bionic *microfuel*

Microwave
Depolymerisation
(MWDP)

Procedural facility
for the 2nd generation production of synthetic fuels
from biomass and waste

engineered and manufactured by

bionic
BFT Bionic Fuel Technologies AG

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Abstract

The Bionic Fuel Technologies Group (BFT) has further developed a technology for catalytic depolymerisation of hydrocarbons. The process and its chemo-physical basis have been known since many decades ago and its functionality has been proven successfully several times.
BFT has achieved the break-through in using microwaves as the source of energy in the important dry reaction phase of the material. With this approach not only have all previous difficulties of plant development been overcome, but also additional improvements have been achieved.

No carrier oils or pump systems susceptible to failure are used in the dry microfuel process.

BFT named the further developed process therefore microwave depolymerisation (MWDP).

The actual process is preceded by a pretreatment, which is heavily dependent on the chosen material. The input material is shredded, and then mixed with a catalyst on a zeolite basis and other additives. It is then pelletized.

The pellets produced in the pretreatment are then inserted in the high frequency molecule disintegrator (HFDMI) and heated step by step and treated with microwaves. The initial high vapor pressure generates inside the pellets facilitates an additional hydration of the material, until the pellets burst due to the high pressure. The remaining water pressure then leaves the microwave disintegration chamber.

After further heating up to 350°C the activity of the catalyst in conjunction with the pulsed microwaves begins. The long hydrocarbon chains inside the material are cracked for the most part into chains of a molecular length of C16-C24, which are leaving the system as oil vapor.

The remaining residue consists mostly of carbon and may– dependent on the input material – constitute a valuable commodity itself.

The produced condensed oil can be transformed into oil products conforming to fuel norms using centrifuge-filters, distillation and blending with additives, if desired.

If necessary for certain input materials, a highly efficient desulphuring technology well suited for this size of facility can be applied.

Most of the facility consists of standard machines and components. Only the core unit, the molecule disintegrator has been developed by BFT specifically for this application.

BFT has entered several patent applications in course of the development of the microfuel™ system.

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Background

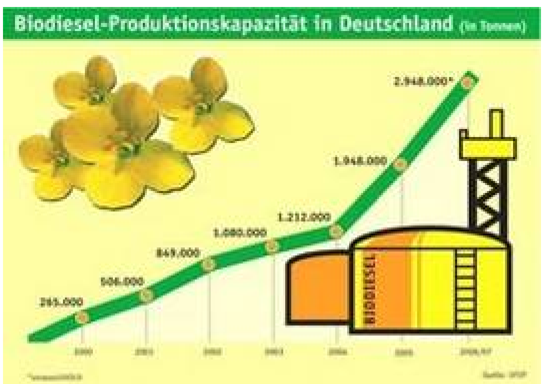
Climate protection and the development of sustainable energy sources are some of the most imminent challenges for mankind.

In light of the shortage of oil reserves the importance of creating alternative fuels has gained importance over the past few years.

But the public's awareness of the reduction of green house gases through consistent use of renewable resources is also increasing due to the pereptible climatic changes.

Finally, a reasonable utilization of the enormous waste masses of modern societies piling up over the last few decades has become a top priority on the agenda of all industrial nations.

The many close connections between those three subjects lead to the high political rank the production of green fuels rightfully achieved today. Consequently a unique, prospering industry has developed, promising the highest growth rates for many years to come.



Science offers solutions

One of the ground breaking technologies in this context, the flash pyrolysis, had been developed in the late 50s and was further improved during the 80s by Professor Bayer at the University of Tübingen, Germany. His research at laboratory level demonstrated the effectiveness of certain catalysts in conjunction with various types of feedstock containing considerable quantities of hydrocarbons. He called the process low pressure catalysis (Niedertemperaturkatalyse NTK).

Based on these findings it became possible to transform hydrocarbon containing materials like plastics and a wide range of biomass into shorter aliphatic hydrocarbon chains. The resulting products are similar to light crude oil products with comparable characteristics as Diesel or light heating oil.

The products match – for the most part - the characteristics of known products made from crude oil such as diesel or light heating oil.

A closely related technology has been widely used in refineries for a long time for the transformation of heavy oils into transportation fuels. In this case the process is called "catalytic cracking". The so called Houdrey process was introduced for the first time in 1937 at the Marcus Hook refinery. The process allowed doubling the amount of gasoline produced from crude and played a significant role in the supply of fuel to the Allied Forces during the Second World War.

The microfuel™ process in detail

Basic functionality

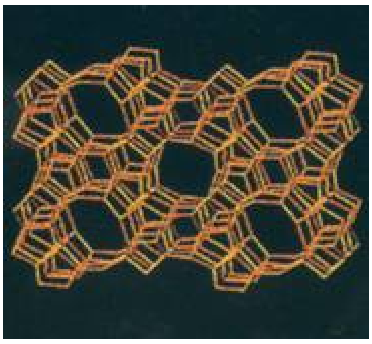
Many attempts have been made over the last 20 years to implement the chemo physical process described above in a production level plant. BFT finally succeeded by using a fundamentally different approach to the energy application during the reaction phase.

The particularly distinctive feature of the microfuel™ technology presented here is the direct, single phase transformation of the feedstock. Possible feedstock materials range from energy crops like miscanthus (elephant grass), colza cake, palm cake, olive cake to wood, but also biogenic and animal wastes as well as plastic waste or rubber crumbs from used tires can be processed into fuels. Thus the high caloric fraction (HCF) from MSW gets a new, additional possible utilization besides direct combustion.

All of these materials can be converted to valuable fuels or oil products.

The in the waste industry known as refuse derived fuel (RDF) gains new importance due to a new application besides direct incineration.

The catalysts used possess a constant pore diameter in their crystalline nanoparticle structure. This gives that only specific molecules can enter the crystals and come in contact with the highly reactive center of the crystal, which in turn only very specific products (molecular chains of a certain length) can leave.



Gittermodell des Katalysators

Due to this property zeolites are also called molecular sieves. By choosing the right type of catalyst, exact control over what transition steps are generally possible can be gained, in order to produce the desired properties.

In conjunction with the pulsed microwave radiation, which excites oscillation of a defined frequency and amplitude inside the polar molecules in the material and thereby heats the material, the cracking of the hydrocarbon chains takes place under lower reaction temperatures.

A key disadvantage of common technologies: production of highly toxic dioxins and furans from plastics at temperatures of more than 550°C has been eliminated completely with the new microwave technology as temperatures never go beyond 400°C.

The technical process

Pre-process

In the beginning of the process the input material is being shredded, blended with the catalyst and the pressed into pellets of 6 x 40 mm standard size pellets under high pressure. If necessary the material is dried before pelletizing in order to gain the optimal moisture content.

