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International Conference on Industrial Waste & Wastewater Treatment & Valorisation 21. – 23. May 2015

CombiTech Waste Treatment Process for mixed unsegregated Municipal Waste with no Presorting and no Residues

Abstract:

Waste separation at the source (in the household) makes collection costly for the city. In addition the housewives are usually not careful so that additional separation in the plant is again required in order to safeguard the process agains unwanted congestions and contaminations.

The CombiTech process treats mixed unsegregated waste in two stages. Each stage works in a liquid environment which allows an easy and automatic separation by gravity and screening.
The first stage uses the automatically separated organic fraction with anaerobic digestion to generate electricity and high quality compost fertiliser.

The residues from the first stage are plastics, wood, textiles which are treated by gasification, again into an energy rich gas and subsequently into electricity. This fraction contains highly toxic components (halogens and heavy metals) and a direct gasification would release these components into the atmosphere.
The solution is to liquefy this fraction in a specific salt solution, in which the toxic ingredients can be eliminated with simple chemical neutralising rteactions. Te remaining liquid is absolutely free from toxic components so that also the generated gas burns only into water vapour and CO_2, without any complicated filter installations.
The only finally remaining components are the mineral raction (stomes, sand, broken glass, ceramics, etc.) which then can be safely mixed with concrete or asphalt.

The results from the practically 100% use of the input material is a very high energy output which exceeds any existing technology such as anaerobic digestion or incineration.

Key Words:

municipal solid waste; mixed waste; biogas; synthesis gas, electricity generation; compost fertiliser

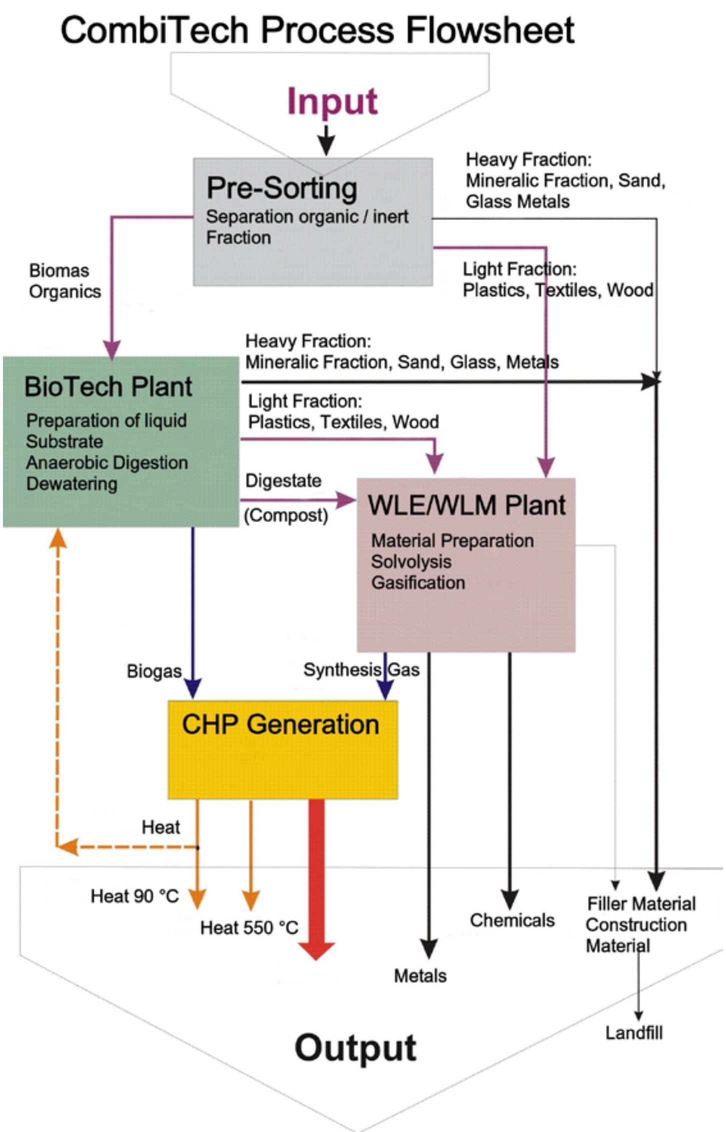
1 Introduction

Separation at source of municipal waste is still rare. Most countries find it too expensive to install such a system.

