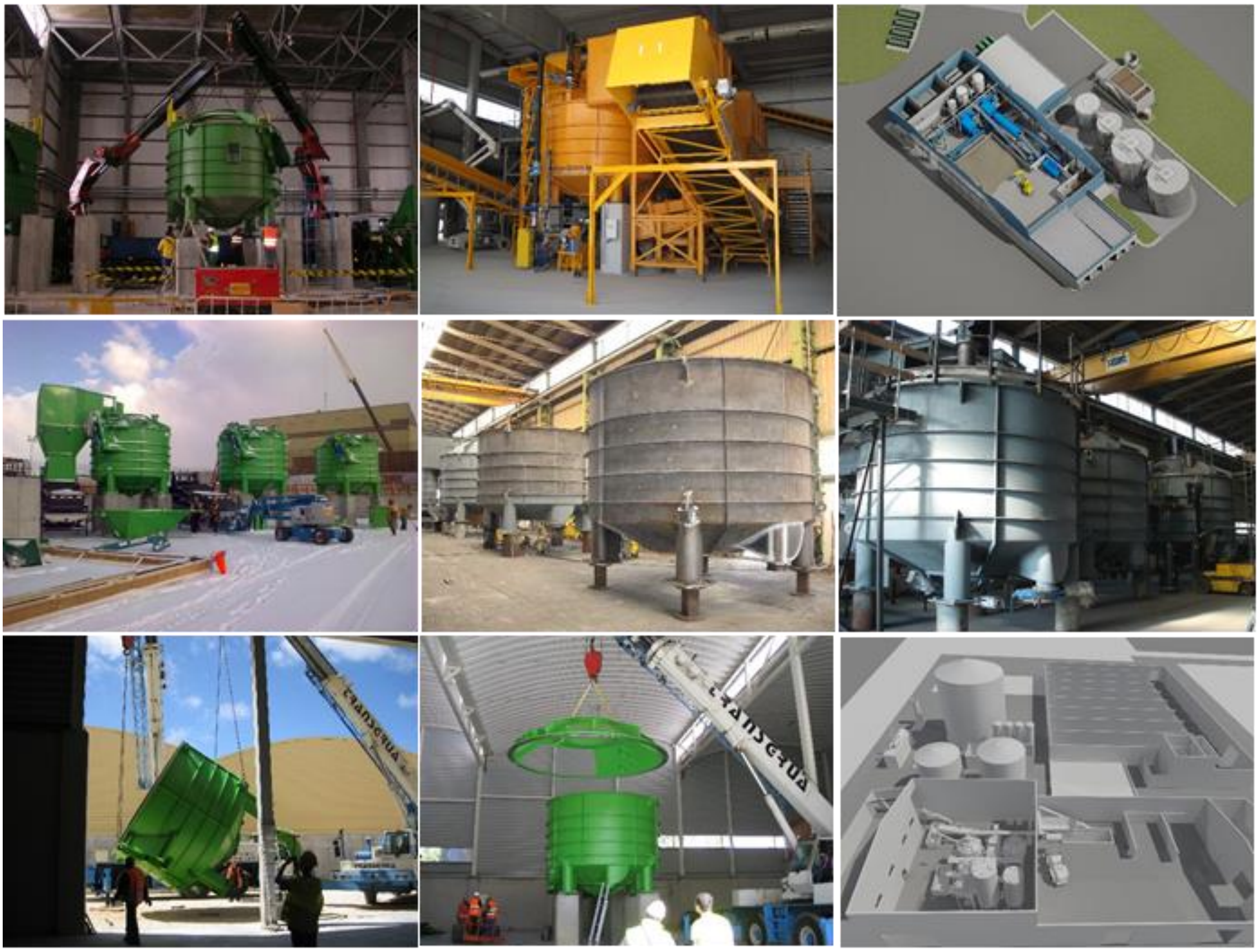
The BTA Process – General Description



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1. The BTA® Process

In the middle of the 80's the BTA® Process was developed and then tested and optimized over ten years in the pilot plant in Garching, near Munich. With this pilot plant, unique in its kind in this branch, it was possible to demonstrate the suitability of the BTA® Process for the treatment of different kinds of waste.

Already in 1991 the first industrial anaerobic digestion plant for biowaste based on the BTA® Process was built.

Since then 70+ BTA Waste Pulpers and 90+ GRSs have been supplied and installed and more than 50 plants in over 15 countries world-wide have been designed according to the overall BTA® Process or with key components from the wet mechanical pre-treatment with a total capacity of approx. 1,7 million tons per year (see reference list).

More than 110 million Nm³ biogas are annually produced in BTA Plants, which corresponds to the energy equivalent of approx. 70 million Nm³ natural gas.

The BTA® Process comprises the key steps

- hydro-mechanical pre-treatment and
- the subsequent wet Anaerobic Digestion

Yet, a BTA Plant consists also of further steps and processes as e.g. the solid-liquid-separation and the process water management (see fig. 1.1). A general description of the BTA® Process can be found under Chapter 3.

