

Hydrothermal Carbonization

The path to an energy autonomous sewage plant



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Hydrothermal Carbonization

The path to an energy autonomous sewage plant

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What is HTC?

Hydrothermal Carbonization (short: HTC) is the conversion of biomass waste to biocoal and water in a closed system und water under conditions of temperature and pressure.

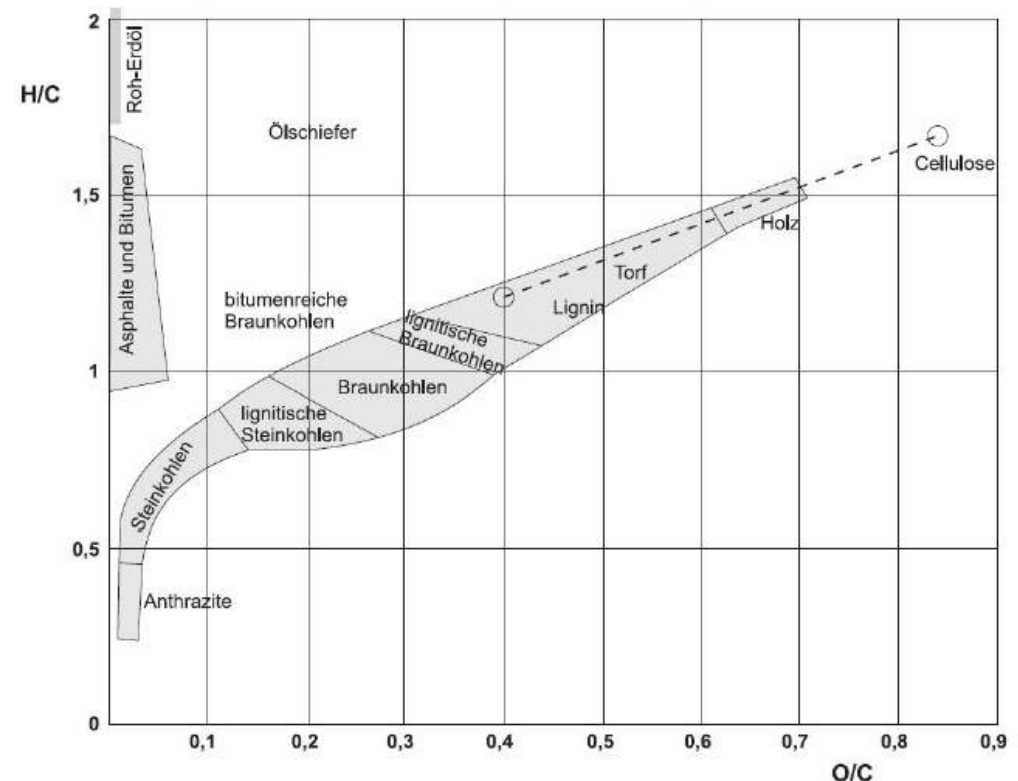
Technical parameters:

- HTC is conducted at a temperature of 220 °C and a pressure of 22 bar above the steam pressure curve in water.
- HTC is a physico-chemical procedure. HTC is an exothermic process.
Example of sugar: $\text{C}_6\text{H}_{12}\text{O}_6 \rightarrow 6\text{C} + 6\text{H}_2\text{O} + \text{heat}$.
- In the process of breaking up carbon hydrate chains to carbon and water, heat is released (exothermic energy).
- The carbonization process occurs in very short time (2 – 6 hrs)
- Almost 100 % of the carbon and 2/3 of the energy contained in the original biomass are preserved with the conversion to coal. In the form of coal, the energy is easily storable and transportable.

Hydrothermal Carbonization (HTC) / Vapothermal Carbonization (VTC) is a procedure for refinement of biomass waste material.

Basic information

- Conversion of biomass waste into a coal product (e.g. peat/humus, brown coal or black coal from original biomass).
- Time span of coalification:
 - about 4 Mio. years in nature
 - about 2-6 hrs. with HTC/VTC
- Any moist or wet biomass can be converted to coal products with HTC/VTC within a few hours.