The CombiTech process takes care of this situation and transfers the separation process into the waste treatment factory. This also acknowledges the fact that the housewife usually is not very careful and an aftersorting in the factory is usually still required.

Why CombiTech? CombiTech is a two stage process consisting of an anaerobic digestion stage specifically for the biodegradable organic material and a gasification stage for the entire residues such as plastics, wood, textiles, leather, etc. This allows to convert the entire waste stream (excluding the mineral fraction consisting of stones, sand, broken glass, ceramics, etc.) and accordingly to extract the maximum of energy from the input material.

The CombiTech process can treat all „soft“ waste materials, that means any kind of plastics and organic waste and convert them into energy. Accordingly from the initial waste volume less than about 5% of its original volume remain, and even this mineral fraction can be mixed as aggregate into concrete or asphalt thus clearly achieving the “zero waste” target.



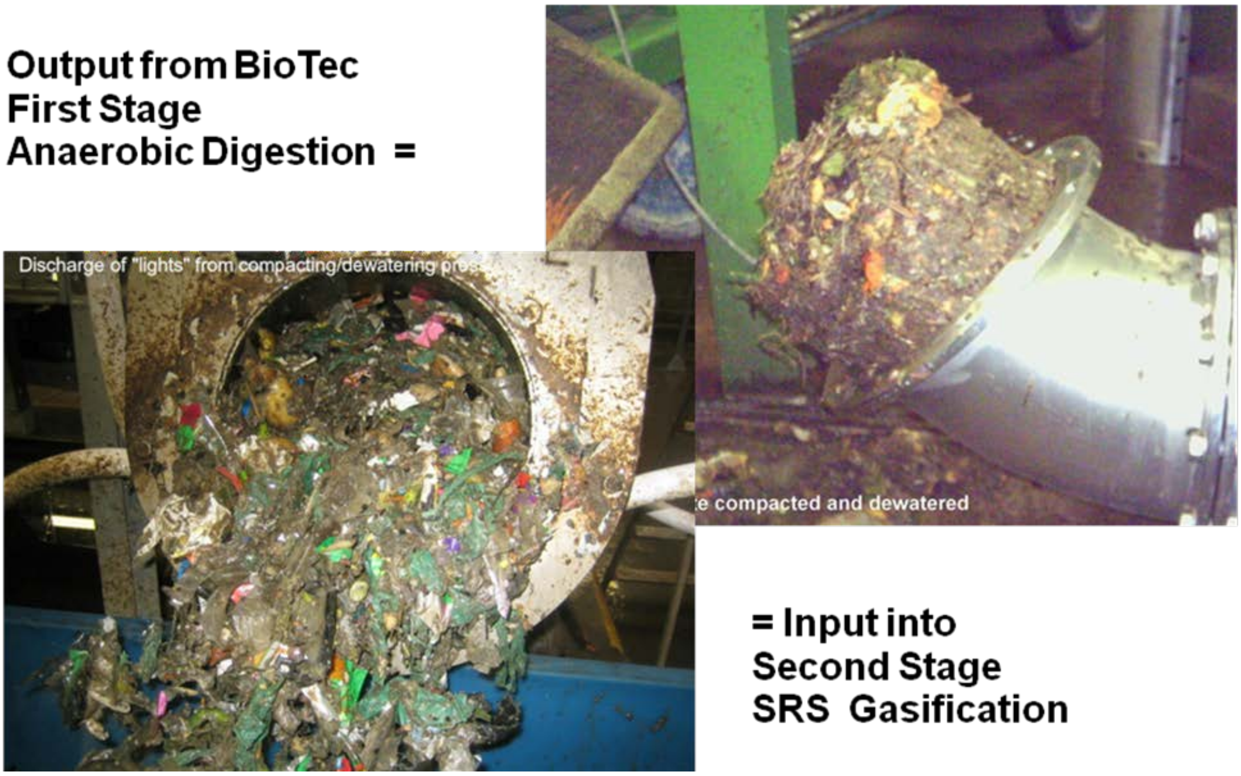
Accordingly waste replaces the use of fossil fuel thus avoiding the emission of additional global warming gases