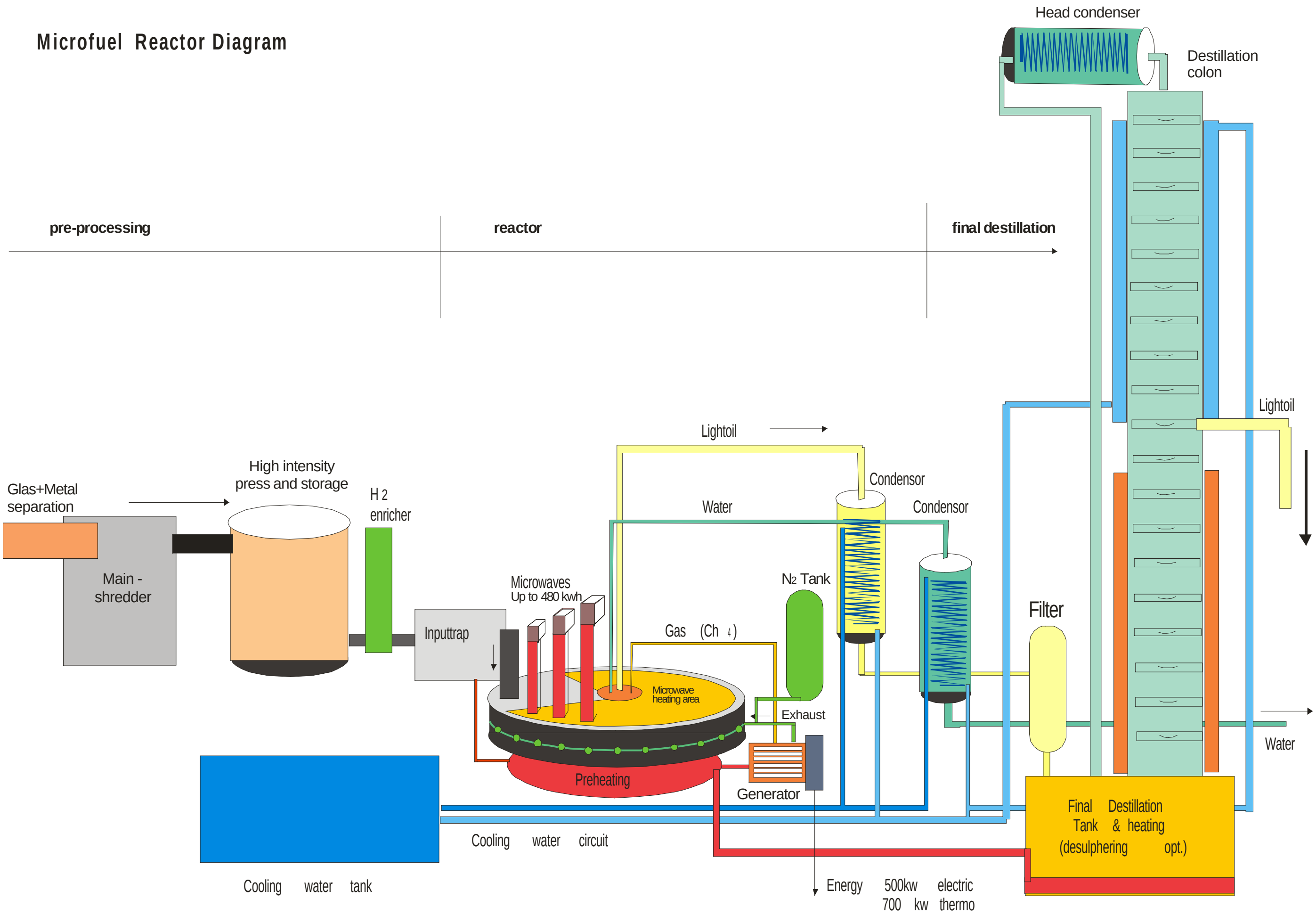
Dryer

It is of high importance that the used shredding technology is low maintenance and efficient.

A standardized production facility uses two parallel pre-processing lines. This leads to acquisition costs, which are a little higher, but this redundant solution allows maintenance and repair while production continues uninterruptedly.

Paladin Pelletiser

Reaction process



The produced pellets are inserted in the microfuel™ reactor and heated in an inert nitrogen atmosphere with pulsed microwaves with more than 450 kW of power up to 350°C.

Hereby the material is heated homogeneously from the inside.

The impact of the extremely high microwave radiation on the pressed material leads to an accelerated heating of the dielectric highly reactive catalyst and destroys the organic molecules of the material in a surface reaction.

Organic cells burst through spontaneous evaporation of the water molecules contained in the cells.
The effect of the catalyst as a molecular sieve facilitates the spontaneously starting cracking process and thereby the separation of hydrocarbons.

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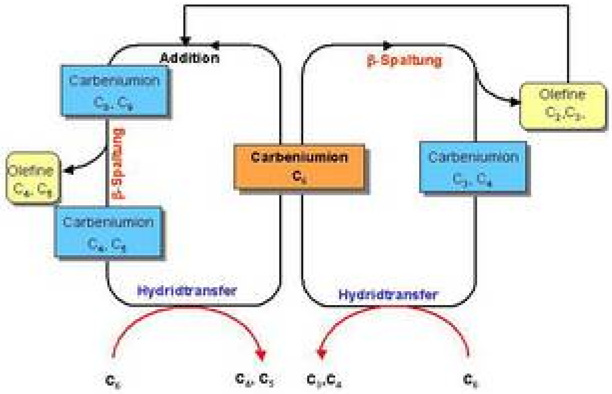


catalytic reaction example

The example catalytic reaction equation can be understood using sewage sludge as bacterial biomass:

Composition of biomass:

Lipids	ca. 30%
Proteins	ca. 50%
Polysaccharides	ca. 20%

Transition formulas:

Proteins

$(C_{70}H_{135}O_{38}N_{18}S)_n$ > $C_xH_y + H_2O + CO_2 + NH_3 + H_2S$

Lipids

$C_{50}H_9 2O_6$ > $C_xH_y + CO_2$

Carbo-
Hydrates

$(C_6H_{10}O_5)_n$ > $x\,C + 5\,n\,H_2O$

Analyses of the University of Giessen have shown that:

„the oil is mainly composed of fats (lipids) and proteins. Hydrocarbons (sugar, starch, cellulose) are converted to carbon and water. Therefore this process is a model of geological formation of oil from micro organisms and coal from plants.

Through elimination of the heterofunction of ammonium (NH3), dihydrogensulfite (H2S), water (H2O) and carbon dioxide (CO2) hydrocarbons are also created from proteins.