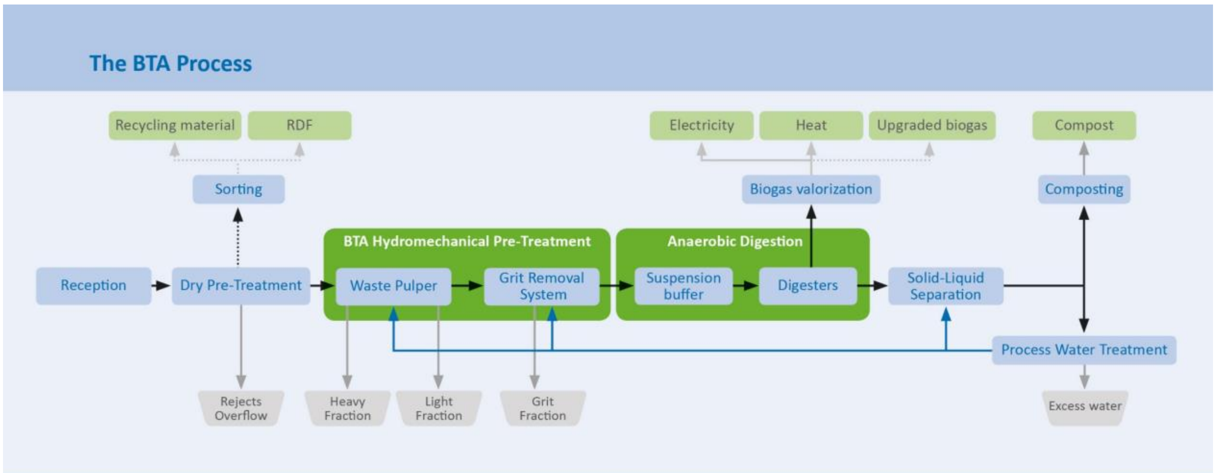

Fig.1: BTA® Process

2. Advantages of the BTA Process

The BTA® Process has many advantages for the treatment of any organic residues with impurities:

- High Flexibility
  - for different types of organic wastes, e.g. biowaste, source separated organics (SSO), the organic rich fraction of municipal solid waste (OFMSW), food waste and / or commercial waste)
  - for fluctuations in the waste composition, e.g. amounts of impurities as well as temporal peaks

- High Selectivity
  - Heavy contaminants, e.g. glass, stones, bones, batteries and metals, are effectively removed before biological treatment in the pulpers heavy fraction trap
  - Light contaminants, e.g. plastics, textiles, twigs and string are effectively removed before biological treatment by the pulper light fraction removal system (LRS), and are dewatered (by an optional Light Fraction Press) to reduce disposal costs
  - Grit down to >250µm is effectively removed in the Grit Removal System (GRS)

- High Operation Security
  - Wear on equipment downstream of the wet pre-treatment is minimised as any heavy material and grit is removed from the waste before the AD
  - The excellent preparation of the biodegradable pulp together with the optimum process conditions provided in the fully mixed digester(s) guarantee max. stabilisation of the organic material

- High Quality of Products
  - The removal of contaminants before the biological treatment reduces potential cross contamination of the treated digestate with heavy metals, glass, plastic etc.
  - The hydro-mechanical pre-treatment and wet AD system have a washing effect on the material being processed, which improves the quality of the digestate

- Maximal Biogas Production
  - Max. biogas production by the defibring and highest possible concentration of the digestable biomass in the organic suspension going to AD

- BTAs Proven Track Record
  - Since 1987, BTA has continuously pioneered its waste pulper concept that have allowed us, together with our partners and clients, to supply and install reliable waste treatment and AD solutions.

- 50+ projects helping us to constantly improve our technology, know-how and capabilities that we can offer today to our business partners in order to help to establish and to proof our renewable energy production concept by the BTA Process from waste (for more details please access our latest reference list under: http://www.bta-international.de/en/downloads.html)

- Industry Leader
  - 70+ BTA Waste Pulpers and 90+ GRSs have been supplied and installed in 15 countries worldwide.