2 The CombiTech Waste Disposal Concept

The proposed waste treatment plant consists of two parts, the first part for treating the organic fraction by anaerobic digestion (BioTech)
and the second part for treating all the remaining residues by a specific gasification technology such as plastics, celullose/ lignin fraction and possibly also the non digestable compost substrate fraction from the digestion plant, all materials which are not accessible to the biological attack of bacteria.

Obviously anaerobic digestion is a standard technology which requires little additional explanation. Our approach however is somewhat different: We have added a liquefaction stage at the beginning of the preparation process with special turbo disintegrators whereby the organic fraction is disintegrated into a slurry while all the inerts such as plastics, wood, stones, batteries etc. are not affected. Now in liquid phase an easy automatic separation by gravity and sieving allows to separate them from the organic slurry. The result is an unproblematic digestion process without scum layers and resulting in a high quality, ultra clean compost substrate with 99,5% pure organic content which can be sold for 50 to 100 Euro/ton.

The residues from the first anaerobic digestion stage form the input material for the second gasification stage. This is a wild mixture of plastics, cellulose/lignin, textiles, rubber, etc. which usually ends up on landfills or in incineration.



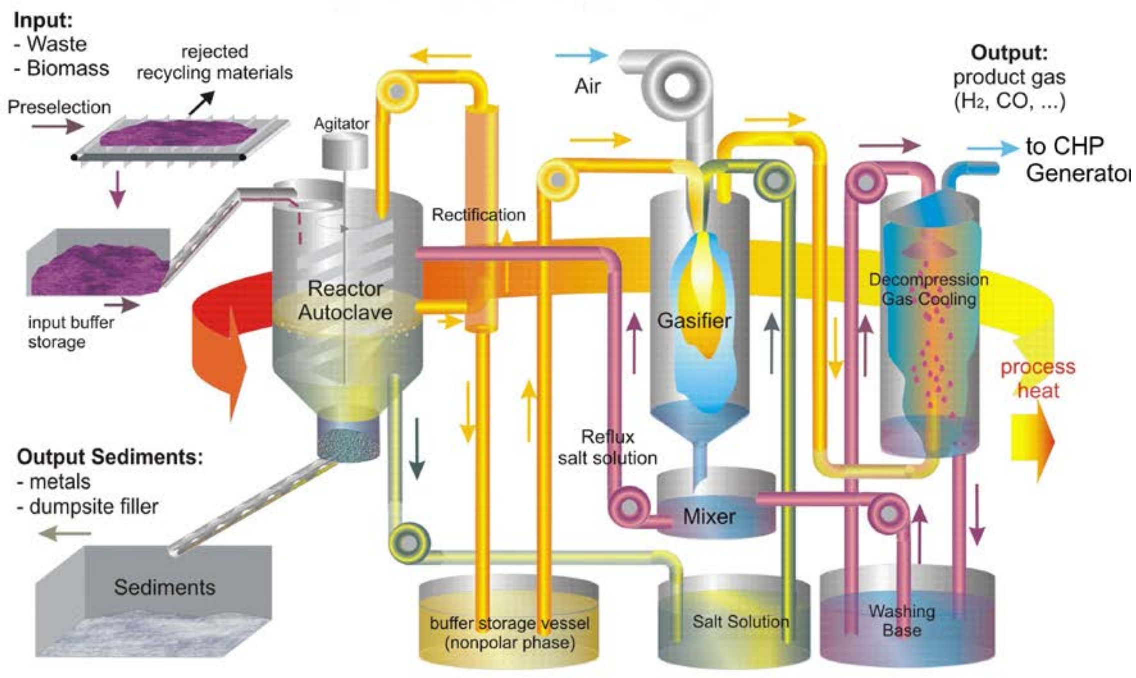
Gasification also is not a new technology. However all the proposed technologies work from solid material, with no possibility to extract the toxic/hazardous contaminants, basically various tar components, different halogens and heavy metals, which during gasification remain in the generated synthesis gas, and after conversion into energy are emitted directly into the environment. Filter installations have only a limited effect, and they pose an additional environmental problem when the highly contaminated filter dust has to be disposed of.