Nitrogen appears inside the oils and the reaction water respectively also in form of amines (R-NH2), acid amides and heterocyclic aromatics.

For the yield of oils the content of fats and proteins is significant. Therefore instable sewage sludge produce a higher yield of oil (~20%) than stabilized especially putrefied sludges (~10%).

In case of digested sludge, the most part of the carbon has already been eliminated as biogas (CO2 + CH4) and is not available for the creation of oil.“

Contrary to other processes the input material does not have to be dried completely. The residual moisture inside the input material leads leas to critical water steam inside the pellets due to the high dielectric properties of water.
Hereby the hydrocarbons are hydrated partially and the hard consistency of the pellets bursts under high pressure. The effect is comparable to the effect of popping popcorn in a microwave. Adding hydrogen gas to optimize the final pro-duct is often reasonable.

With the pulsed microwaves a very effective, homogenous and very fast heating of the material occurs.

In conjunction with the specially developed catalyst emulsion which is pressed inside the pellets in an inert atmosphere, the hydrocarbon chains, which are in the molecular area of diesel, start separating at 280°C (the boiling point of diesel fuel).

The separation process takes place due to the strong bonding forces of the used catalyst – in case of the molecular bonding with the CH-chains contained in the input material.

The “long” hydrocarbon chains are loaded asymmetrically and break due to the thermal movement of the molecules.

Due to precise control of the boiling points (270-350°C) and choosing of the catalyst, the produced product can be predefined. Materials with lower boiling points are extruded and the heavier CH-chains are cracked, until they leave the process through boiling. They are later collected in a condenser and distilled.

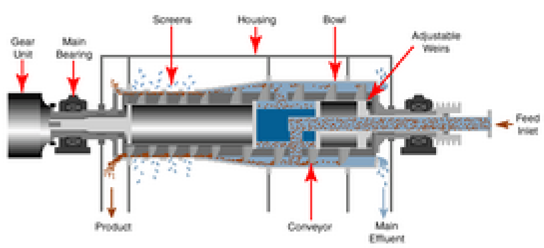
The microfuel process is a dry process, so there is hardly any coking or plugging in the system.

Post-process

The gases of the group C16-C64 (diesel like oils), are inserted in the end distillation.

Hydrocarbons that have not yet been used are reentered in the pelletiser. Residues not further usable in the process are extruded. Using a decanter fluids and liquids are separated and transformed in further processes or discharged in the usual channels.

Decanter



The scope of delivery includes a complete high quality laboratory, which includes all the analysis equipment, necessary for permanent monitoring of the product quality.

Therefore the continuous adherence to the relevant norms can be proven at any time.

In cooperation with one of the most renowned producers of analysis equipment a standardized analysis system has been developed.

Application of energy with microwaves

The special kind of application of energy using pulsed microwaves is a very environment friendly and efficient method of heating input materials homogenously and at the same time ensure a high lifetime of the energy.

The hybrid-designed application of energy utilizes the excess heat energy of the integrated combined heat and power plant (CHP) to preheat the materials and uses the microwaves almost solely for the short time heating to cross the threshold for the reaction temperature.

The microwave radiation penetrates the materials, without the source of the radiation being subject to friction.

The long-life magnetrons (microwave generators) used are maintenance free during their lifetime of more than 10.000 h. Changing the magnetrons is inexpensive and occurs about every 14-18 months.

Contrary to common belief energy application with microwaves is highly efficient. The industrial application of microwaves is not to be compared to devices used in households.

Through directed, focused microwaves the energy of 480 kW microwaves, that are used in the MF 480k facility, is comparable to about 5.000 household microwaves.

Absolute safety of personnel is ensured by the shielding and an additional housing of the molecule disintegrator. This excludes the possibility of radiation leaks.

Safety switches at the doors and at the peripheral equipment are a matter of course.

The radiation at the MF 60k at full operation is at 2 mW at a distance of 5 cm. The permitted radiation is of 20 mW at 1 m distance. Therefore the microfuel units are well within the legally permitted limits.

Energy supply of the facility

As a by-product, gaseous hydrocarbon chains with low boiling points are produced. By using them in a CHP is energetically self-supported and for the most part independent from the energy grid. One or more CHPs with 900 kW permanent electric power supply the magnetrons with sufficient energy and deliver enough heat to preheat and dry the input materials.