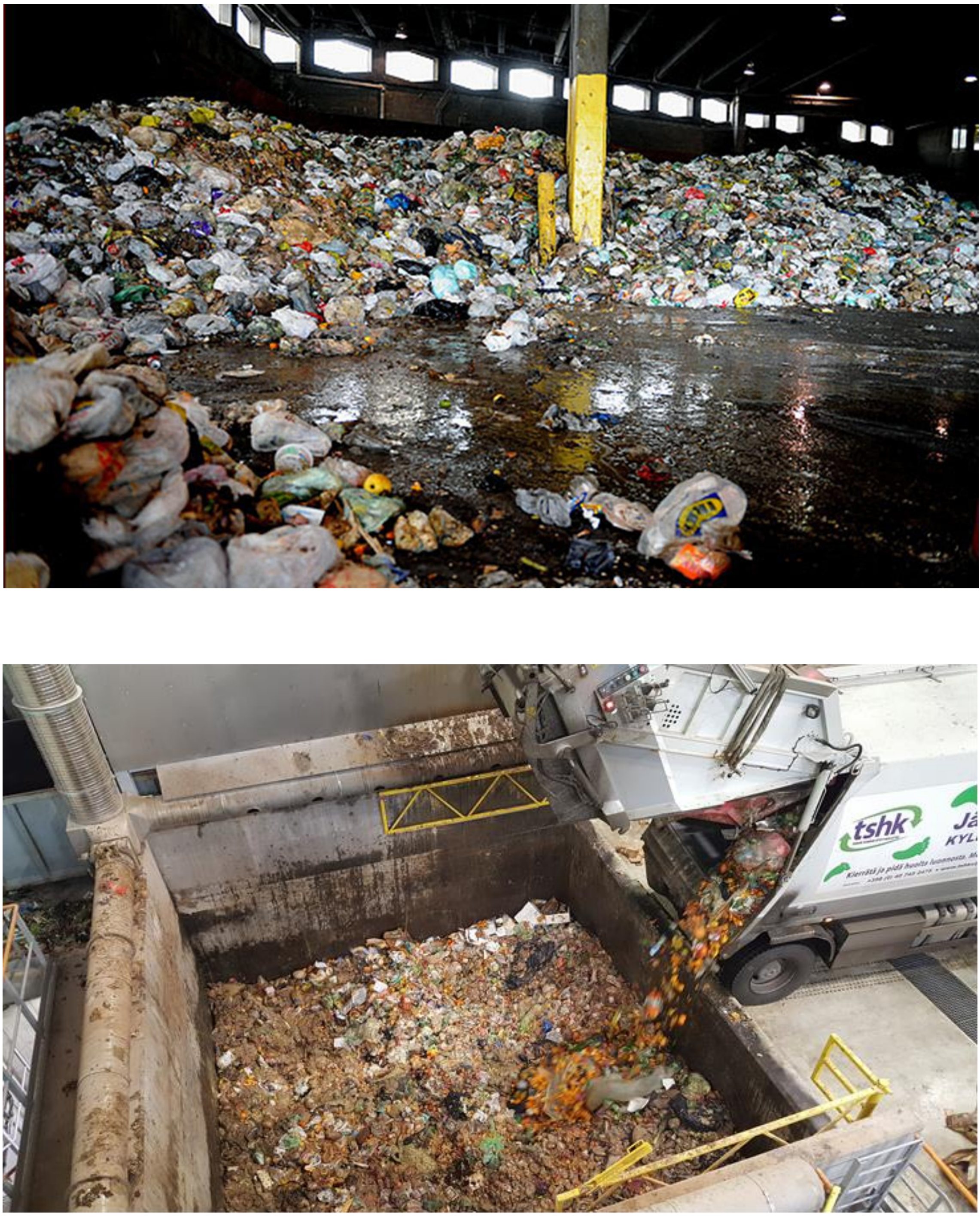

Fig.2: Waste received and treated within BTA Reference Facilities (above: SSO - Toronto Disco / Canada and below: Biowaste – Topinoja / Finland)

3. General Technical Description

3.1. BTA Hydro-mechanical Pre-treatment

The BTA® Hydro-mechanical Pre-treatment consist of two steps:

- Dissolution and defibring of the digestible organics into an organic suspension and removal of coarse impurities in the BTA® Waste Pulper
- Removal of fine impurities in the BTA® Grit Removal System

3.1.1. BTA® Waste Pulper

Fig.3: BTA Waste Pulper (blue) incl. Feeding Screw (middle of picture) in Lohja / Finland

Pulping is performed to facilitate three objectives:

- Disintegration of biodegradable waste to enhance the subsequent digestion process
- Removal of non-biodegradable contaminants as a “heavy” fraction (stones, large bones, batteries and metallic objects)
- Removal of non-biodegradable contaminants as a “light” fraction (textiles, wood, plastic film, string etc)

In the BTA® Waste Pulper, process water is added to the waste, which produces a suspension with a water content of approx. 90 weight-percent. The suspension is pumpable and mixable and thus easy to handle in terms of process technique.

The BTA® Waste Pulper is operated in batch-mode. This batch-mode consists basically of the following operation steps:

- charging of the Pulper
- dissolving process (defibration of the biowaste)
- pumping out of the biowaste-suspension
- filling with process water
- heavy fraction discharge and
- light fraction removal