The proposed gasification stage again is different from all existing gasification technologies! Our approach with our new SRS technology (Selective Residues Solvolysis) includes a liquefaction stage before the actual gasification.
By mixing the input materials into a watery salt solution and with specific additives, approx 200 °C and 5 bar pressure we can achieve a first disintegration of the molecules which **renders them soluble.** Now – in liquid phase – all the hazardous molecules can be converted into harmless substances, for instance chlorine by adding sodium hydroxide is converted into simple cooking salt, and heavy metals by adding sulfides is formed into metal sulphides, which are all insoluble and can be eliminated as sediment.
When lignin (wood, straw) is gasified, a common problem is the formation of tar which creates problems in the subsequent CHP unit. The above mentioned initial molecular degradation also removes any tar forming agents, so that the tar problem no longer exists.

An additional advantage of this so called Solvolysis stage is the 100% recovery of metals from E-waste. While the plastic parts are converted into liquid, the metals remain as pure metal or as metal salts and can be easily recovered by any metal refinery. With recovery of only 2 -4 % metal from the waste stream and its sale on the metal exchange the revenues are boosted by 50 – 100%

(as compared to sale of only electricity) which makes the technology extremely profitable with payback periods of 4 – 6 years.

Equipment List (Flowsheet) WLE-Technology



The result from the above described two-stage process is an absolutely clean synthesis gas, which – with no additional filters – just burns into water vapour and CO_2, an ecologically extremely positive result!

3 Products from CombiTech Process

The most important products resulting from the CombiTech process are:

a) Biogas is an inflamable gas which consists 65 - 70% of methane (practically natural gas). About 25 % are inert CO_2. The calorific value of biogas is in the order of 6,5 kWh per standard m^3.

This gas like natural gas may be used directly in an industrial plant (such as ceramic, brick, cement, chemical plants etc.). It can also be purified and used as gaseous fuel for vehicles or may fed into the city gas grid.
But the most frequent use is the immediate conversion into electricity in a local CHP power plant.

b) The SRS process as second stage generates a clean synthesis gas consisting of hydrogen and carbon monoxide (H_2 + CO).

c) The proposed technology, apart from electricity also generates substantial quantities of excess of high and moderate temperature heat (95 °C from cooling water of the CHP unit as well as 500 °C from exhaust flue gas).
In case no consumer of thermal energy is available in the vicinity, this excess heat may be converted into absorption cooling energy, and here again into moderate temperature cooling energy (- 5°C for example for air conditioning etc.) as well as deep freeze cooling energy (- 25 °C for cold stores and similar).

d) The SRS technology allows to extract any metal 100%, even smallest particles which are normally not detected by rag pickers. The sale of such recycled metals, especially non-ferrous metals, with current metal prices will substantially increase the overall revenues.

4 Great Variety of Input Materials

Municipal Household Waste is a very problematic substance due to its heterogeneity and inconsistency. It consists of an undefined mixture of organic material with varying degrees of inert materials. Thus a plant for treating of household waste requires a high degree of flexibility

The CombiTech process can treat this great variety without an presorting or source segregation.