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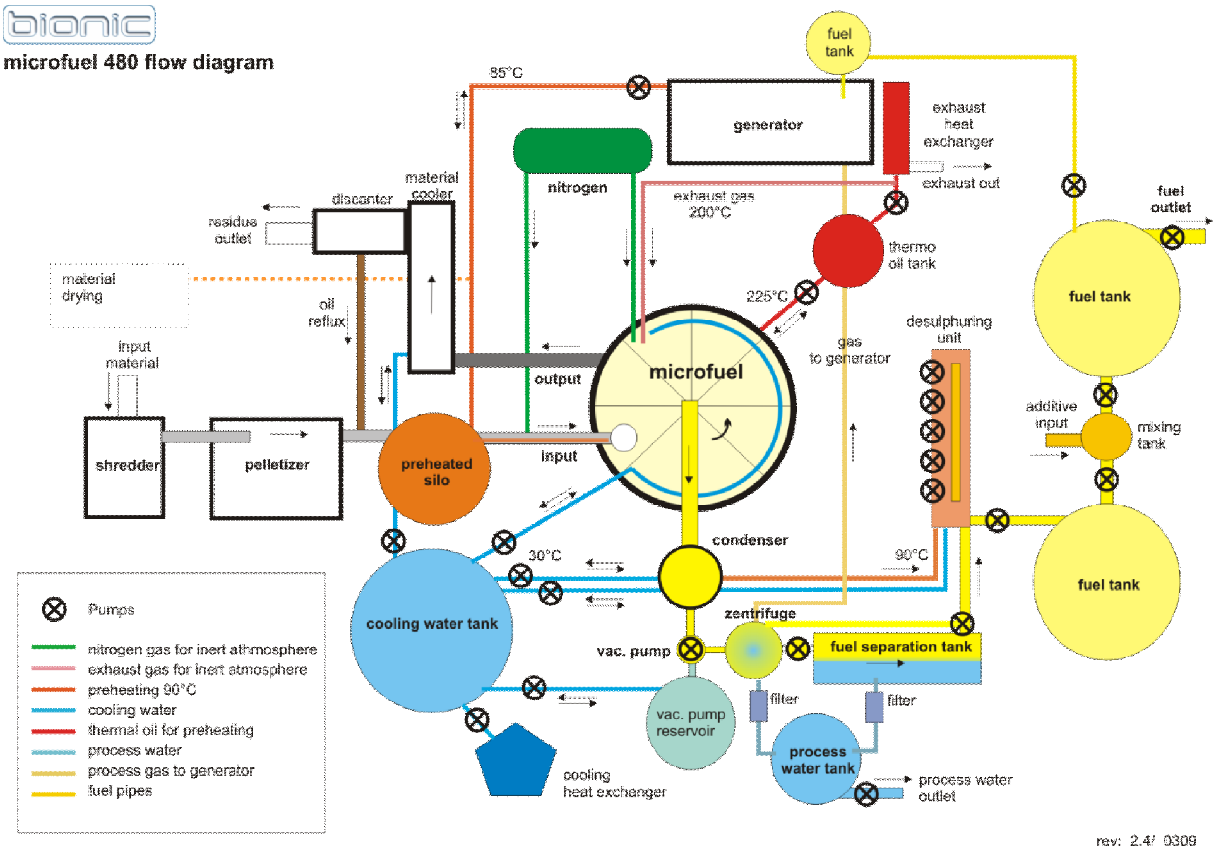
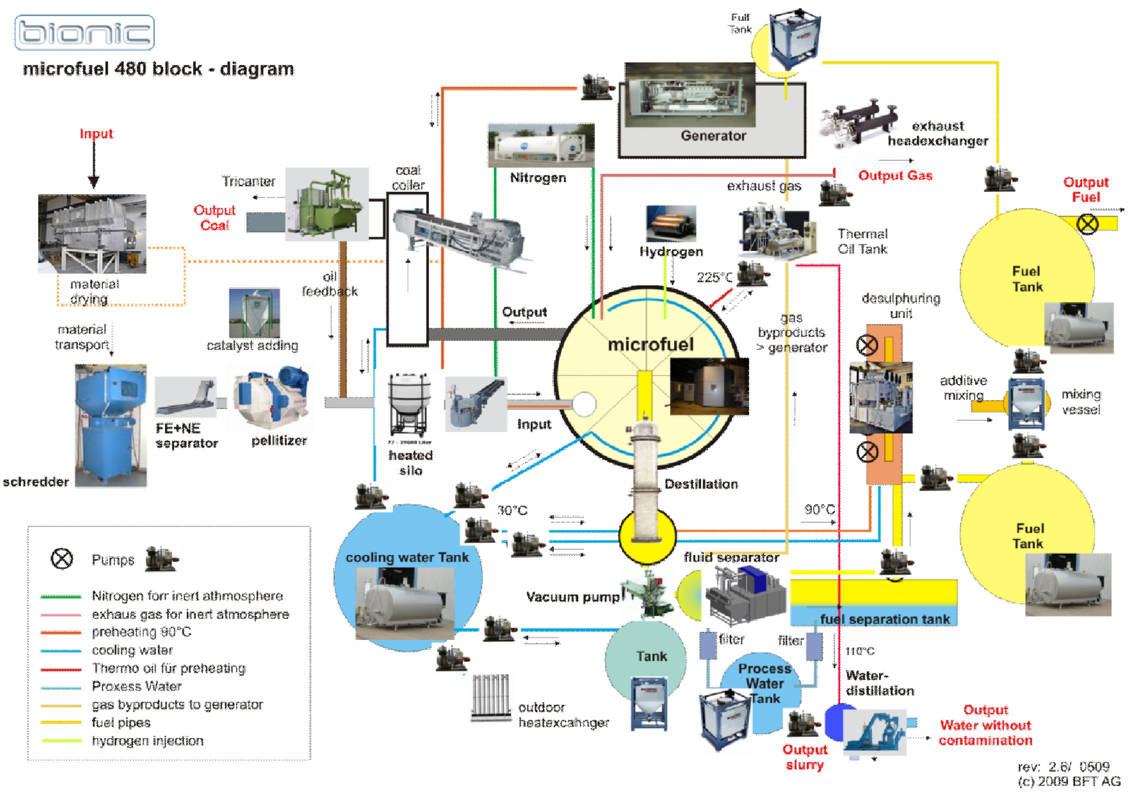

microfuel 480 flow diagram
fuel tank
85°C
generator
exhaust heat exchanger
exhaust out
fuel outlet
nitrogen
exhaust gas 200°C
material cooler
discanter
residue outlet
thermo oil tank
material drying
oil reflux
225°C
desulphuring unit
fuel tank
input material
gas to generator
output
microfuel
additive input
mixing tank
shredder
pelletizer
preheated silo
input
condenser
fuel tank
30°C
90°C
Pumps
nitrogen gas for inert athmosphere
exhaust gas for inert atmosphere
preheating 90°C
cooling water
thermal oil for preheating
process water
process gas to generator
fuel pipes
cooling water tank
zentrifuge
vac. pump
fuel separation tank
filter
filter
vac. pump reservoir
process water tank
cooling heat exchanger
process water outlet
rev: 2.4/ 0309


microfuel 480 block - diagram
Fuel Tank
Generator
exhaust headexchanger
Input
Tricanter
coal coller
Nitrogen
Output Gas
Output Fuel
Output Coal
exhaust gas
Hydrogen
Thermal Oil Tank
Fuel Tank
material drying
oil feedback
225°C
desulphuring unit
material transport
catalyst adding
Output
microfuel
gas byproducts > generator
additive mixing
mixing vessel
FE+NE separator
pellitizer
heated silo
Input
schredder
Distillation
Fuel Tank
30°C
90°C
Pumps
Nitrogen forr inert athmosphere
exhaus gas for inert atmosphere
preheating 90°C
cooling water
Thermo oil für preheating
Proxess Water
gas byproducts to generator
fuel pipes
hydrogen injection
cooling water Tank
fluid separator
Vacuum pump
fuel separation tank
filter
filter
110°C
Tank
Process Water Tank
Water-distillation
outdoor heatexcahnger
Output slurry
Output Water without contamination
rev: 2.8/ 0509
(c) 2009 BFT AG