**Can HTC/VTC be a sustainable instrument
for the protection of natural resources?**

**What natural resources
must be protected in a
sustainable manner?**

**1. fossil energy
sources: peat, brown
coal, black coal,
crude oil, natural gas**

**2. The atmosphere
must be protected by
preventing CO₂, CH₄, CO
and other climate
damaging emissions.**

So, clearly yes!!!

How can a sewage plant become self-sufficient on energy?

- This can only work, if the organic biogenic material gained from the sewage plant (sewage sludge) are used and additional communal waste (e.g. „German brown container“, green waste, residues from biogas plants) are used for energy production.
- This way, the gain for the sewage plant is beyond the pure energy production. This saves the costs for the treatment and disposal of biogenic waste from the local community.

HTC plants for an economic usage of sewage sludge

- The problem with sewage sludge is becoming increasingly difficult, due to new government regulation and law.
- The latest German regulation concerning the disposal of sewage sludges contains regulation, that sewage sludges flocked and drained with polymeres must no longer be disposed on agricultural soil.
- With „state of the art technology“, this means, that sewage sludges must go to incineration. Because sewage sludge is still waste according to (German) law, not the energy value of the sewage sludge is honored in terms of pricing, rather significant amounts of money have to be paid for incineration of sewage sludge. The price 60 €/t up to 120 €/t of drained sewage sludge.

Consequently, a different, more cost saving solution is needed!!!

HTC plants for the economic usage of sewage sludge

What targets are to be reached by using the sewage sludge on site?

1. A cost saving solution.
2. Using the energy sources,
3. Usage of own energy sources from biogenic waste material in the sewage sludge and rake.
4. Independence from external pricing for sewage plant because there remains only little waste material for disposal
5. Autonomous energy production from biogenic waste material on site, up to complete self-sufficiency on energy.

What is the contribution of HTC?

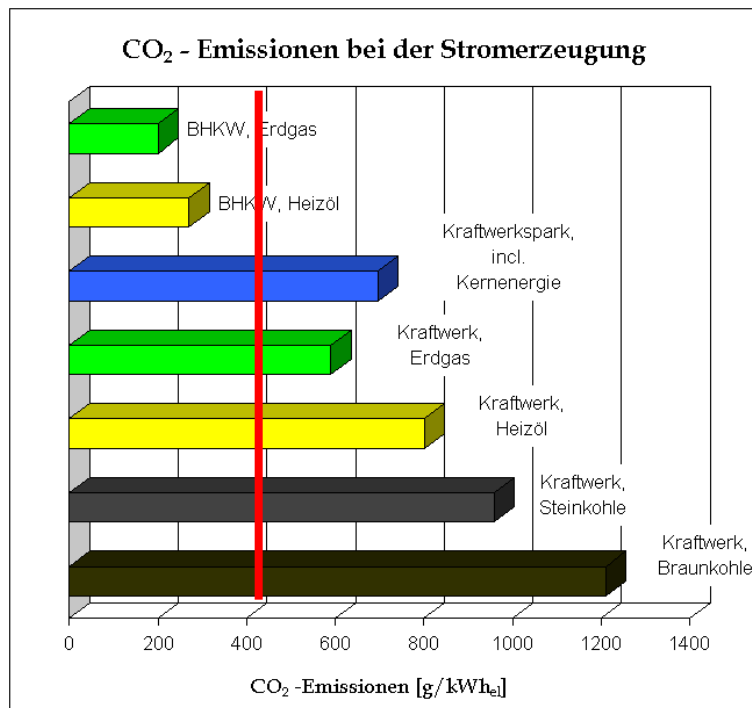
- In the physical-chemical process of HTC, the carbon contained in the original biomass is bound in the carbon. The calorific value augments by 20-30 % up to about 7 KWh/kg coal (waf) at an energy content of about 75 % to 80 %.
- Due to the process of drying and briquetting, the HTC coal becomes permanently storable and transportable.
- The next step is the energetic usage of HTC biocoal. In a wood-/coal gasifier, the biocoal is converted to synthetic gas. Then, in a two fuel engine, the synthetic gas / heating oil is converted to electric and thermal energy.

