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SOLVENTURE

A combined two-stage Process to "Zero-Residue" Solution

Processing and Disposal of unsorted, unsegregated Muncipal Solid Waste

Presentation at ATHENS2014 International Conference on
Sustainable Solid Waste Management

Abstract:

Municipal waste should not be considered as a burden but rather as a valuable input material for material and/or energy recycling, with generation of sufficient income to make such plants not only self sufficient but rather a highly viable investment opportunity

To implement a plant which will fulfils these targets, the following prerequisites should be fulfilled in order to match the conditions prevailing in most countries:

- No source segregation. The entire waste should be sorted and treated more or less automatically in the factory
- Wide range of possible input materials in order to treat the entire range of waste materials
- Ability of the plant to treat input materials without predrying and precleaning
- Possibility to recover valuable recyclables such as a variety of plastics, but also any type metals, also with small particle size and/or as compound with plastics, as we can find it nowadays in electronic devices
- Treatment of any remaining waste material which has no recycling value, in form of electric and thermal and/or cooling energy.
- The selected technology must not only avoid solid, liquid and gaseous emissions but should also avoid sophisticated filter installations, which poses again the problem of disposal of highly contaminated filter dust.

This presentation describes a two-stage technology which can achieve these targets, consisting of first stage anaerobic digestion and second stage gasification of the residues from the first stage. The gasification stage however before actual gasification includes a liquefaction of all the input materials into a watery solution (Solvolysis), which allows to eliminate **all** toxic/hazardous components with simple chemical reactions. Only the purified slurry is gasified, generating an absolute clean synthesis gas which avoids filter installations completely.
Since the process is water based, no predrying of the waste is required, thus allowing a conversion efficiency of the waste into energy of over 80%.

Key Words:

Municipal Waste; Anaerobic Digestion; Gasification; Liquefaction; Solvolysis

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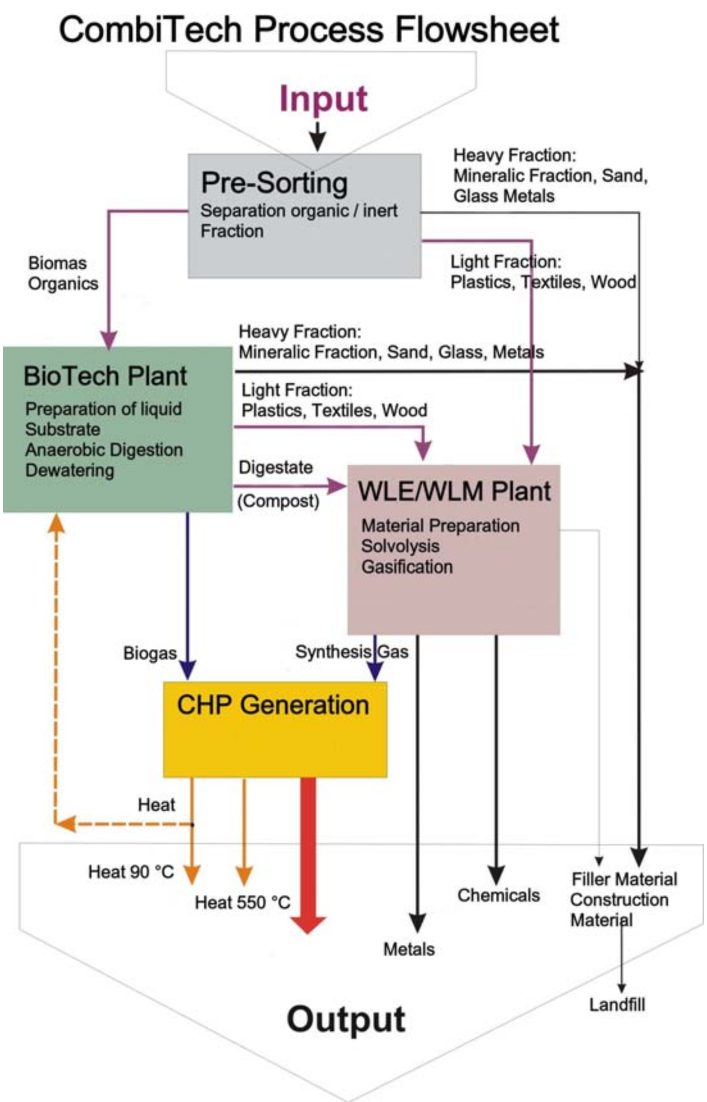
A combined two-stage Process to "Zero-Residue" Solution

Processing and Disposal of unsorted, unsegregated Muncipal Solid Waste with our patented CombiTech Process

1 Introduction

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 only the mineral fraction will remain as residues such as sand, stones, broken glass, etc. usually to less than 5% of its original volume, and even this mineral fraction can be mixed as aggregate into concrete or asphalt thus clearly achieving the "zero waste" target.



