TREATING ORGANIC WASTE WITH CAMBI® THP

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ABSTRACT

This paper describes how the Cambi Thermal Hydrolysis Process (THP) treats biodegradable organic waste and converts it to renewable energy and pathogen-free and bio-fertilizer. The interest for the process is expected to increase due to new environmental legislation as well as increasing demand for renewable energy. The implementation of the European Landfill Directive 1999/31EC and the Animal-by Products Regulation (ABPR, 1774/2002/EC) are two major regulatory drivers in the European Union. This paper should encourage and will assist energy companies, waste management companies and consultants to carry out comprehensive feasibility studies prior to investment, including technological, economic and environmental aspects. Due to increased environmental awareness there is a growing interest for biological treatment of renewable sources and organic waste. Increasing environmental pressures on waste disposal (landfills) have also increased the use of anaerobic digestion (AD) as a process for reducing waste volumes and generating useful byproducts. An anaerobic digester is an industrial biological system that harnesses a natural process to treat and convert biodegradable organic waste, producing digestate and biogas. The digestate can be converted to organic fertilizer by a short maturation/composting. The biogas can be used to:

- provide heat
- power a gas engine to produce electricity and heat
- produce compressed bio-methane after CO_2 removal that can be used as vehicle fuel gas,

The Cambi thermal hydrolysis process (THP) is a well proven and patented technology to pre-treat biological waste for sterilization and high organic matter conversion. Organic waste treated with thermal hydrolysis at high temperature undergoes both extreme disintegration, i.e. breaking up cells and dissolving organic solids into water, and complete pathogen, seed and helminth (parasite) kill. In the THP process complex carbohydrate and protein substrates are reduced to single monomers of saccharides and amino acids that rapidly acidify in the digestion process to give short chain volatile fatty acids. These fatty acids are rapidly converted to biogas in an anaerobic digester. The positive consequence is increased and accelerated biogas production during anaerobic digestion and improved dewaterability of the digested product (digestate).

In a conventional digester a complex range of micro-organisms slowly undertake the process of biological hydrolysis that limits the rate of biogas production. In the Cambi process hydrolysis occurs rapidly as a result of heating the material under pressure to around 165°C and then releasing the pressure. This results in substantially more of the biodegradable material being made available for conversion into gas. All inputs to the digester are sterilized and therefore there is no risk of pathogen contamination in the digestate.

The technology was first implemented in Norway at Hamar in 1995 on sewage sludge and subsequently applied to biodegradable municipal waste (BMW) at a plant nearby Lillehammer. The organic waste is treated at a minimum of 133°C for 20-30 minutes combined with pressure drop disintegration prior to anaerobic digestion. ABP Regulations for cat II material require a temperature treatment of min 133°C for 20 min. The plant is currently treating source separated household waste and ABPR category III waste. The customer is considering upgrading the plant to treat category II waste.. With a new separate reception hall combined with the high temperature treatment the plant will meet the Animal-by Products Regulation (ABPR, 1774/2002/EC) treatment method 1 which allows treatment for cat II waste as well. Conventional pasteurization systems use 70°C for 60 minutes and cannot treat ABPR cat II.

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It is very important that new AD facilities fulfill the Animal By-Products Regulation (ABPR EC 1774/2002). Several biodegradable organic waste fractions can be classified as ABPR cat II and III material. Due to the high-temperature thermal hydrolysis process the Cambi system is adapted to these more stringent environmental requirements. Environmental requirements for organic waste treatment have always grown stricter and there have so far been no signs that this process will stop.

Key words: Thermal hydrolysis, biowaste, pre-treatment, anaerobic digestion, biogas, animal by-products.

INTRODUCTION

New developments in anaerobic digestion (AD) include integration with waste sorting systems and pre-treatment technologies such as the Cambi thermal hydrolysis process. In addition to thermal hydrolysis the Cambi BMW (biodegradable municipal waste) plant design has a dry (mechanical) and a wet pre-treatment stage. Both these stages enable recovery of the waste materials in a form that can easily be processed in anaerobic digesters. In most AD projects there are different types of waste that have to be treated, so the plants must be designed and tailor made for each specific project.