Benefits of energetic usage of synthetic gas

The energetic usage of the synthetic gas takes place in two steps: first - gasification, second - conversion of synthetic gas to electric and thermal energy. This procedure offers the following benefits:

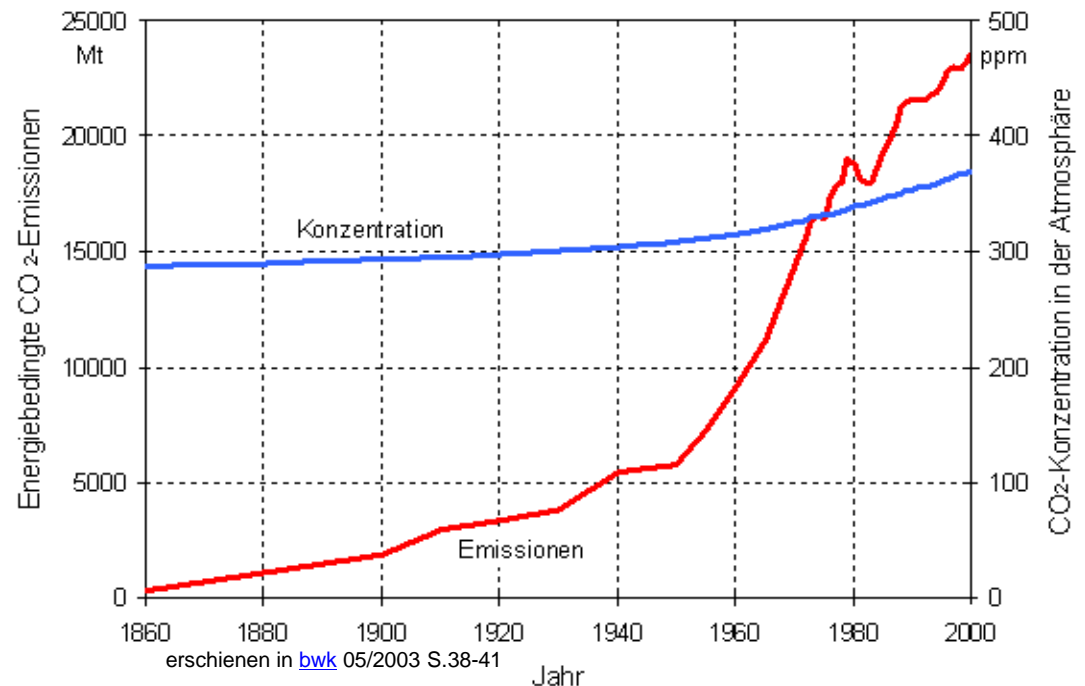
1. No disposal of sewage sludge and biogenic waste material
2. High efficiency in the conversion of HTC biocoal to energy
3. Very little CO₂-emissions as compared to incineration of HTC biocoal in a mono combustion plant (see image left next slide)
4. Potential to produce activated coal with process of gasification (up to 20 % of the coal)
5. Only a little quantity of waste material for disposal (ashes, volume equals about 1 % of the amount of sewage sludge)

Benefits of energetic usage of synthetic gas



eine Informationsseite der GLIZIE GmbH

CO₂ emissions from energy production



CO₂ emissions from energy production (red line)
Share of CO₂ in the atmosphere (blue line)

Volume: from liquid sewage sludge to ashes

100 % liquid sewage sludge
3.5 % DM = 35 g DM
1.000 g liquid sludge

Drained sludge
8 % DM = 35 g DM
125 g sludge

After carbonization
of drained sewage
sludge 60 % DM =
25,55 g DM
42,6 g biocoal
from sludge

Ashes from sewage sludge
10 % content in DM
3.5 g ashes per 1000 g sludge



Source: Revatec GmbH, 2012

What can be achieved by carbonization of sewage sludge?

