermal units and the percentage of co-combustion is increased to ten percent, to increase these quantities up to 100,000 tons/year.

The goal of 100,000 t per year of enhanced RDF would save about 65,000 tons of coal with a reduction of CO_2 released into the atmosphere equivalent to 93,000 tons per year.

In the following graph, energy balance is presented a comparison of the energy balance in case of use of MSW directly in WTE plant or in the case of the supply chain in Fusina.

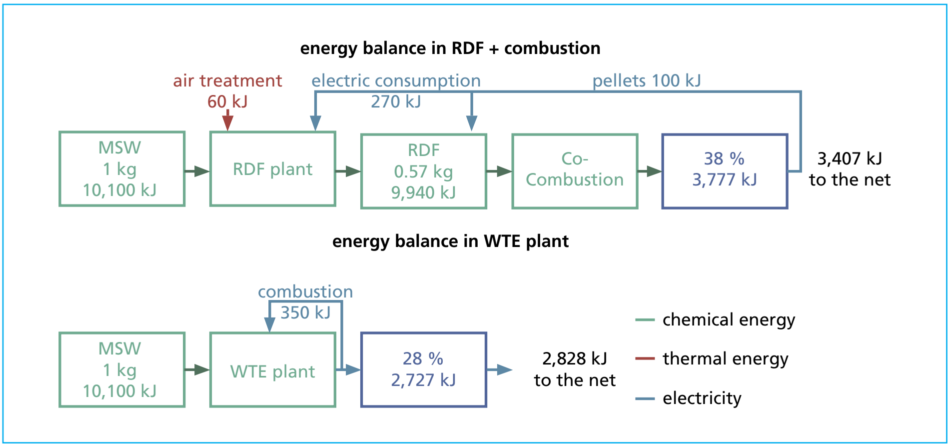

Figure 2: Comparison of the energy balance in case of use of MSW directly in WTE plant or in the case of the supply chain in Fusina

7. Conclusions

Twelve years of continuous management of a facility such as Fusina gave us many suggestions for improvement of the process.

Moreover, the experience of co-combustion at the power plant represents a case study in the EU, which provided unequivocal data on the environmental goodness of this option.

In summary:

- The RDF high quality allows its use in systems not designed for waste,
- the co-combustion is competitive with incineration,
- it is also suitable for medium-sized basins (300,000),
- the environmental balance is positive,
- dumping is reduced up to ten percent (or less).