When treating organic waste it is very important to design highly reliable and well functioning pre-treatment systems combined with enclosed and air-tight treating areas to avoid odour. In addition the Cambi pre-treatment system is equipped with several advanced screening and exit systems to sort out unwanted waste fractions, such as plastics, textiles, glass, and sand.

The material specification and potential odour will always vary a lot when treating organic waste. Therefore the process is enclosed, allowing a safe working environment with a controlled and closed odour treatment. In existing systems approx. 70-80% of all mechanical failures and shut downs can be tracked directly back to the waste quality and the chosen pre-treatment process. Other shutdowns in conventional plants have been odour related problems. The Cambi plant at GLØR, Lillehammer (Norway), treating BMW, has shown high process reliability with data shown in chapter eight, below.

Important issues associated with successfully digesting organic waste are:

- Reliable and stable pre-treatment process with a minimum of shut downs and mechanical failures
- Closed systems with a minimum of odour
- Meeting safety standards for pathogen control
- Meeting the Animal By-Products Regulation (ABPR EC 1774/2002)
- Removal of trash from the material to be treated, especially plastics
- Ability to cope with varying waste composition

The GLØR plant at Lillehammer - www.glor.no - was commissioned in 2001 to treat 14,000 tonnes (at ~35% DS) per year of source separated BMW. At the GLØR plant all biogas is converted to electricity using gas engines. The engine heat is used to run the Cambi THP and heat buildings. The plant is manned by 3 operators. The plant was designed in order to:

- produce a hygienised product that meets any standard for pathogen control (including autoclaving);
- produce a high volume of digester gas from reliable digestion;
- produce a low volume digestate that is free of plastic and glass;
- produce final bio-fertilizer/soil conditioner that meets the Norwegian standard for domestic use.

The plant has been able to meet all these requirements and is currently producing a highly sought-after bio-fertilizer as well as covering all its electricity and heating (both process and building) needs from biogas cogeneration.

Based on the successful experience of the Lillehammer plant Cambi is now building the next plant generation in the area north of Trondheim - the Ecopro project. The plant will be in commercial operation in April 2008.

Ecopro AS (www.ecopro.no) is a single-purpose company created to build and operate an enclosed plant for advanced and automated processing of bio-waste, including biodegradable municipal waste, sewage sludge, category II and III slaughterhouse and fish waste, with subsequent anaerobic digestion (AD) for biogas production. The plant is located in Verdal Municipality, north of Trondheim, and will treat organic waste from 41 municipalities, representing a population of 350-400,000. Ecopro is owned by five municipal waste management companies, representing the 41 municipalities, and plans to treat 40,000 - 50,000 tonnes/year, with an estimated yearly biogas production equivalent to 20-30 million kWh. The plant will be manned by 5 operators.

Electricity production is the chosen alternative and will reduce greenhouse gas emissions by the equivalent of 50,000 - 60,000 tonnes CO_2 per year. In addition to production of green energy the system achieves the following:

- Reduces organic waste going to landfill (will be prohibited).
- Sterilizes the waste materials making it possible to treat a mix of category II and III animal waste, bio-waste (BMW) and sewage sludge (bio-solids), according to EU regulations.
- A continuous and closed industrial process with automatic operation of all systems that avoid operators coming into contact with the waste during daily operations.
- Low environmental impact, especially in relation to odour, visual impact and H&S (health and safety).

The basis of the technology is to pre-treat all the organic waste prior to digestion to at least 133°C for minimum 20 minutes and thus meet method 1 of the animal by-products regulations 2002 (ABPR EC 1774/2002). This will allow the treatment and subsequent AD of category 2 wastes including non-mammalian abattoir waste and fish mortalities.