1. Reliable hygienization of sewage sludge with carbonization (220 ° C, > 3 – 4 hrs.)
2. The phosphate can be easily regained from the sewage sludge.
3. After „Hydrothermal Carbonization“, separation of liquid and solid material is much easier!
For this separation with chamber filter press, no FHM is needed.
4. The coal and water separation can go up to 70% DM in the coal from sewage sludge.
In HTC process, original DM is converted to coal products.
This means, the DM volume is reduced! (conversion rate about 70 % from original DM)
5. The specific calorific value of HTC coal from sewage sludge augments as compared to the original sewage sludge by about 20 to 30 %! The result is a rather uniform fuel.
6. HTC coal from sewage sludge can be burned much better than drained sewage sludge!
7. HTC coal from sewage sludge can be converted to energy with a wood-/coal gasifier and CHP.
8. In the gasifier, activated coal can be produced from the coke.

Where and how to integrate an HTC plant in a sewage plant

To obtain the best result from carbonization of sewage sludge. It should be taken at the specific point, where the largest organic share can be expected:

- After primary treatment
- After secondary treatment / pre-thickener

The HTC plant takes in the sewage sludges - more liquid, more solid or mixture – from a storage container.

After carbonization, the HTC biocoal will be converted to synthetic gas in a wood-/coal gasifier adapted to the capacity of the sewage plant and immediately be converted to electric and thermal energy by a CHP.

The electric energy is consumed on site. The thermal energy is needed for the heating process of the HTC reactor and for the drying process of HTC biocoal.