BioTech Process

- **Organic waste from households, restaurants, supermarkets (expired foodstuff), garden and park trimmings in various compositions**
- **Agricultural wastes such as remains from olive pressing, from canning of citrus fruit, from grapes after pressing, etc.**
- **Slaughter houses waste**
- **Sewage sludge from waste water treatment plants**

SRS Process

- **Any type of plastics, including PVC**
- **Any type of wood (trunks, branches, chips, saw dust, also treated and contaminated wood like railway sleepers, used furniture etc.)**
- **Any type of textiles, diapers, hides**
- **Straw, stalks, reed grass, rice straw,**
- **Also digestate/compost from anaerobic digestion processes (if not saleable)**
- **Shells, stones, kernels, husks from nuts, fruit, grain**
- **No limitation in respect to input moisture**
- **No limitation in respect to dirt, contamination; no specific requirement for purity or composition of the input waste**
- **Safe elimination of toxic input such as Cl, S, Br, Cr, Hg etc.**

residual waste compacted and dewatered

Discharge of "lights" from compacting/dewatering pres

Output from BioTech Process
=
Input for SRS Process

Samples of different Input Materials:

5 Basic Features BioTech Process (Anaerobic Digestion)

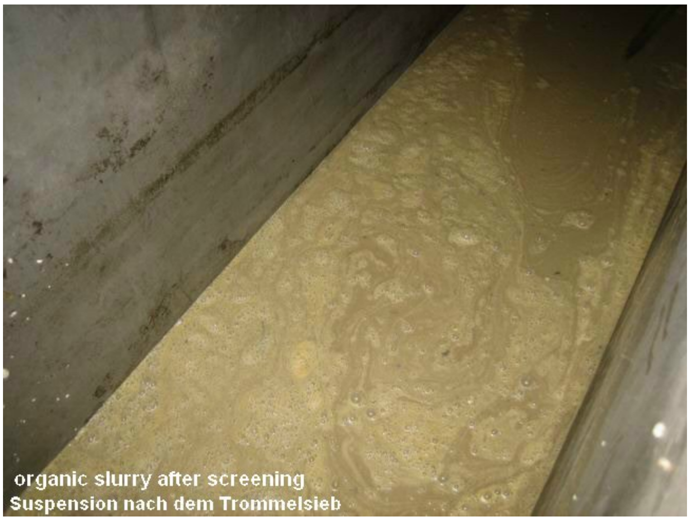
5.1 Preparation

We just want to show your certain basic machinery.
Below is the turbo dissolver where the organic fraction is disintegrated into a fine slurry, while the inert fraction remains unaffected, so that an automatic separation by sedimentation and/or sieving becomes possible.

High speed turbo-dissolvers

turbodissolver inside view after slurry discharge

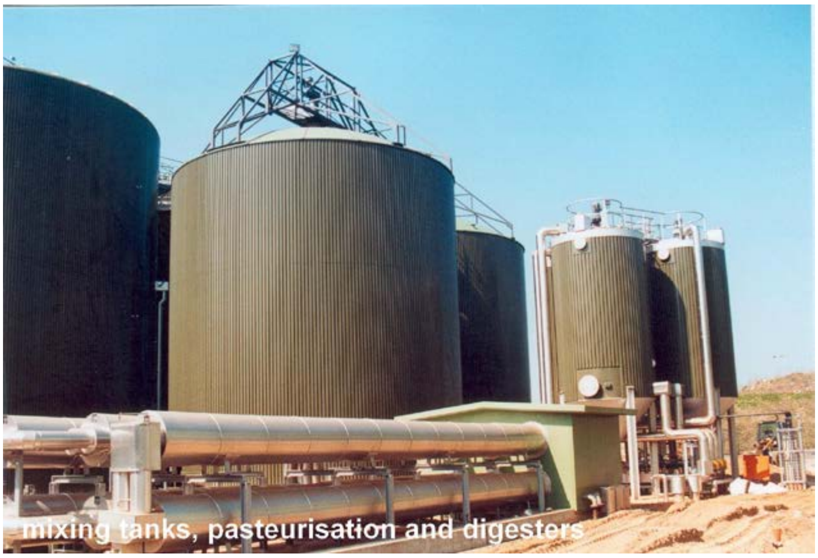
rotating screen for separation of "lights" from slurry