The simultaneous generation and sale of an energy-rich gas and/or the resulting electricity as well as the recovery of recyclable materials from the waste stream such as all metals, even smallest particles which will not be discovered by scavengers as well as certain valuable plastics fractions (such as PET) not only cover the operating costs but result in considerable operating profits for the plant.

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

2 The CombiTech Waste Disposal Concept

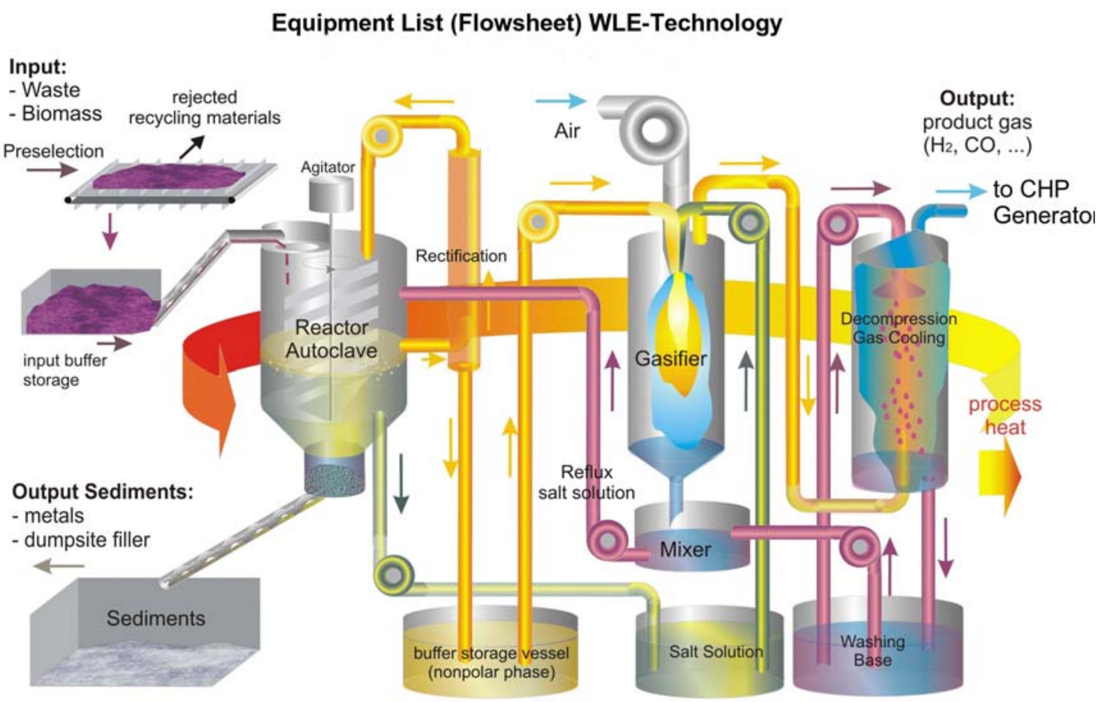
The proposed waste treatment plant consists of two parts, the first part for treating the organic fraction by anaerobic digestion (BioTech) and the second part for treating all the remaining residues by a specific gasification technology such as plastics, celullose/ lignin fraction and possibly also 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 as 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 a unproblematic digestion process without scum layers and of course 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 gasifcation 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 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.

We have again developed a different approach with our new SRS technology (Selective Residues Solvolysis). Before the actual gasification we have inserted a liquefaction stage. By mixing the input materials into a watery salt solution and with approx 200 °C and 5 bar pressure we can achieve a first disintegration of the molecules which renders them soluble. Now – in liquid phase – by adding specific additives, 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 usually insoluble and can be eliminated as small grains.
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.



SRS Flow Sheet

The result is an absolutely clean synthesis gas, which – with no additional filters – just burns into water vapour and CO_2.

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.**

Output from BioTech Process
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Input for SRS Process


Waste Input Material

Supermarkt-Abfälle


Material washed ashore or on weirs


Reisstroh
rice straw

5 Basic Features BioTech Process (Anaerobic Digestion)

5.1 Preparation

Garbage is delivered by truck into the preparation building. This building is equipped with exhaust fans and bio-filters, which assure that no smells escape into the environment.
The waste is directly emptied into a storage area. This stock can bridge a one-day-delivery of waste. The waste passes a coarse screening machine(> 80 mm). The oversize practically contains no organic material and will pass a sorting conveyors, where a certain amount of recyclables such as paper, metals, different plastic, glass, may be sorted out, while the remaining bulk of inert material shall be sent to to the second process stage, the SRS process line.