MATERIALS TO BE TREATED

The Cambi system can handle many different types of organic biodegradable wastes such as:

- Source separated household waste
- Organic waste from catering kitchens, canteens and restaurants
- Fish waste
- Organic residues from industrial manufacture of foods, fat and other similar residues (ABP cat II & III).
- Slaughterhouse waste (ABP cat II & III)
- Solid organics
- Biological sludge
- Sewage sludge

Physical condition on arriving material can be liquid, pasty and solid

The moisture content in organic waste varies a lot due to organic lumps and different packaging. Experience shows that a content of ~30% dry solid is typical in most cases. The organic matter composition also varies a lot due to some fractions containing inert material. However we have made some relevant estimates below.

Dry solids	Organic matter		Water content
~30%	Ash ~20%	VS ~80%	~70%

The viscosity and the dry matter content in the material are adjusted with water / organic liquids in order to optimize the pre-treatment process and the anaerobic digestion.

The source separated waste tested by the GLØR plant comprised the following constituents:

• Food waste 70-82%
• Garden Waste (seasonal) 2-7%
• Paper 3-7%
• Disposal Nappies (diapers) 8-12%
• Contrary items 1-4% (plastics, metals, stones, soil)

PROCESS DESCRIPTION (ECOPRO)

Waste reception for solid waste

Waste reception takes place behind closed tight doors inside the reception hall. The hall is under negative pressure in order to avoid odour. The fans push the air through the biological filter placed outside the process building. If needed the biological filter can also be built inside a closed area equipped with an active carbon filter on the top as a second stage filter. This will reduce all potential odours to an absolute minimum.

After unloading the organic waste vehicles and containers are washed and cleaned with hot water pressure washers and steam if needed. Spillage from cleaning and washing is collected in a closed system and pumped back to the process.

The material can arrive in liquid, pasty or solid condition. Liquid material will be pumped directly into the mixing tank. Solid material is dumped into one of the two reception bunkers which also serve as a storage buffer.

The two reception bunkers are designed for;

a) oversized material
b) undersized material

Depending on the material to be treated the bunkers can be equipped with following feeding systems;

- An overhead crane mixes and feeds the waste into the feeding bins
- A bottom feed pusher system (moving floor)
- A screw transporter system placed in the bottom of the bunker

All feeding systems will homogenize the material a bit and transport the material to the below placed feeding bins. The feeding bin for oversized material is equipped with a bag opener system (not a shredder). This bag opener is mainly used for organic waste packed in plastic bags. The main purpose is to open up plastic bags and similar so the organic waste can be exposed and sorted out more easily. Another advantage is to keep larger and longer plastic pieces intact as long as possible through the sorting system. Larger plastic pieces will be sorted out more efficient in the autogenous drum separator compared to smaller pieces. Screw conveyers at the bottom will ensure to transport the material to the autogenous drum separator. If for instance oversized material enters the screw conveyer and causes stops, the pressure inside the screw conveyer is measured through frequency converters. The converter sends a signal to the PLS system which stops the screw conveyer. If this occurs the screw can be reversed and oversized material/lump can be taken out or fall out from the exit hatch for oversized lumps.

The feeding bin for undersized material is similar as the described bin above with the exception that the bin is not equipped with a bag opener. This system will handle all unpacked undersized material.

The waste reception can treat a very broad range of biodegradable inputs e.g. source separated household waste, organic fractions from canteens and restaurants, other vegetable fractions, biological reject and other similar fractions.

The reception area will only be manned when it receives waste; however the waste reception can receive waste 24 hours a day. The chosen design results in minimum handling by the operators.

The dry solids content in received organic waste to be treated is ~25-35%.

Waste reception for animal by-products category II

Animal by-products category II must arrive in leak proof containers. The transportation of animal by products must take place at an appropriate temperature to avoid any risks to animal or public health.
Reception of animal by products category II will take place in a separate reception hall. The hall is equipped with the same odour system as described in chapter 4.1

At the reception hall the material is dumped into a funnel where screw conveyers will transport the material to a mill where the material is minimized to ≤ 30 mm. (According to the ABPR category II, the maximum size of material to be treated is set to 50 mm.)