The path to an energy autonomous sewage plant

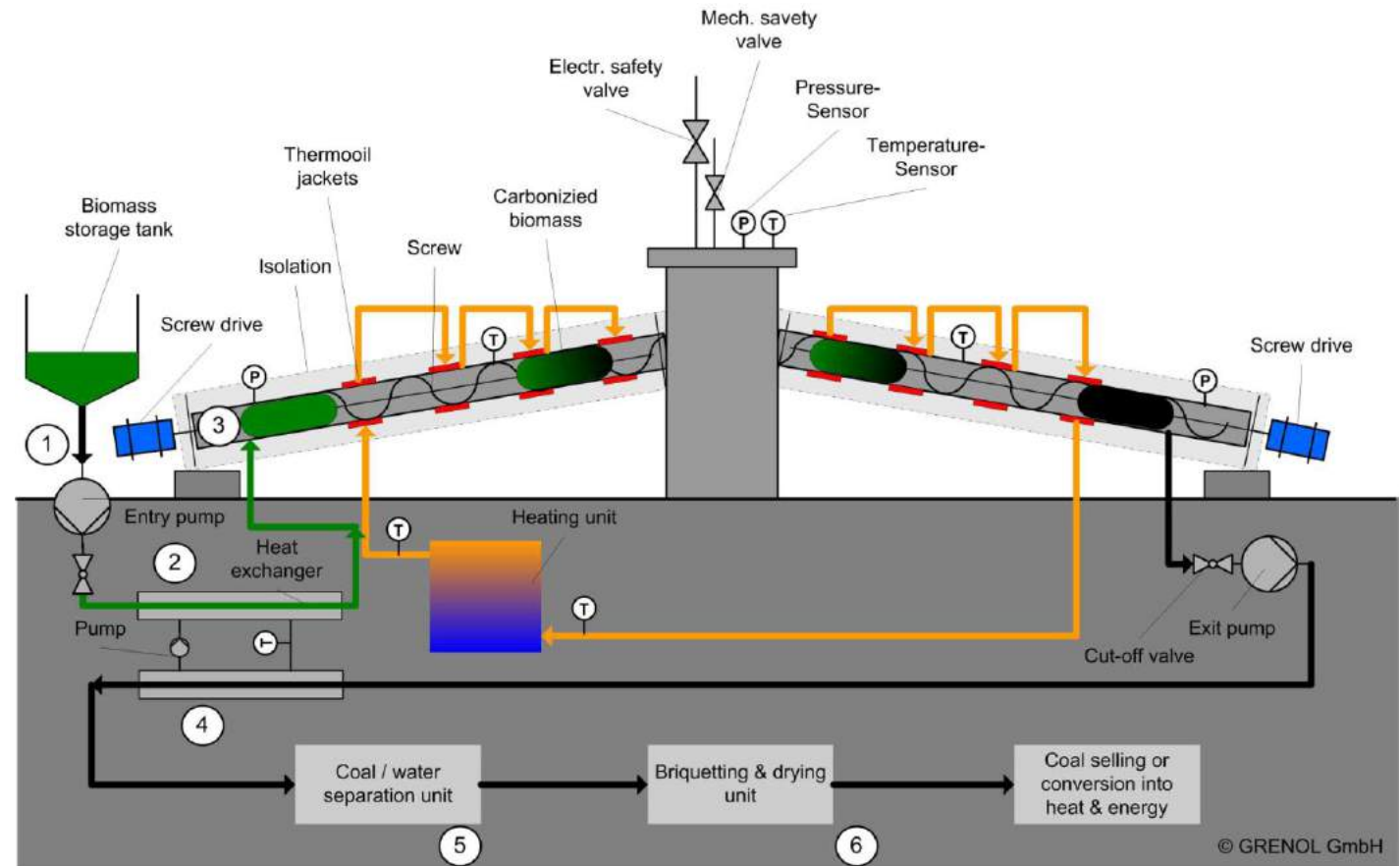


GRENOL HTC Base module - How it works

Modular
construction on
a 40' container

Continuous filling with
biomass and
continuous discharge
of HTC coal and water,
fully automated
system

Usage of exothermic
energy for preheating
new biomass
due to heat exchange
system