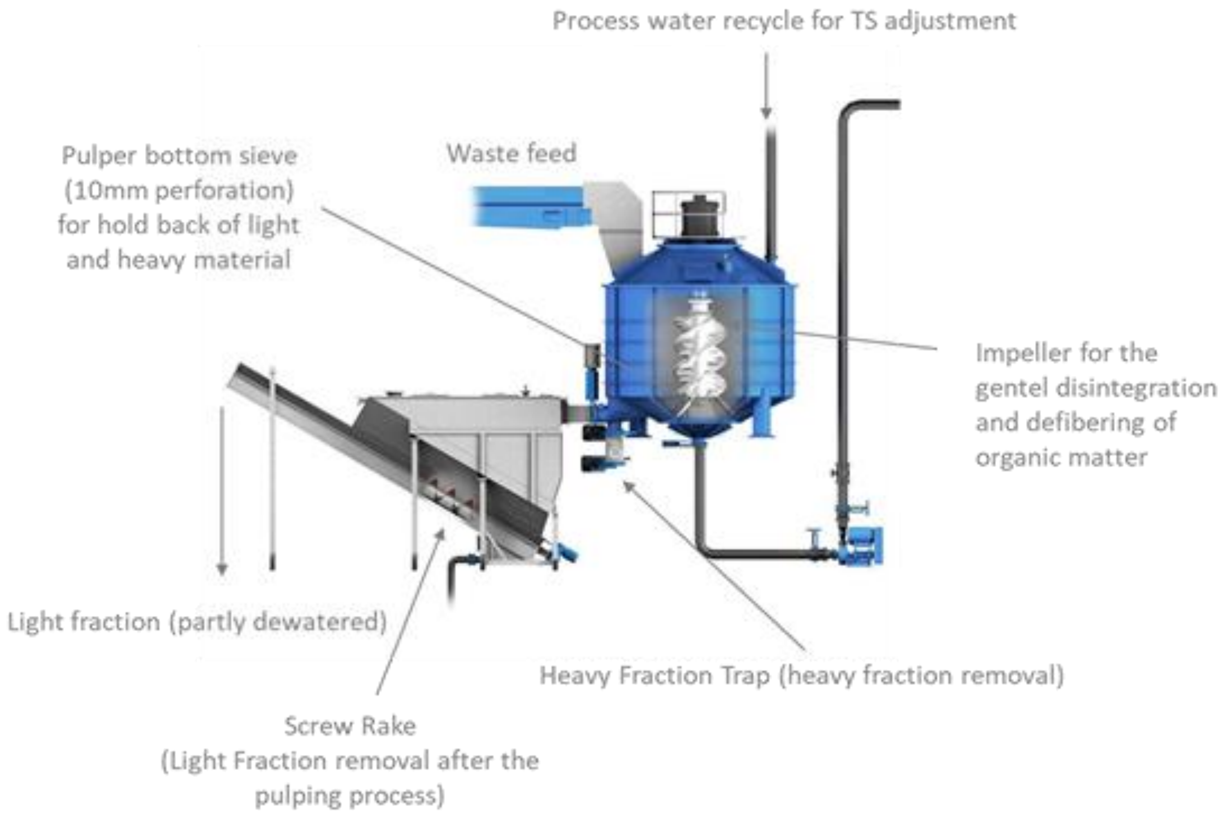

Fig.4: BTA Waste Pulper with Light Fraction Removal System Screw (LRS Screw)

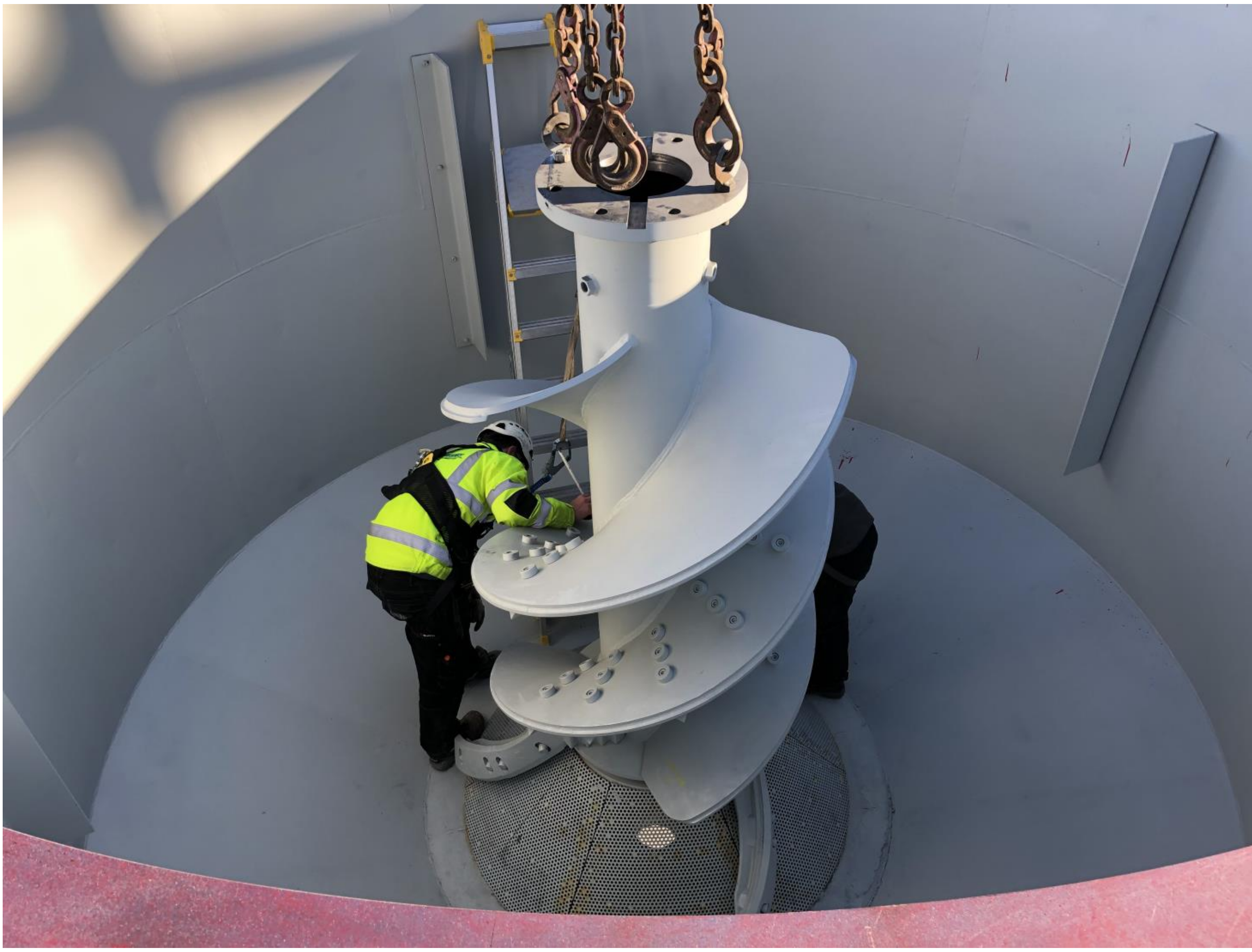

Fig.5: BTA Pulper Installation (here the impeller inside the Pulper)

In function of the waste composition it is possible / necessary to foresee a second dissolving cycle.

The charging of the BTA® Waste Pulper is controlled by a specially developed automation system. Once the optimal concentration of solids in the Pulper has been reached, the charging with waste is stopped automatically.

The BTA® Waste Pulper is equipped with a special turbine. When it rotates, fluidic forces defibrate, suspend and partly dissolve the digestible organic fraction contained in the waste. Biologically non-degradable substances, such as plastics, textiles, metals, glass etc. are <u>not</u> damaged in the process. These contaminants are separated at the end of the treatment cycle.

After the dissolving process the waste-suspension is extracted through a sieve plate with a perforation limit of 10 mm at the bottom of the Pulper by means of a centrifugal pump. It has a dry substance of approx. 10 weight %.