After the mill the material will be transported to the buffer tank for ABPR cat II waste. All pre-treatment will take place in a separate process line until the material has entered the pulper. At the pulper the material will be mixed together with all other pre-treated material such as source separated household waste and other organic fractions. Any rejects from this process line will be collected in a separate closed container and sent to an incineration plant.

If spillage occurs, the reception is constructed in such a way that floors are sloped and it is easy to clean and disinfect. To prevent re-contamination the area is clear separated from other areas.

After discharge vehicles and containers will be washed, cleaned and disinfected with a separate washing facility equipped with hot water and steam systems. A closed waste-water system will also collect all potential spillage and pump it directly to the mixing tank.

The average dry solid content in ABP category II to be treated is approx. 25%.

Waste reception of liquid waste

Liquid waste will be screened (≤ 40 mm) and pumped directly into the mixing tank.
If needed vehicles and containers can be washed and cleaned as described in chapter 4.1.1.
If the liquid waste is classified as ABPR category II the reception will take place as described in chapter 4.1.2

Autogenous drum separator

The autogenous drum separator is an advanced separator designed to maximize separation into several fractions and disrupt unopened bags, packages, bottles, cans and other similar products. The objective with the separator is to sort out unwanted waste fractions by mechanical treatment and keep the organic fraction for further treatment and finally biogas production. Some positive homogenization of the organic fraction is also achieved during the separation process. The drum separator can also be set to re-circulate an amount of waste to increase the separation and the quality of the organic waste. During the separation process the dry matter content is relatively stable. The dry solids content is only decreased by 1-3%.

The drum separator will sort out and homogenize following fractions.

a) > 110 mm = heavy fractions containing iron, steel, glass, rocks, gravel etc. This fraction is collected in a separate container

b) > 110 mm = light fractions containing plastic bags, textiles, plastic bottles etc. This fraction is collected in a separate container

c) ≤ 40 mm = accepted organic fraction for further treatment and biogas production

d) 40-110 mm = re-circulated fraction to achieve higher quality

The remaining organic non-digestible high calorific fraction (mainly non-recycled paper and plastics) can be used as RDF (refuse-derived fuel) dependent upon availability of a suitable market outlet.

The process ventilation ensures a negative pressure in the closed drum and the air is treated as described in 4.1.1.

Process water can also be added to regulate the dry solid content.

The drum separator is only operated when receiving material, the drum stops when the material has been treated and stored in the buffer. The buffer capacity can be designed according to the customer requirement (e.g. 1-3 days buffer capacity).

For projects > 50,000 t/a a different type of drum separator will be used to optimize the separation and sorting system.

The dry solid content after treatment is reduced to ~20-28%.

Mixing tank (grit and plastic removal)

The wet pre-treatment area contains a mixing tank with an integrated removal system for light floating fractions and a bottom removal system for heavy fractions. The mixing tank is also pre-heated up to ~50°C to increase separation and homogenization and decrease the viscosity.

Floating reject from the top of the mixing tank is continuously removed with a mechanical removal system. This fraction is collected in a separate container where the material is dewatered. The liquid fraction will be pumped back to the process.

Inside the mixing tank heavy components/fractions settle to the bottom of the tank and will be taken out in an advanced screening system. The bottom fraction is washed in a sand washer. The heavy bottom fraction is then transported with a screw transporter to a separate container. The heavy fraction (inert material) can be used as a top layer on existing landfills etc.

The remaining organic biowaste fraction will be chopped and suspended in the mixing tank before it enters the thermal hydrolysis process.

Dry solids content is regulated by adding recycled process water for dilution.

The dry solid content after treatment is reduced to ~13%.

Thermal hydrolysis process (THP)

Pre-treated material from the mixing tank is pumped batch-wise into the pulper where it is pre-heated up to ~ 97°C. The increase in temperature also decreases the viscosity of the material. The pulper is enclosed and pressurized to assist odour control and enhance energy transfer requirements. The material is mixed by circulation. Steam is added from the reactor/flash tank during the flashing between reactor and the flash tank. During the heating the viscosity is reduced enabling it to be mixed by pumping in circulation. The pulper is under pressure and an odour removal system eliminates produced foul gases. An ejector compressor pumps the foul gases to the digester(s) where they are decomposed.