GRENOL HTC base module

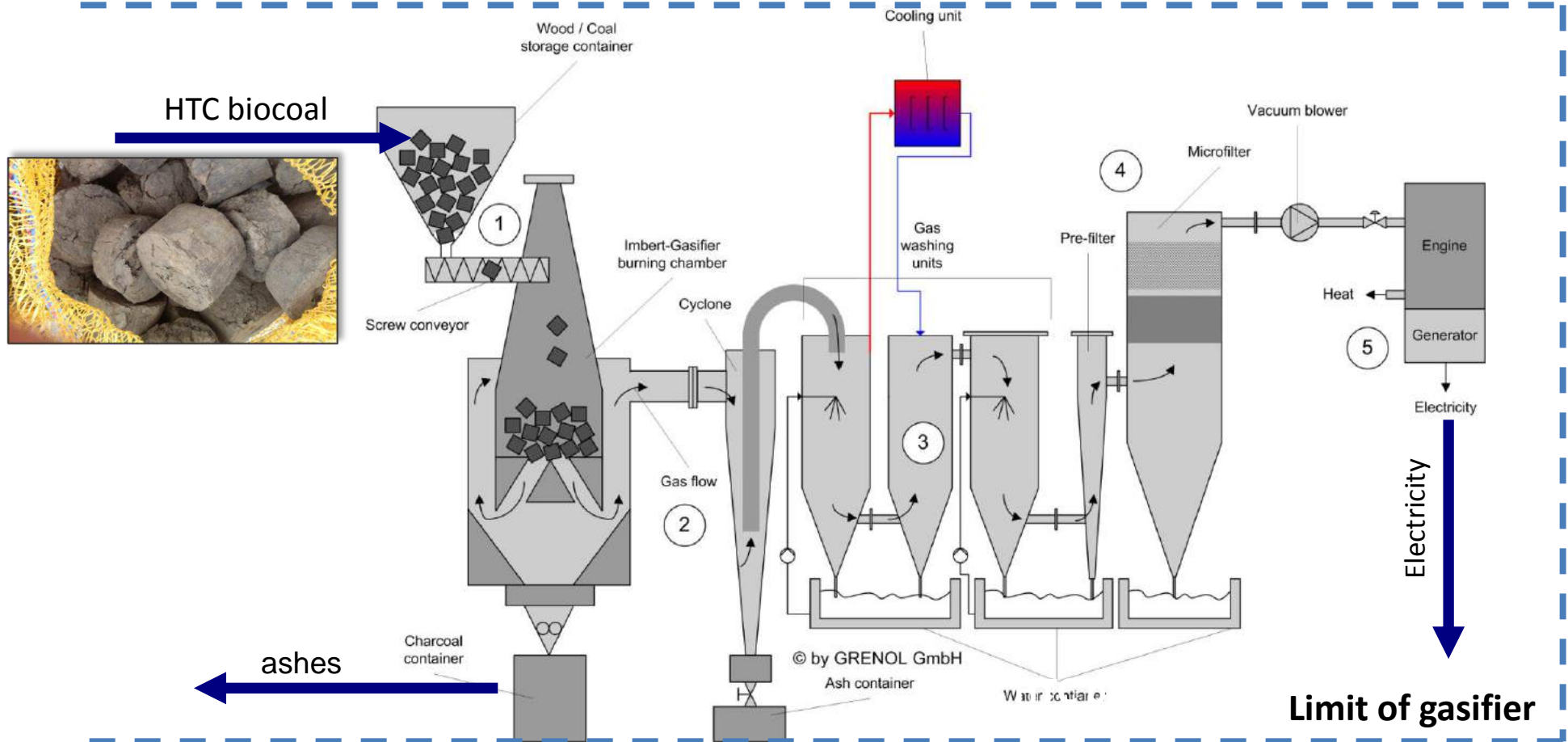


HTC – base module
capacity: 10 t/d biomass
at 5 – 30 % DM



HTC base module with extended heat exchange system

Wood-/Coal Gasifier GRENOL GmbH, Ratingen/Germany



Images Wood-/coal gasifier with CHP



Gasifier for wood + HTC biocoal
GRENOL GmbH, Ratingen



CHP 100 KW, usage of thermal energy for
apartment and drying of grains, GRENOL GmbH

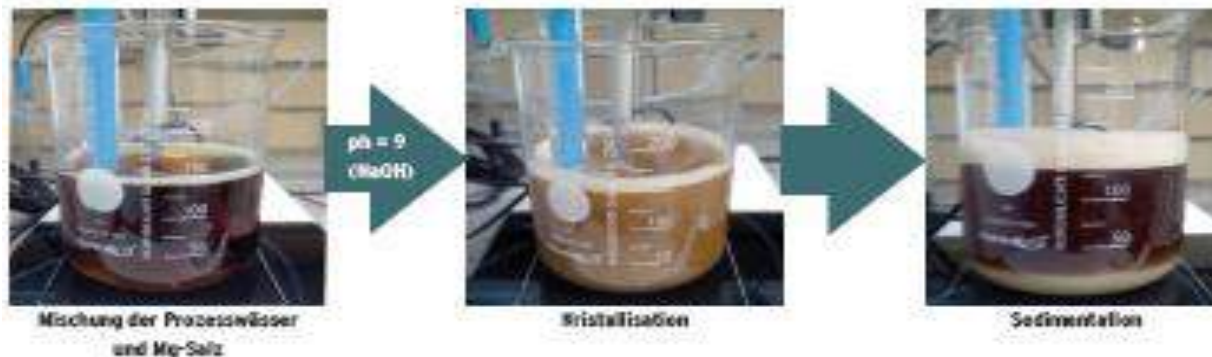
Summary of benefits for sewage plant

With an HTC carbonization plant, a sewage plant will benefit under these aspects:

- No disposal, thus no cost for disposal of sewage sludge.
- Only disposal is ashes from wood-/coal gasifier (small volume).
- By accepting communal biogenic waste such as the German „brown container“ green waste/grass, leaves, foliage etc. a energy gain (electrical and thermal energy) can be calculated; costs for disposal are avoided.
- 100 % gains from electricity for the sewage plant
- Due to independence from public grid, no fee for provision of electric energy
- No cost for heating – heating of buildings and water is free!

With HTC, a sewage plant can achieve full self-sufficiency on energy!!!

Regaining phosphate



Source: „HTP Hydrothermale Prozesse
Innovationsforum des DBFZ“
Prof. Dr. Andrea Kruse

Phosphate (Struvit) – fertilizer from biocoal from sewage sludge

- During the carbonization process, the original biomass is cracked up, it is changed in its chemical structure and dissolved for the largest part.
- The phosphate contained in the original sewage sludge is released as phosphate.
- The phosphates are precipitated, they are not enclosed by polymerisate.
- The phosphates are regained using citric acid or sulphuric acid.
- The process water containing nutrients will be put up to pH9 with NaOH. By adding MgCl_2 and by stirring, magnesium-ammonium-phosphate (MgNH_4PO_4), MAP or Struvit is precipitated.