Before the discharge of the contaminants the Pulper is filled with process water. The contaminants retained in the Pulper are now separated from the mixture of process water and contaminants on the basis of their different sedimentation characteristics.

At the bottom of the Pulper the heavy fraction (glass, sand, stones, batteries, metals etc.) sediments and is removed by means of a trap system from the mixture of process water and contaminants. Before discharge it is rinsed with process water to minimize the remaining content of residual organic substances. With a dewatering screw conveyor the purified heavy fraction is further rid of fine organic particles, then dewatered and transferred to a container.

The light fraction (plastics, textiles, composite materials as well as the hardly or non-digestible organic fraction, e.g. wood etc.) floats in the suspension or rises to its surface. After the separation of the heavy fraction, a gate valve is opened and the light fraction and suspension flushes into the receptacle of the LRS Screw. The LRS Screw removes and transports the light fraction to a light fraction press to reduce the moisture content. The dewatered light fraction is taken to a container by a conveyor belt. The resulting press water, as well as the excess water at the LRS Screw is collected in a drainage system and carried back into the process with a pump.

For applications with very high plastic film content, a removal of the light fraction by means of a rake can be an option.

Finally, a new cycle can start. Processing time of each batch-cycle depends very much on the type of waste and its composition. In general, approx. 60 min for the BTA Waste Pulper with LRS Screw can be assumed.

3.1.2. BTA® Grit Removal System

The pulp withdrawn from the Pulper still has a content of heavy fraction particles up to a size of the screen perforation (grit).

First the pulp is pumped into a surge tank. The pulp is withdrawn out of the coned point of the surge tank and is pumped through the Grit Removal System (see Figure 4). The Grit Removal System mainly consists of a hydrocyclone, a classifying pipe, and a gritbox. Caused by centrifugal forces in the hydrocyclone a sludge enriched with grit is discharged as underflow into the classifying pipe and sediments downwards into the gritbox by occurring a reduction of the content of discharged organics due to a weak counterflow with upstream water. The gritbox is emptied automatically depending on demand.

The (partially) from grit purified overflow is fed back into the surge tank. The pulp is circulated through the Grit Removal System for several times. On completion of the grit removal cycle the recirculation is stopped and the de-gritted pulp is pumped to the suspension buffer.

In case several BTA Grit Removal Systems are applied the systems can be operated both in parallel and as a cascade.

The integration of the Grit Removal System shows the following advantages due to which this step is essential, especially for those types of waste that carry a large load of grit and sand (e.g. biowaste and municipal solid waste):

- Protection against increased wearing of the subsequent technical equipment
- Protection against plugging of the subsequent pipes
- Protection against sedimentation at the suspension tank and the digesters.

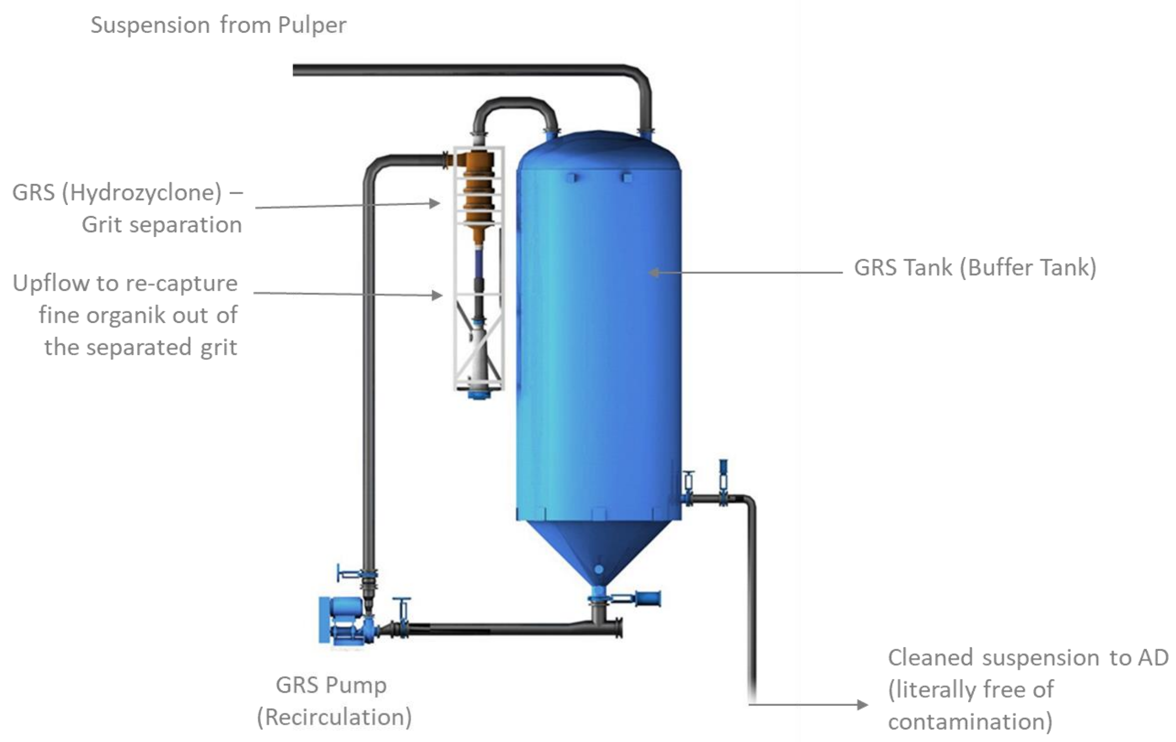

Fig. 6: Grit Removal System

Fig. 7: a) Grit Removal System b) Grit classifier

Sludge Thickeners (optional in case of Organic Fraction of Municipal Solid Waste)

De-gritted pulp is pumped at a controlled rate to drum thickeners. The pulp is thickened from ca. 6-8% to approximately 10-11% for feeding the anaerobic digestion.