From the pulper the pre-heated material is pumped into the reactor. Steam is then injected directly into the reactor until the required operating pressure and temperature is reached. The time cycle for the thermal hydrolysis process in one reactor with a process temperature of 165-170°C is:

15 minutes for filling the material into the reactor
15 minutes for steam injection from the steam boiler
30 minutes retention time
15 minutes to allow the steam to flash into the pulper
15 minutes to flash the material to the flash tank

The reactor is a batch driven process. The total time for one reactor cycle will be optimized during start-up with respect to energy balance. Multiple reactors operate on a staggered basis, creating the effect of a continuous flow between the pre-dewatering and the anaerobic digestion system.

When the hydrolysis process is complete, a pressure driven valve at the top of the reactor will be opened gradually so the pressure can be reduced.

The dry solid content after THP treatment is reduced to ~10%. Water/liquids can also be added to dilute and cool down the hydrolyzed material after thermal hydrolysis before the material enters the digester(s).

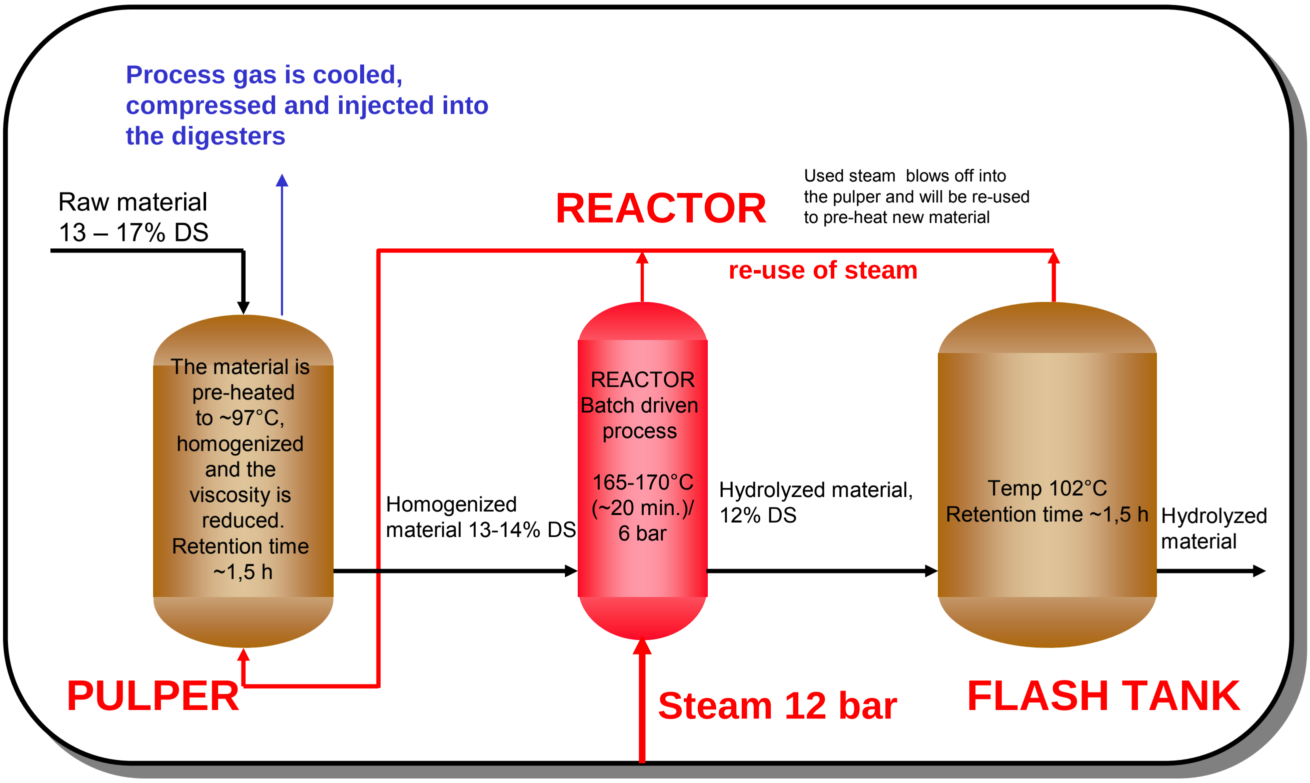

Figure: 1 Thermal hydrolysis process

Anaerobic digestion

Before the hydrolyzed material enters the digester(s), the pasteruised material passes through a cooling heat exchanger which reduces the temperature from 102°C to that required by the anaerobic digestion process (~40°C) and recovers heat which can be used to heat up the building (especially in the winter time). The heat exchanger is a double-pipe construction with hydrolyzed material in the inner pipe and cooling liquid in the outer pipe (anti-freeze if necessary). The chosen digestion process is mesophilic, taking place at 38 - 40°C.

The biogas production takes place inside the digesters. Some part of the gas is re-circulated back to the digester to circulate the material. The digesters are equipped with a cyclone separation system which removes any remaining heavy fraction. The system will separate grit and sand from the bio-slurry and reduces the need to clean the digester(s). After removal sediments are sent to a sand washer unit.

As much as 65% of the organic material is converted to biogas. This increase in energy production is significantly larger than the energy consumption needed in the hydrolysis process, so the process provides a considerable energy surplus.