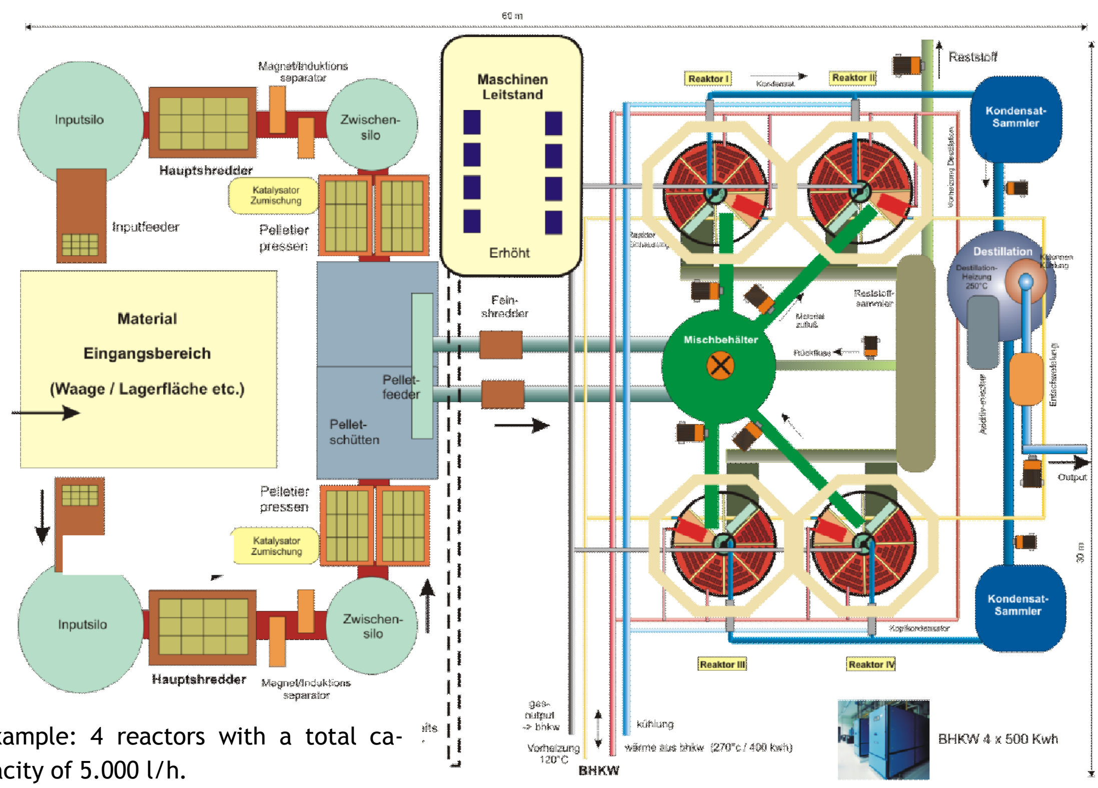
Possible capacities

The high frequency molecule disintegrator of a microfuel™ facility is designed for a capacity of 1250 l/h , while the average yield can be assumed at 30%-40% in case of biomass and 80-85% in case of plastics.

A special property of the plant design is the possibility of down-scaling the capacity. This is carried out by mechanically reducing the volume of the reaction chamber and reducing the number of microwave generators used.

Reducing the capacity to e.g. 50 l or 100 l/h is especially useful, if the facility is used for research purposes or material test. After successful tests the capacity can easily be increased.

Up-scaling is easily achieved by combining several reactors parallel.
By building clusters, the capacity can be increased to up to 6.000 liters per hour by sharing e. g. the distillation.



Example: 4 reactors with a total capacity of 5.000 l/h.

The components of a microfuel™ facility

A complete microfuel™ production plant typically consists of the following components:

Material storage
(Ample storage area to dry store the input material)

Shredder
(Facility to shred the input material)

Pellet press/ Pelletiser
(Facility to press the input material to pellets together with the catalyst)

Microfuel™ high frequency molecule disintegrator
(Chemical flatbed reactor heated with microwaves)

Condensate-tank
(Tank for the reaction product)

Distillation
(Thermal distillation to clean the product)

Desulphurisation plant for biomass

Fuel tanks
(Tanks for the produced fuel)

Mixing vessels
(Vessels to mix the fuel with additives e.g. for DIN Norm)

Water tanks
(Tanks for the secluded water from the reaction mass)

Residue tanks
(Tanks for the residues from the process)

Gas tanks for the inertisation and hydration, oil tanks
(Tanks for process oils und additives)

Combined heat and power plant (CHP)
(Engine and generator for energy production)

Laboratory for the continuous quality management of the products

The facility is produced in certified German specialist companies under observance of the highest quality norms.
Adherence to manufacturing norms is continuously observed by BFT.

Advantages of using biomass in the microfuel process

1. By using biomass energetically, the oxygen carbon-dioxide cycle is mostly a closed loop system as the CO_2 released in the combustion of biomass is reabsorbed by the growing plants.

2. The immense „hunger“ for energy of developed societies uses up in decades what resources have been generated in millions of years. Using biomass energetically means conserving these scarce, valuable fossil resources. Microfuel fuels can replace conventional fuels.

3. Transportation and storage have much lower environmental risks in case of accidents than it is the case with fossil sources of energy. Just think of leaky natural gas lines, damaged oil tankers or burst oil pipelines.

4. The energy balance of the biomass is positive. The energy used for production of this energy carrier is much lower than the energy released when used.
Die Energiebilanz der Biomasse ist positiv. In case of wood chips less than 10 % of the usable energy of the output have to be spent.

5. Renewable resources are usually sources from local areas, so long transport routes can be avoided.

6. As a country low on resources Germany is extremely dependent on import of fossil energy sources. Funds are transferred from the region to other countries. If biomass is used energetically, this added value stays within the region.

7. The intensified use of local energy carriers like e. g. wood reduces the dependency on fossil energy carriers and creates more maneuverability in times of energy crises or increase in energy prices.

8. Agriculture and forestry are operated by people, linked to the region. Almost all funds used for the fuel produced in microfuel facilities stay within the region which again benefits from the. Energy from biomass produced locally not only closes ecologically but also economically reasonable cycles.

9. Improvement of the already highly developed combustion technology requires innovations. Those are normally sourced in small and medium sized businesses. There is also a requirement for innovations in an earlier step, in the production of the biomass. Businesses from Germany - but also international ones – can develop new promising markets

10. Farmers and forest managers often not only produce the biomass, but they also operated the biomass facilities. These facilities and the increased use of unused wastes from forestry and agriculture new job opportunities and sources for income are created.

11. Apart from wood as an input material, crop waste, loopings, press cake, biological sewage sludge and algae are applicable

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The construction process

A microfuel™ facility is typically built and operated in several stages.

In the first stage, the facility will operate at a reduced capacity. This facilitates initial production test, ramping up the facility and training of personnel.

After a successful trial run and adjustment of the produced fuels to the individual input material (e.g. using special additives for EN 590 norm) the planned capacity will be reached by installing further magnetrons.

Depending on the construction of the equipment the pre-process line will be designed in two process lines. This causes less interruption during maintenance work and allows for usage of shredders and pelletisers only at daytime to avoid noise due to the planned over-capacity.

Important plant components are basically designed in two process lines to avoid incidents.

Tanks are dimensioned, so that there is enough over-capacity to bridge e. g. holiday weekends.