Liquors removed from the pulp are discharged by gravity to a low level sump from which they are returned to the hydormechanical pre-treatment.

Fig. 8: Thickening units

3.2. Anaerobic Digestion

3.2.1. Suspension Buffer

In order to obtain a satisfactory digesting operation and the best biogas yield, both in terms of quality and quantity, it is essential that the anaerobic digestion process operates under steady conditions, reducing the fluctuations in the biogas production. In order to achieve this feed regime, and with an intermittent feeding source of pulp from the hydromechanical pre-treatment, one suspension buffer tank is required to provide sufficient feedstock during a 24 hours a day and 7 days a week operation.

To obtain proper mixing, air from the tank headspace is led after extraction of its condensate buffer to the Air Compressor Suspension Buffer, where it is compressed and injected back to the Suspension Buffer via a central gas lance system at the bottom of the tank. This induces a proper mixing of the tank contents.

Bacterial hydrolysis will commence and consume oxygen, so a certain level of oxygen must be maintained in the injected air, by permitting a very carefully controlled rate of fresh air to the compressor suction, which will suppress methane and odour compounds formation. Test results have demonstrated that the anaerobic degradability will improve with these measures. For this very low-emission storage of biological degradable organics a patent has already been applied by BTA International.
The Suspension Buffer is connected to the waste air treatment system in order to abolish possible bad odours.

3.2.2. Digester

The pulp is pumped from the suspension buffer to the digester, where the biogas production will take place.

The digesters are fed with the means of excentric screw pumps (digester feeding pumps). The digester feeding pumps can feed each of the digesters, thus allowing for a certain temporary redundancy.

The feeding process of the digester will be automatic and semi-continuously. It will be fed throughout a twenty-four hour day, seven days a week, for short periods and in frequent intervals by the use of pumps, optimal for the transport of low flowing suspensions containing solids. High liquid level in the digester outlet sump inhibits the digester feed pump.

Fig. 9: Suspension Buffer and Anaerobic Digester Tanks in Portugal (above) and Finland (below)

The digester itself is a completely mixed reactor. Continuous, sufficient mixing of the digester is very important and has mainly three aims:

- Transportation of initial and reaction products to the biomass (bacteria) to allow a maximum degradation of the organic matter. This degases the biomass and maintains constant conditions of temperature and chemical properties inside the digester.
- Create a strong surface current to avoid the built- up of a scum layer or to destroy a floating scum layer as promptly as possible.
- Avoid biomass and organic solids sedimentation, which will cause "dead zones" in the digester and thereby mechanical problems to extract digested biomass.

In order to achieve these goals with maximum performance, mixing with compressed biogas has proven to be a perfect solution.

Part of the biogas produced in the digester is led to one gas compressor per digester where it is compressed after an extraction of its and pushed back into the digester via a central gas lance system at the digester's bottom. The biogas creates bubbles while leaving the gas lances and it rises to water level at the top of the digester. Thus, a tremendous amount of liquid is moved – mammoth pump effect – and creates a high velocity current in the central part of the digester up to the surface. It continues horizontally towards the perimeter of the digester, moves down close to the wall region to the bottom and then back to the digester's centre. This big wave has the capability of mixing all the digester's volume. The high surface velocities avoid the formation of scum layers or floating debris in this region. In comparison to mechanical mixing with motor driven stirrers, biogas mixing does not have any moving parts inside the reactor which might fail or must be replaced and maintained. Due to this, no shutdowns caused by emptying of the reactor are to be expected.

The two gas compressors can be arranged in such a way that one compressor can serve respectively the two digesters of the same size, if necessary, allowing for a certain temporary redundancy.

The temperature of the digester is monitored and maintained by an external recirculation heat exchanger system provided for each digester. In the corresponding heat exchangers, the organic suspension coming in a bypass from the digesters is heated up with the heat from the warm water coming from the CHP unit.

The biological process operates at mesospheric temperature conditions, i.e. between 36°C and 38°C, which gives considerably higher operating and disposal safety within the process. Approximately constant temperature will be kept by means of external heat exchangers.

The digested pulp (digestate) is automatically pumped from the digesters to the dewatering station under level control.

The reactor is equipped with all corresponding safety fittings.

3.3. Biogas Cleaning and Storage

Hydrogen sulphide (H2S) needs to be removed from the biogas, produced in order to avoid corrosion and to reduce SO_2/SO_3 levels when the biogas is burned. Considering that higher H_2S concentrations of 1.500 – 3.000 ppm may be expected, an external biological desulphurisation is necessary to reach the required values for the valorisation of the biogas in CHP units. The external desulphurisation is dimensioned to ensure the treatment of the biogas production of 120% the average hourly biogas production.

The outgoing biogas is conducted over a condensate trap, which is filled with gravel. In it, the water is partially separated from the biogas. In addition, the gravel heap however also serves to retain possibly entrained solid components such as foam particles.

This biogas can be valorised in CHP units, bolier systems or upgraded to natural gas quality.

A gas flare is installed for emergency purposes to burn the biogas in case of a failure e.g. maintenance or breakdown, designed to flare 120% of assumed hourly gas production for Phase 2.

3.4. Dewatering

The aim of the solid-liquid separation is to divide the digested biomass (digestate) into a thin liquid fraction with low total solids content (approx. 1,5-2,5%) and a solid fraction with high total solids content (approx. 28-30%).