The decision between one- or two-digester(s) is based on digester sizes and hence costs. The two-tank design provides better control of the digestion process, with a consequential increase in efficiency. The dry solid content into the digester(s) is ~10%, where liquids are added to dilute the material after the thermal hydrolysis, and approx. 6% out of the digester. After anaerobic digestion the decomposed material is fed to a buffer tank.

Dewatering

The purpose of dewatering is to remove liquids from the digestate. From the buffer tank the material will be dewatered in a two stage dewatering system. To ensure an optimal process the material is first pre-screened in a screw press. Particles > 10 mm are removed and the remaining cake is transported to a container. The second stage of dewatering takes place in one or several centrifuges. The material is dewatered with a minimal use of polymers.

The remaining fraction after anaerobic digestion and dewatering is called digestate or cake. This fraction can be applied directly on agricultural land after maturation or used to make pasteurized compost.

Process water

If the material to be treated contains a high content of liquids some sterilized liquids needs to be pumped to the external local waste water treatment plant. Most of the liquids will be re-used in the plant to regulate the viscosity and the dry solid content.

All water consumption is measured with magnetic flow meters in order to control the plant's liquid balance.

If any liquids are needed to for dilution purpose after the thermal hydrolysis, potable water will be used to prevent contamination.

The main objective is re-using liquids as much as possible to minimize the consumption of potable water.

MASS & ENERGY BALANCE

The process is converting waste into biogas that can be utilized to several purposes such as heat, power electricity or vehicle fuel gas. The biogas can be combusted in a combined heat and power installation in order to produce as much electricity as possible.
In some markets converting biogas to green electricity gives an important income source for the plant, especially in those markets where green certificates has been implemented. In other markets the biogas has been converted to compressed biogas (CBG) for vehicles due to better profitability.

Energy recovery with CHP (combined heat & power)
The gas from the methanogenic digester(s) is typically 65 per cent methane, the remainder predominantly being carbon dioxide. The gas can be burned in a gas engine driving a generator. Steam is raised in a waste heat boiler using the hot exhaust gas from the gas engine. Surplus steam can be supplied for heating or other process use. Additionally waste heat at up to 85°C can be provided from the gas engine-cooling jacket.