Site-specific requirements

In order to construct a microfuel™ plant, the following preparations on part of operator are necessary:

Paved area of at least 800 qm
A building of the dimensions l 20 x w15 x h 12m
Area for input material storage (1000 qm recommended)

Power supply of 380 V/kW continuous load for emergency operation

Separate housing for the attached CHP (900 kW elec. energy)

Water connections and cooling water tanks
Water drain (for cooling water, not contaminated)

Area for fuel tanks

Legal permits are to be obtained, while the microfuel technology is classified as an "other recycling facility" and all requirements of the legal regulations are met.

The microfuel facility is completely made from high-grade steel. The used microwave generators comply with the technical regulations for high-frequency facilities and is certified following the current regulations. Even though it is not necessary, the facility is designed explosion proof following the ATEX standard.

In designing the plant the almost entire recycling of the end product was very important. End products are reintegrated and waste is avoided.

E. g. the water contained in the input material vaporizes and is collected again. It is then cleaned in a distillation at low costs and then available as cleaned water of drinking water quality.

The exhaust gases of the generators are used for the inertisation of the plant to save nitrogen and the waste heat of the generators are used for the drying of input material and pre-heating.

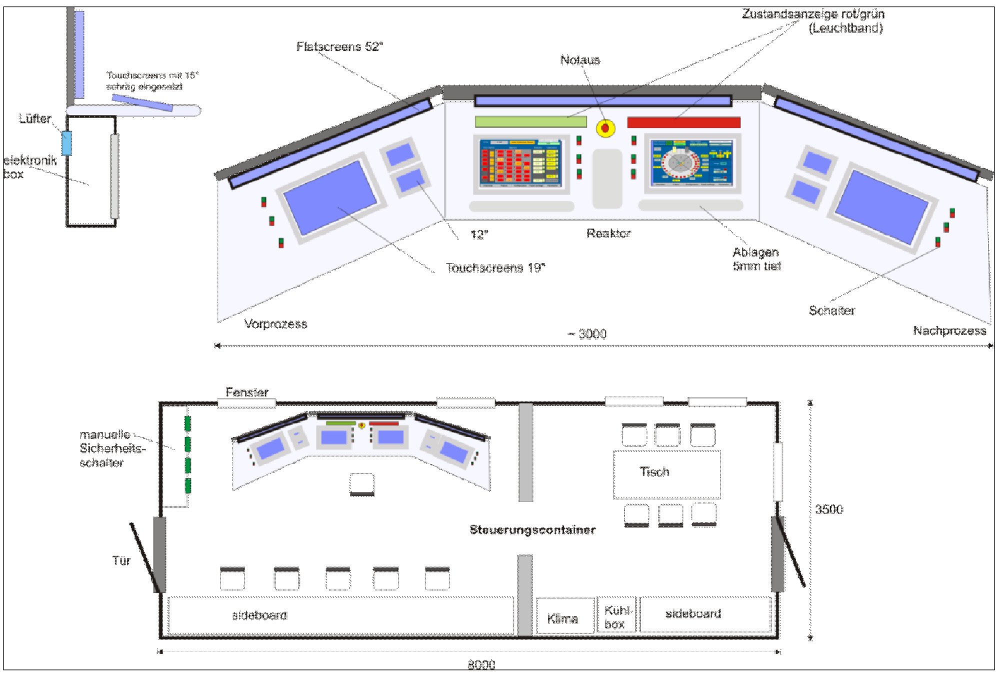
The facility is designed for operation time of min. 7.680 h (24 h/d x 320 d) per year. Continuous operation is possible if the maintenance intervals are adhered to.

Through the modular design and the for the most part automatic control, the unit can be operated by one and is low in maintenance.

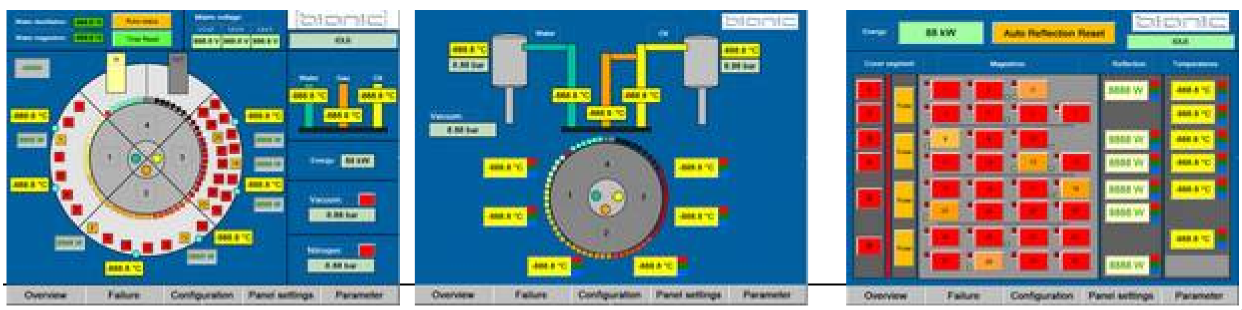
The entire control is placed in a container, from which the significant plant components can be controlled by cameras.

Uninterruptible emergency power supplies are standard for the electricity.