High speed turbo-dissolvers

The undersize material from the screen (< 80 mm) will contain the bulk of the organic material but still approx. 20 – 30% non organics. This material passes a magnetic metal separators before it is crushed once again to about 25 mm and then transported to the turbo-disintegrator tank.

Water is added and by imposing high shearing forces, the organic material is disintegrated down to fibre size to form a pasty slip, while the inert materials are practically not affected.

Heavy components like broken glass, batteries, stones, metal parts etc. are sinking to the bottom and are discharged from the slurry via steep worm conveyor. They are eliminated via a double valve lock.


turbodissolver inside view after slurry discharge

The slurry is gradually emptied onto a vibrating dewatering screen. The non-disintegrated inert materials are then compacted and dewatered in a pressworm separator. The screened slurry passes a sand separation tank.


rotating screen for separation of "lights" from slurry

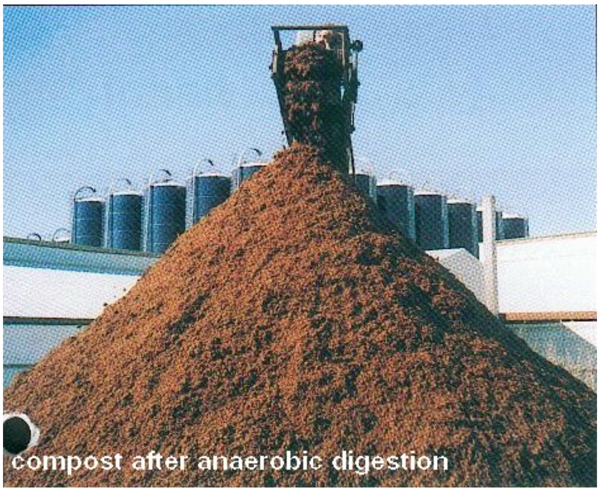
The remaining slurry, now practically pure organic material, is collected in an underground reservoir and then pumped to the buffer tank holding a storage capacity of 2 – 3 days in order to assure a certain homogenisation of various input materials

5.2 Pasteurisation, Fermentation

Depending on local legislation the ready slurry/suspension shall be pasteurised (retention for one hour at 70 °C) in separate tanks (28) in order to immobilise pathogens and active seeds. By heat exchangers (25,26) the slurry is brought to the required temperature of 70 °C, using the cooling water of the motor generator-sets (36). Through air coolers (29) the temperature of the slurry is then reduced to the 37 °C required by the digesters.

The slurry is pumped into the Bio-Reactor or digester/fermentation tank (30) for anaerobic fermentation (fermentation under elimination of air access).
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.
The fermentation process requires approx. 15 – 20 days to form a stable non-odorous compost material.

5.3 Treatment of final Products



The liquid fraction of the digested slurry is dewatered in a dewatering screen press 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.
Excess water is screened again in order top remaining solid particles

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 motor-generator set. Biogas in case of maintenance of the generator or absence of any direct consumer is flared off in a special flare.

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:

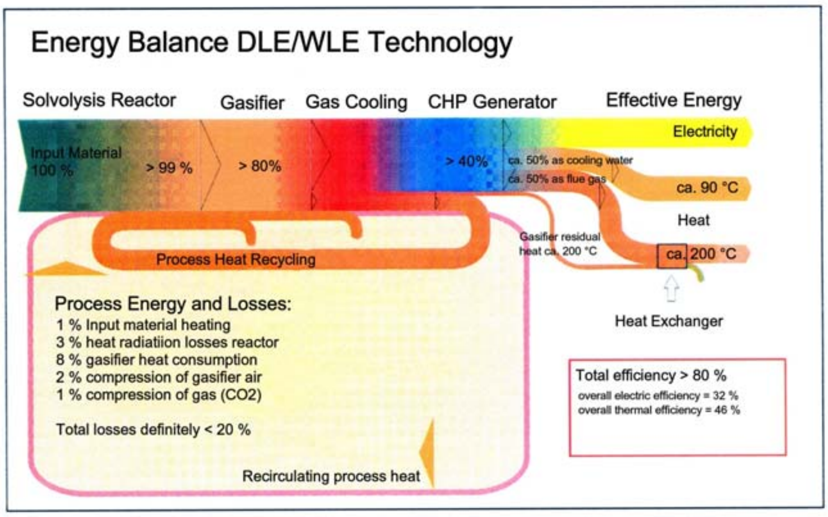
6.2 Liquefaction

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 ligno-cellulose molecular structures, causing disintegration and dissolving of the biomass 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)