Regaining phosphate

Due to the conversion of sewage sludge to HTC coal products, it is possible to regain almost 80 % of phosphate contained in the sewage sludge as fertilizer.

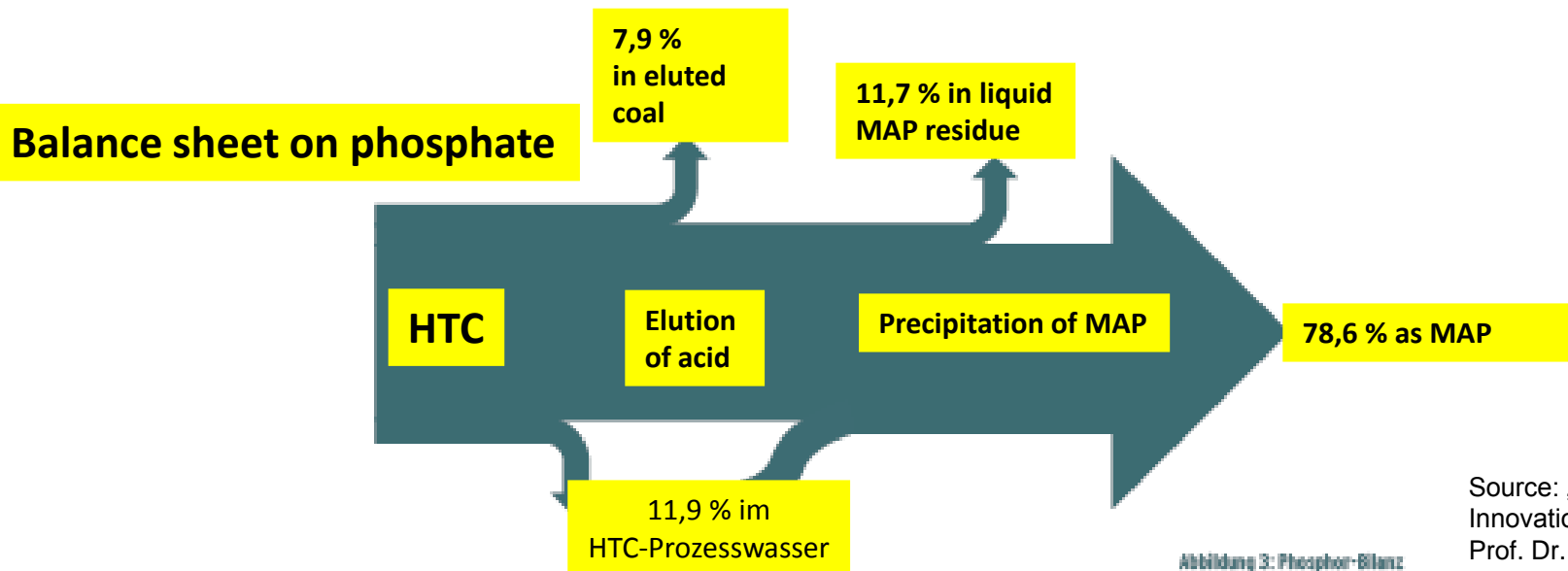


Abbildung 3: Phosphor-Bilanz

Source: „HTP Hydrothermale Prozesse
Innovationsforum des DBFZ“
Prof. Dr. Andrea Kruse

With the perspective of a general prohibition of agricultural usage of sewage sludge, due to the novel regulation of AbfKlärV, there is an objective need for regaining phosphate!!!!

References

GRENOL GmbH, Ratingen

HTC carbonization of sewage sludge

Kalkar/Germany

TerraNova Energy GmbH, Düsseldorf

HTC carbonization of sewage sludge

HTC carbonization of sewage sludge

KA Maribor/Slovenia

KA Jining / China 13.000 t/a

Capacity 40.000 t/a

in 2017 in final construction

Thank you for your attention!

For further information, or in case you have any question, please contact us via phone or e-mail at
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