The digestate is continuously pumped at a controlled rate from the digester to a dewatering unit (centrifuges or screw presses).

Prior to entering the dewaterinug unit, the pulp can be conditioned by the addition of polyelectrolyte solution. The sludge is transported into the flocculation reactor by means of the sludge pump. The coagulant required is continuously prepared in a fully-automatic coagulant plant and added to the sludge. A static mixer in the sludge pipe guarantees an intensive and constant mixing. In the flocculation reactor is integrated a vertical wedge wire, so that a pre-dewatering takes place just by action of the hydro-static pressure.

It is aimed to operate the dewatering unit almost continuously, also during the weekends, in order to ensure a constant discharge of the digester(s) and therefore constant level in the digester(s).

Fig. 10: Dewatering of the digestate with screw press

The dewatered digestate is placed on a conveyor belt and is transported to a small storage area, that allows to bridge the weekend production. From here it is transported with a front loader to the composting. As the dewatering step operates also on weekends and around clock, the storage area must be dimensioned to bridge the weekends. The liquid fraction (centrate) is discharged into a small tank and, from here it is pumped to the Process Water Buffer 1.

3.5. Process Water Management

The liquid phase extracted from the solid-liquid separation will be stored in the Process Water Tank 1.
The Process Water Buffer is equipped with a mixer and with all the necessary measurement and safety mounting parts.

Most of the process water will immediately be re-used as Process Water 1 in the BTA®Waste Pulper to obtain the required dry matter content in the pulper. The remaining process water is pumped to the internal process water treatment.

In the first step of the waste water treatment suspended solids are removed by means of a micro strainer with a 150-250 µm mesh size to avoid overloading of the following biological treatment as well as to get suitable water to be used as flushing and rinsing water in the process.
The removed solids are collected and pumped back to the dewatering unit. The liquid phase is stored in the Process Water Buffer 2.
Part of this water (process water 2) is used as flushing and rinsing water in the process (Pulpers, Grit Removal Systems and dewatering unit). For this, the process water 2 is led through a pressurisation unit.
Therefore, only a minimal amount of fresh water is required for the rinsing of specific valves in the BTA ® Waste Pulper as well as for the preparation of the flocculants. The remaining water demand is covered by the reutilization of the process water.

The Process Water 2 that is not required for the process (excess water) can optionally be further treated in an internal wastewater treatment plant with a biological nitrification / denitrification and sedimentation.

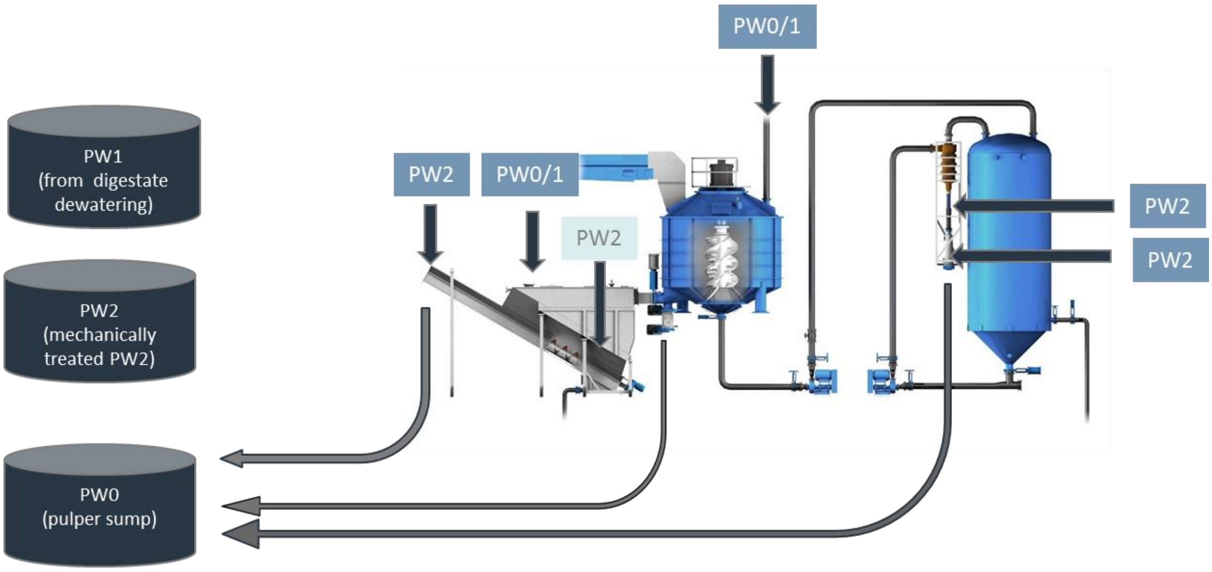

Fig. 11: Process Water Qualities, place of origin and use within the BTA Process

3.6. Composting / Dewatered Digestate Handling

The dewatered digestate (cake) is an optimal material for the following composting/stabilization steps.