organic slurry after screening
Suspension nach dem Trommelsieb

heavy weight residual waste fraction

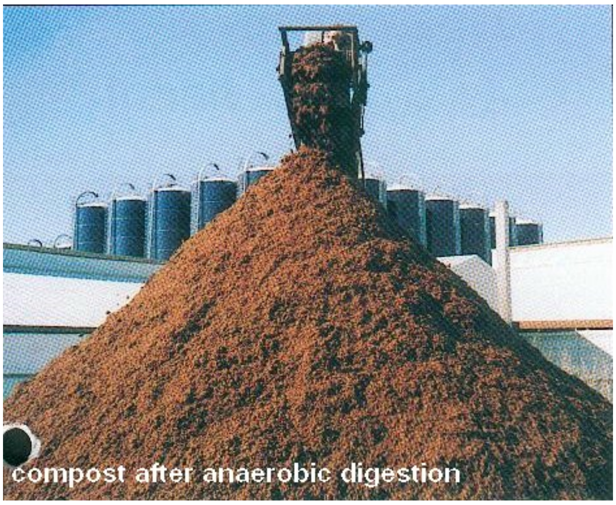
5.2 Pasteurisation, Fermentation


mixing tanks, pasteurisation and digesters

This is now a standard procedure which you all know. The slurry produced from the turbo dissolver is pasteurised (retention for one hour at 70 °C) in separate tanks in order to immobilise pathogens and active seeds.

In the digesters the slurry remains in average 15- 18 days.
Micro -bacteria start the fermentation process and disintegrate the organic material thus forming the Bio-Gas.
The slurry in the digester will be constantly mixed by reintroducing part of the generated biogas.
In a continous process fresh slurry is fed into the Bio-Reactor and simultaneously fermented liquid is drained from it.

5.3 Treatment of final Products


compost after anaerobic digestion


gasmotor-generator set


compost

The liquid fraction of the digested slurry is dewatered in a centrifuge in order to separate the remaining solids. This solid fraction, called Bio-Compost, forms a stable soil substrate, a compost-like material with an agreeable smell, which may be directly used for soil improvement in agricultural applications.
As you can see there is no plastics and no glass or other inert materials left

The generated gas is transported into a gas storage tank via filters suitable for drying and purification (elimination of Hydrogen Sulfide H_2S) from where it is conveyed to the CHP motor-generator set. Biogas in case of maintenance of the generator set.

6 Basic Features SRS Process (Selective Residue Solvolysis)

6.1 Preparation of Waste Input Material

The waste is dumped into the receiving area and then picked up by a payloader and fed into a coarse shredder which reduces particle size to about 20 mm.
The material may contain up to 50% of moisture; no drying is required!

The actual conversion process takes place in three stages:

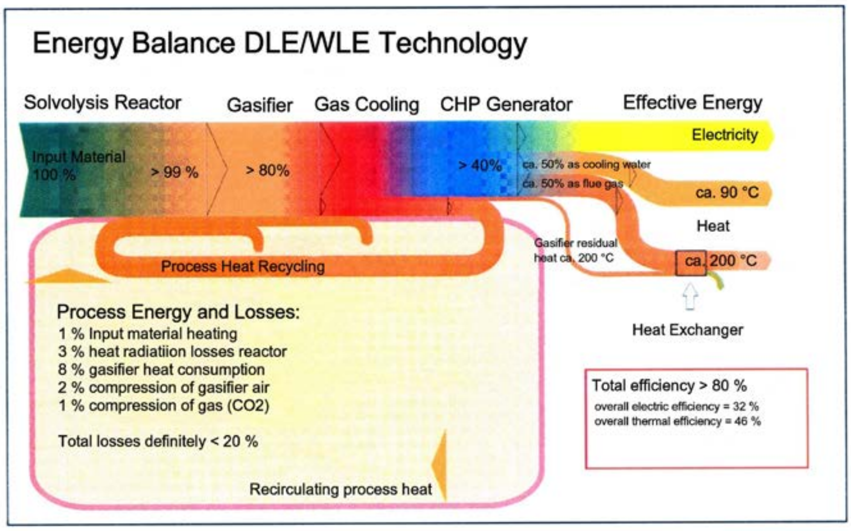
6.2 Liquefaction

Pre-shredded input materials are filled into the reactor vessel and mixed into a saturated alkaline salt solution.
A chemical reaction at 200 °C / 6 bar loosens the bonding of the molecular structures, causing disintegration and dissolving of the lignine and plastics materials into a variety of soluble organic salts.
Mineral (unsoluble) particles sediment at the bottom of the reactor vessel from where they are extracted.
If necessary special additives bind toxic elements such as Chlorine, Bromine, heavy metals etc. into unsoluble compounds which are also eliminated by sedimentation
The remaining solution consists of pure organic energy-rich salts.

6.3 Gasification

The liquid solution is pumped to a gasifier. Since all cellulose/lignin containing compounds have been broken down, the resulting synthesis gas (H_2 + CO) is absolutely clean and **free from tar**.
Alkaline salts from the solution precipitate in form of a smelter along the walls of the gasifier from where they will be recovered for reuse in the reactor.

6.4 Energy Conversion Efficiency > 80%



The generated synthesis gas is decompressed and cooled down and taken to a CHP motor-generator.
Overall energy conversion efficiency is 80% of which 40% will be recovered inform of electricity.
Excess heat amounting to 60% of the recovered energy is available for the process itself, but also for external use with various options such as

- cooling energy
- additional electricity generation (ORC)

7 Some Economic Facts

Calculation of a typical 100.000 t/year MSW installation:

A) Investment Costs (Capex)

- Machinery ex works	Euro	57.000.000
- Civil works, buildings	Euro	2.500.000
- Transport	Euro	500.000
- Erection, commissioning	Euro	1.100.000
- Engineering, Planning	Euro	1.250.000
Total	Euro	62.350.000

B) Operating Costs (Opex)	Euro/year
- Salaries (8 operators)	350.000
- Electricity (consumption)	320.000
- Auxiliary Materials	150.000
- Maintenance	850.000
- Various, others	450.000
- Depreciation	4.290.000
- Licence Fee, Telemonitoring	480.000
- Total	6.890.000

Calculation of a typical 100.000 t/year MSW installation:

C) Turnover

- Electricity 70.000.000 kWh/year à 0,10 €/kWh (installed capacity 9,0 MW)	Euro	7.000.000
- Compost 30.000 t/year à 20 €/t	Euro	600.000
- Tipping/gate fee 100.000 t/year à 20 €/t	Euro	2.000.000
- CDM CO_2 certificates 47.000 t/year à 10 €/t	Euro	470.000
Total		10.070.000

D) Profit

- Income/turnover	Euro	10.070.000
- Opex	Euro	6.890.000
- Profit	Euro	3.180.000

E) **Possible additional revenues:**

- **Sale of thermal energy**

100.000.000 kWh à 0,03 /kWh	**Euro 3.000.000**
or equivalent cooling energy	
70.000.000 kWh à 0,10 €/kWh	**Euro 7.000.000**

- **Recovered Metals**

iron scrap 750 t/year à 200 €/t	**Euro 150.000**
copper 750 t/year à 4900 €/t	**Euro 3.675.000**
other non-ferrous metals 700 t/year	**Euro 960.000**

8 Summary of Ecological/Economical Highlights

- **Treatment of all Carbon containing materials in various compositions, no pre-segregation, no cleaning, no drying required**
- **Large variety of input materials**
- **Utilisation of garbage from existing landfills (Urban Mining)**
- **No Residue Technology, no landfills anymore**
- **High energy conversion efficiency**
- **No smell, no noise, no leachate**