The control desk



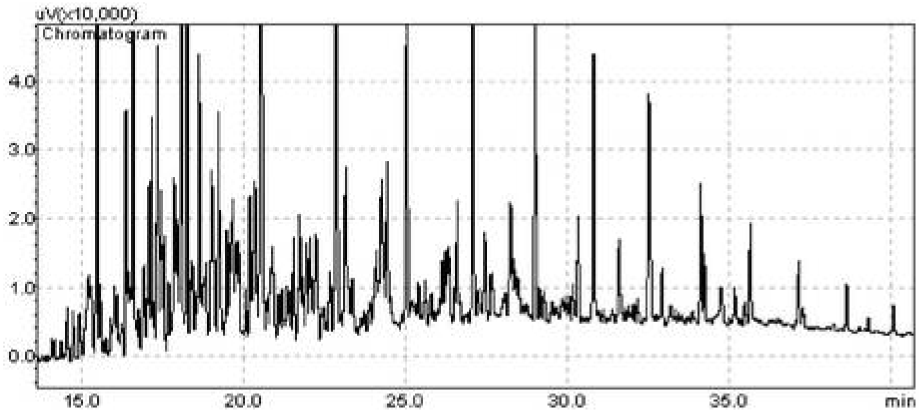
Example of the control unit



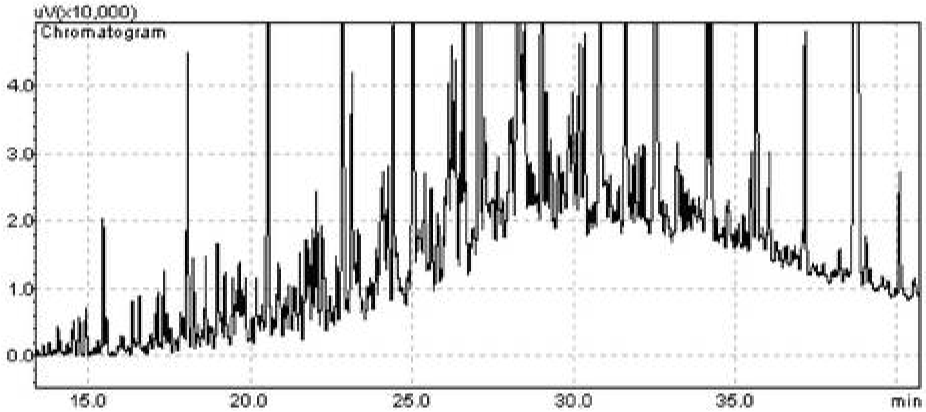
Properties of the distillate

The following analyses for a mixture of high caloric plastic wastes show that the product lays qualitative unlimited within the EU norms for diesel fuel.

Parameter	EN 590	RDF distillate	Unit
Kin. viscosiy at 40°C	2,00 to 4,50	2,94	mm^2/s
Density at 15°C	820 to 845	831,40	kg/m^3
CFPP	Max. -20	-15,00	°C
Cetan index	Minimum 46,0	42,90	-
Distillate at 250°C	< 65	60,17	Vol. %
Distillate at 350°C	Min. 85	95,21	Vol. %
95% percentile	Max. 360	351,19	°C
Heating value	40- 42	40,2	MJ



Petrol station diesel



microfuel light oil from straw

Typical yields from various input materials

The following table gives an overview over the versatile capabilities of the process regarding possible input materials.

Input material	Yield in % (dry matter)	Catalysat Requirement kg/t
Wood	34,0%	34
Sweet corn	35,0%	32
Slurry	44,0%	24
Miscanthus	39,0%	28
Biomass (Richtwert)	35,0%	35
Olives	47,0%	27
Palm cake	49,0%	23
Sewage sludge+RDF Mix	53,0%	19
RDF(42MJ)	54,0%	12
RDF hydrated	68,0%	16
Rape cake	55,0%	26
Tyre dust	60,0%	32
Saw dust	34,0%	34
Reed	36,0%	33
Light fraction (Weißware)	78,0%	15
Straw	35,0%	36
Wax	89,0%	21
Wheat bran	42,0%	29

The values given are guideline values and can be greatly improved upon by adding hydrogen gas and/or pretreating the materials with steam-reforming in an additional step.
In plastics the content of halogens show not exceed 15%.
Basically tests are necessary for every input material in order to specify the exact yields.
Special constructions for oils sands, oil sludge, coal hydration and animal meal are available.

Byproducts

Due to the fact that the conversion to light oils is only possible for the most part of the hydrocarbon contained material and the concentration of carbon and hydrogen are not optimal in most materials, other products beside light oils can be generated.

Those are:

Water (of the moisture in the material, typically 10-18%, purified through distillation, unloaded)

Carbon (96% pure, powdery, calorific value ~5,5 MJ/kg)

Inorganic salts (in the carbon, e. g. Sodium-, Calcium-, Potassium- salts, already contained in the input material, residual catalysis as silicate, environmentally neutral)

Gases (Methane, propane, pentane and other organic highly volatile compounds, which are burned inside the generator, nitrogen and carbon dioxide in small amounts, which are also cleaned inside the generator)

Solids (Sulfur, which is separated from the process in a desulphurisation unit)

Residues (heavy oils from the distillation sump ~5%, oil emulsion from water cleaning ~2%)

Revenue possibilities

Fuel

Primarily the sale of the produced oil is self evident. A distinction is to be made between fuels from waste and fuels from renewable resources, which can be used tax exempt in engines until 2015)

As far as the fuel is removed from the bonded storage (production site) it has to conform to the EU Norm DIN 590.

This means that produced fuels, similar to the ones produced in refineries have to be blended with additives in order to meet the norm. For use in generators that produce energy or similar machines, which are located on site, this refinement is not necessary.

In case of fuels produced from waste, input materials containing plastics, the petroleum tax has to be observed.

Carbon

The carbon produced in the process can be sold for various different purposes.

Initially sale as combustible seems apparent, but there are other applications:

During the tests it was found, that the carbon produced in the process as a residue has an open molecular structure, which has all the properties of bio char, for which it seems possible to be used as fertilizer.

- Open porous structure, therefore water collecting
- The carbon contains all minerals, contained in the input material
- NH^3 from manure and microbiological wastes is decomposed in the microwave process and leaves the system.
- Through homogenous heating the carbon is evenly distributed and the desired residual organics can be produced
- The crystal structure of the carbon is polarized due to the microwave radiation. The water absorption is increased therefore
- The carbon is sterile and can be treated with micro organisms to increase fertilizing capabilities with e.g. nitrobacter (species of this type can be found in the ground, sweet water and in the sea. They are rod shaped, gram-negative bacteria, which are used for energy production oxidizing in oxidic and environments nitriteions ($NO2-$) with oxygen ($O2$) to Nitrateions ($NO3-$)

The presence of the zeolitic catalyst (sodium-silicium-aluminate-sand) which is completely environmentally neutral, leads to an additionally high water absorption of the carbon.

There is also the possibility to separate the phosphates from manure as an input material.

A complete disintegration of organic compounds in bio char as fertilizer produces much higher revenues than carbon as a combustible

Carbon produced from waste is only suitable as a fertilizer, is the input materials do not contain heavy metals. A special selection of the input material is necessary in these cases.

Process water

The water produced during the process is cleaned in a distillation process after passing the reactor and separated from aromatic byproducts and oils.

The water can be induced in the sewers, used for irrigation or after an additional cleaning process sold as cleaned water.

Sulfur

Sulfur is contained in the amino acids cystein/cystin and methionine and in all peptides based here on, proteins, co-enzymes and prostetic groups in form of thiol groups (oxidation level +II) or thio-ether groups

Furthermore it is contained in several cofactors (biotin, thiamin pyrophosphate) in heterocyclic compounds.

Sulfur is therefore an essential element of all living cells.

Disulfide bridges are very common and help in building and stabilizing protein structures.

In oxidized form sulfur is also integral in the aminosulfon acid taurin (oxidation level +IV).
Most of the input materials contain sulfur in the basic substance.

Sulfur melts at ~115°C and is discharged with the gases due to its low melting point. A complex desulphurisation separates the sulphur as an element so it can be sold.