Typical mass & energy balance

Product	Output/result	Comments
Input waste	1000 kg	Food waste 70-82%
Sorting reject+grit	150-200 kg	
Digested cake	~150 kg	
Biogas at ~65% CH_4	100-150m3	
KWHs electricity	200-300 KWh	

DISCUSSION – ORGANIC FERTILIZER

The final product from the GLØR plant digester is an attractive bio-fertilizer that they sell to the local farmers and building contractors in big-bags to be used on grass-covered cabin roofs. At the plant they also mix the digestate with sand, structure from garden waste and some bark to make a soil substitute. The thermal hydrolysis effectively destroys every weed, fungus and infection source for plant disease, which might be in the raw organic waste.
The top priority is to make a completely safe and attractive product containing no trash to meet the highest Norwegian classification for compost.

Analysis of fertilizer taken out directly from the digester, (GLØR plant)

Parameter	Method	Result	Units	Limit. Quality class 0	Limits Quality class I	Limits Quality class II	Limits Quality class III
*Thermotolerant coliform bacteria	NS 4714	<2	/g	Max. 2500 g/DS inc. salmonella	Max. 2500 g/DS inc. salmonella	Max. 2500 g/DS inc. salmonella	Max. 2500 g/DS inc. salmonella
*Salmonella	Internal	Not detected					
Cd	ICP-MS	0.37	mg/kg DS	0.4	0.8	2	5
Hg	CV-AES	<0.1	mg/kg DS	0.2	0.6	3	5
Pb	ICP-AES	15.5	mg/kg DS	40	60	80	200
Ni	ICP-AES	8.6	mg/kg DS	20	30	50	80
Cr	ICP-AES	22.1	mg/kg DS	50	60	100	150
Zn	ICP-AES	340	mg/kg DS	150	400	800	1500
Cu	ICP-AES	74	Mg/kg DS	50	150	650	1000
Ca	ICP-AES	6.21	% DS				
DS%		29.1	%				
pH		8.43					

Analysis of bio-fertilizer mixed with structure and bark (GLØR plant)

Parameter	Method	Result	Units	Limit. Quality class 0	Limits Quality class I	Limits Quality class II	Limits Quality class III
*Thermotolerant coliform bacteria	NS 4714	1090	/g	Max. 2500 g/DS inc. salmonella	Max. 2500 g/DS inc. salmonella	Max. 2500 g/DS inc. salmonella	Max. 2500 g/DS inc. salmonella
*Salmonella	Internal	Not detected					
Cd	ICP-MS	0.48	mg/kg DS	0.4	0.8	2	5
Hg	CV-AES	<0.1	mg/kg DS	0.2	0.6	3	5
Pb	ICP-AES	20.4	mg/kg DS	40	60	80	200
Ni	ICP-AES	10.0	mg/kg DS	20	30	50	80
Cr	ICP-AES	11.0	mg/kg DS	50	60	100	150
Zn	ICP-AES	179	mg/kg DS	150	400	800	1500
Cu	ICP-AES	32	Mg/kg DS	50	150	650	1000
Ca	ICP-AES	2.67	% DS				
DS%		34.8	%				
pH		8.43					

*Cambi guarantees no more than 1000 E.Coli per gram dry solids, no Salmonella species in 2 grams dry solids, 6 Log10 reductions in numbers of E.Coli.

Norwegian classification for compost

Class 0 = Can be used on agricultural land, private gardens, parks, green areas and similar.

Class I = Can be used on agricultural land, private gardens and parks up to 4 tones dry solids per 1/4 acre per 10 years. Can be used on green areas, parks etc. where no food or fodder products will be cultivated.

Class II = Can be used on agricultural land, private gardens and parks up to 2 tones dry solids per 1/4 acre per 10 years. Can be used on green areas, parks etc. where no food or fodder products will be cultivated.

Class III = Can be used on green areas where no food or fodder products will be cultivated. Can also be used as a top layer on landfills (with a maximum covering layer of 15 cm).

Other requirements are:
The maximum content of plastics, glass or metal pieces with a particle size > 4 mm shall not exceed 0, 5 % in weight.

FLOW CHART

The flow chart shows a typical multifunctional Cambi. The process can treat a very broad range of biodegradable inputs.