Fig. 12: Dewatered digestate in Ieper, Belgium (from biowaste)

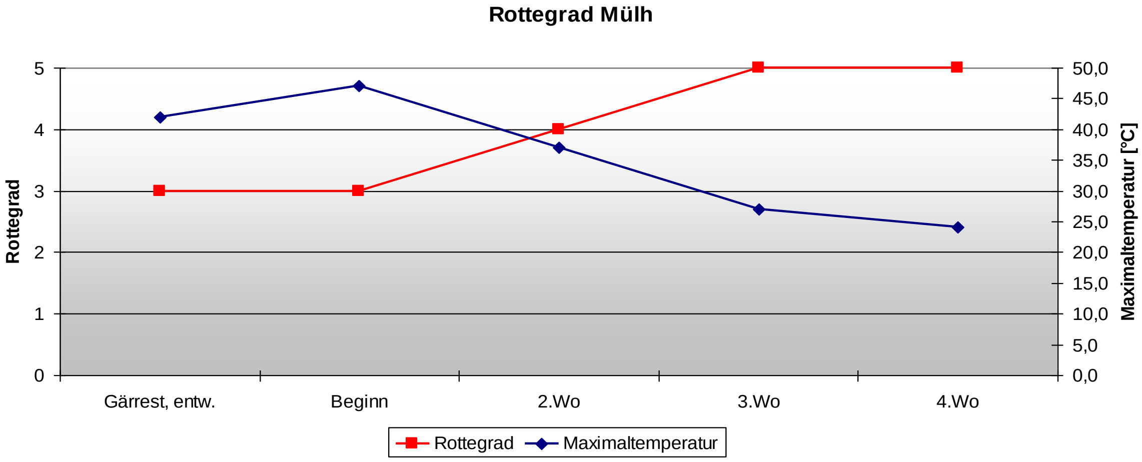

Fig. 13: Rottegrad of dewatered digestate (Mülheim, Germany)

Tests executed with the digestate from the AD plans in Mülheim and Kirchstockach have shown that with a simple windrow composting with controlled air system it is possible to achieve the "Rottegrad V" quality within 3- 4 weeks, thus allowing reducing the composting time considerably.

Fig. 14: Composting box in Suldouro, Portugal

3.7. Plant Control System

Aim of the specially designed SCADA system (Supervisory, Control and Data Acquisition) is to provide a tool for the operator in running the plant as well as for optimisation of the plant.

The control computer is connected by the PLC serial interface. The installed programs meet the following assignments:

- operating the total plant by mouse action at the monitor
- showing the process condition by pictures: the switch conditions of consumers are presented in colours as well as in bars, coloured areas and numeric of important measured values
- signals are continuously controlled for alarms. Any alarm is immediately reported and the corresponding action is set. To re-enact troubles later on they are stored in special files with date, name, time and comment.

The total operating surface is designed under ergonomical aspects. This is not only comfortable to the operator but also minimises the development of faults. Operating at the monitor demands no special knowledge and can be learned intuitively.

For advising by phone in case of troubles a modem can be installed. Faults registered by the control can be passed on to any phone connection wanted.

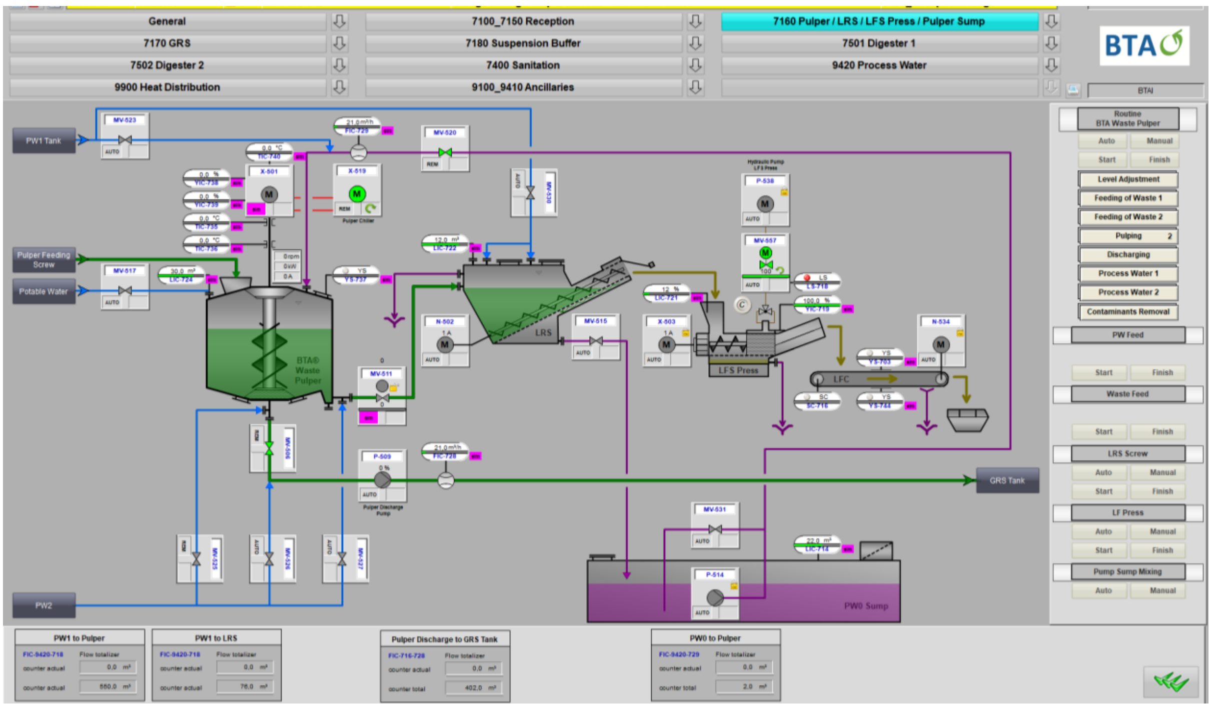

Fig. 15: SCADA Screenshot BTA Waste Pulper with LRS Screw and Light Fraction Press (LF Press) (exemplary)

For a tour of one of our plants, please visit: https://kuula.co/post/n1/collection/7l5C9

You can do this on computer screen or using a google cardboard or similar for a 3D experience.