Residues

The residues produced in the process have to be discharged in accordance with regulations. Low quantities of heavy oils (below 5%) arise from the distillation sump and the water cleaning process.

Exhaust fumes

The process does not produce any exhaust fumes. Only the generators (CHPs) for the production of energy are emitted. Combustible and non combustible gases produced in the process are induce in the air intake of the generator and neutralized inside the combustion chamber.

The soot is filtered after this afterburner in a particle filter.
As the process occurs in an inert atmosphere, parts of the gases are reused in order to make the atmosphere inside the microfuel reactor inert and to preheat the input material.

Possible applications

Combined locations

The application of the microfuel technology to produce light oils is feasible in combined locations. The immediate availability of generator power at peak times and the storability of the fuel have to be pointed out.

Therefore the application at municipal locations is feasible, in cases where e.g. sewer sludge is mixed with municipal solid waste and loopings of the municipality and the oil produced is used to produce electricity and heat.

Agricultural application

As the carbon resulting as a byproduct to the oil produced from renewable resources can be used as a bio fertilizer, the technology can be applied optimally at agricultural locations.

Aside from the availability of the input material, short channels are required for the application; additionally cultivation cycles can be used optimally.

If the fuel should be used in agricultural machines or for the production of energy and heat to dry the materials needs to be decided from case to case.

Elimination of residues

The microfuel technology can also be used to eliminate problematic wastes such as flotsam in coastal areas or land fills.

Through impact reactors as possible pretreatment of the material, nearly all materials can be applied.

Of course, the contamination has to be checked in each case, and special neutralization or cleaning processes may become necessary. Due to the low process temperatures it is not problematic to implement these steps.

Consulting

BFT values the planning security of its customers. A key component to meet the goals is the diligent implementation of a pre-project to clarify all technical and business parameters of the project.
Experts at BFT research all the data necessary for the customer, carry out material tests on BFT's own facility.
The customers have the opportunity to create reliable business plans together with BFT consultants for their project.

The parameters from the pre-project will be included in the delivery contract of the facility and become part of a broad function guarantee of BFT towards its customer.

The costs of the pre-project will be settled in the order of the facility.

In regard of such a pre-project the following activities are planned:

Analyses and tests

- Chemical analysis of the input material e.g. for calorific value (energy content),
  organic contents (PCB, PVC, PU, PAE etc.), inorganic salts , metals and metal compounds, water content, toxins

- physical analysis of the input such as
- odor structure
- grain size,
  specific weight
- hardness
- processability: solid/ liquid
- pourability
- porosity
- own temperature
- properties of storability

- Processing of a sample in a test unit to determine the yield

- Analysis of the produced oil in terms of EN 590
  Water content
  Sulfur content
  Temperature stability
  Boiling point, C-O-H , NO, NOX, TOC

- Test of the light oil for engine suitability
  test in a test engine
  exhaust testing
  Cetan value- measuring

- Analysis of the residue
  Chemical analysis for organic compounds and soluble salts, landfill suitability in terms of Euro DIN

- Determination of the scope of delivery, the parameters of the facility and the interfaces with the customer

- Determination of the chemical specifications of the input material

- Determination of the physical specifications of the input material

- Determination of the max water content of the input material

- Determination of the amounts to be provided for by the customer in terms of the input material determined by the customer and the material mix of the applied materials. The mass proportions of the input materials and permitted material mixes

- Determination of the statistic control samples for the operative use

- Determination of the functionality parameters (Input-Output-Relation)
- Determination of the interfaces with the pro-process
- Determination of the location
- Determination of the interfaces with the post-process
- Determination of the additionally needed resources provided for by the customer (water connection, sewers connection, electric connection, noise control, etc.

- Determination of the timeframe for the production of the facility and the ramp up
- Determination of the personnel training times and location

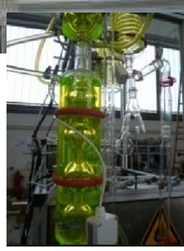
Bionic research institute for renewable energies

Beginning at the end of 2009 the Bionic research center for renewable energies will start working on a systematic, scientific research of the optimization of the microfuel technology and additionally secure the planning of our customers.

Financial investors have the opportunity to take part in this enterprise with participation certificates and thereby participate in the operation of the test and demonstration unit and the success of the technology.

Customers can have their materials tested without having to operate their own laboratory unit.

The bionic research institute will also test the combination of different pre-processing technologies with micro-fuel high frequency disintegrators in continuous operation.



Feasibility

The construction and operation of a microfuel™ facility based on substantiated planning is a highly feasible investment.

The product prices are immediately determined by the world market for oil. The long-term trend shows prospect for above average increases in price.

In addition, depending on the input material and the location, additional profits can be earned.

Using waste as an input material, high gate fees can be included in the long-term calculation.

The operator of the facility will not only be working in the fuel sector, but also in the waste management industry.

The production of oil from biomass is a highly supported area in the EU-regulations. E. g. the tax exempt status of biofuels until the year 2015.

Due to the nature of the technology high governmental grants can be included in the calculations for the investment.

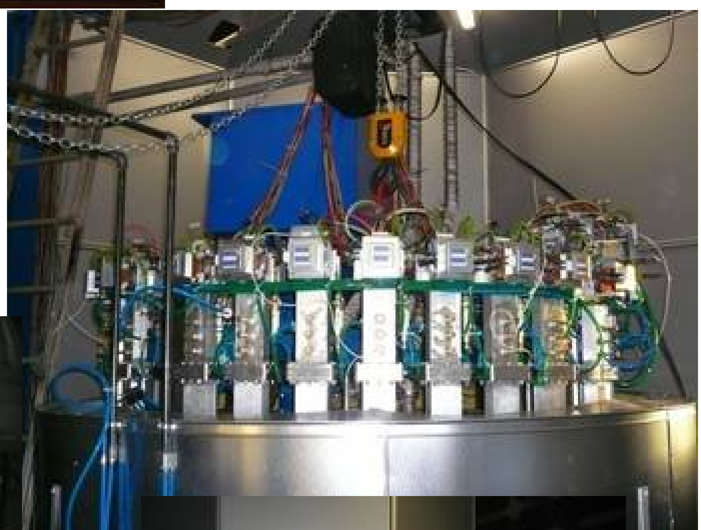
Due to the fact that the key parameters have to be individually analyzed for each project, it is not possible to offer a one-size-fits-all calculation. Exemplary calculations are available on request at BFT.

Microfuel pilo plant

Nitrogen tanks

Control

Octogon on the inside



Visit of the New York based waste disposal contractor Michael Bellino

Visit of the Danish Minister for Environment T.L. Poulson