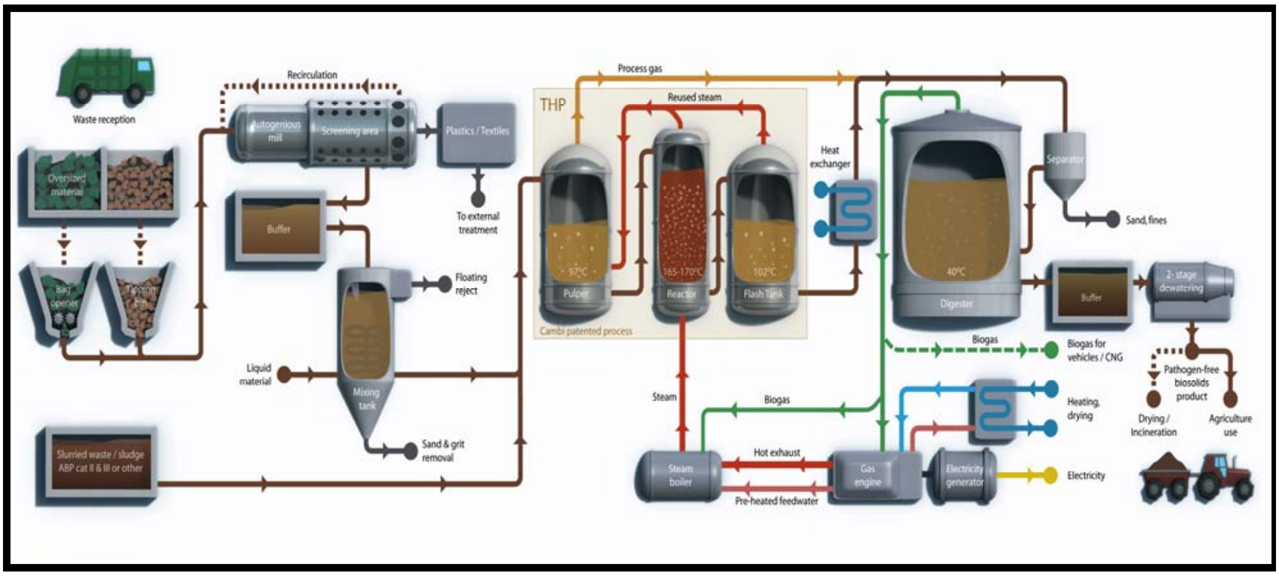

Figure 2: Typical Cambi biowaste process

PROCESS AVAILABILITY AT THE GLØR PLANT

The process runs reliably seven days per week. In order to secure a proper operation an extensive training of the operators was given high priority.
The GLØR plant has now been in operation since 2001 and has now achieved a process availability of 82%. The total operational hours in 2006 and operational stops are specified as follow:

Process availability -2006	Hours-2006
Maximum: 24h/day x 7 days/week x 50 weeks/a	8.400 (100%)
Operational hours for 2006 at the GLØR plant	6.898 (82%)
Operational stops and causes	**Per cent**
Stops caused by unwanted waste fractions	13%
Automation/process control failures	4%
Break in local electrical network	1%
Total process stops:	**18%**

CONCLUSIONS

1. Based on the experience since 2001 in the full-scale plant at Lillehammer (Norway) Thermal hydrolysis has been shown to be a very effective way of treating biowaste before digestion. It is a very stable and rapid process with high VS destruction and good dewatering and consequently very little final digestate.

2. Experience from Lillehammer has shown the importance of improving the pre-treatment of the incoming waste. This has been taken into account in the next generation bio-waste projects, represented by the Ecopro plant.

3. The pathogen-free digestate is of high quality and is in great demand as an organic fertilizer and soil conditioner.

4. Many of the problems of dealing with a complex and variable waste stream have been overcome by the use of thermal hydrolysis combined with advanced pre-treatment systems.

5. There is a high market demand for biological technologies that can handle and treat inputs from multiple organic wastes in an efficient manner. In the European political context there is a pronounced need for dispersed energy solutions. In particular local European mid-size municipalities are being considered for this technological approach.

ACKNOWLEDGEMENTS

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