
# Wet and Dry Anaerobic Digestion Processes

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## Definition wet fermentation

- Dry matter / total solids (DM / TS) below 15% in the process
  - Pump able sludge
  - Mixable sludge
- In most cases CSTRs
- Requires low DM substrate or good degrading feedstock

# Definition dry fermentation

- Dry anaerobic digestion is a kind of wrong expression. The microorganisms require of course moist conditions !!!

- According to the feedstock and its properties „Solid state fermentation“ would fit much better.

Dry anaerobic digestion is if not pump able, stackable feedstock with a TS content higher than 30 % is utilized in an AD plant without the addition of external liquids.

- $TS_{feedstock} > 30$ %
- No external liquids



# Dry Anaerobic Digestion Processes

# Wet anaerobic digestion processes

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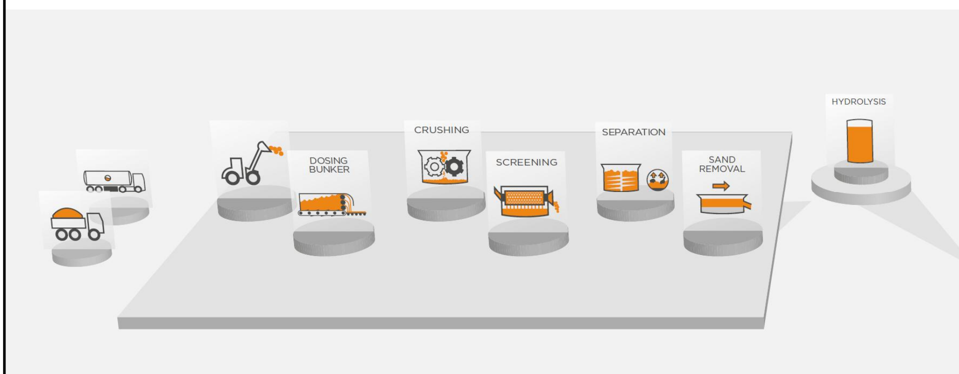
# Substrate treatment systems for bio waste and residual waste

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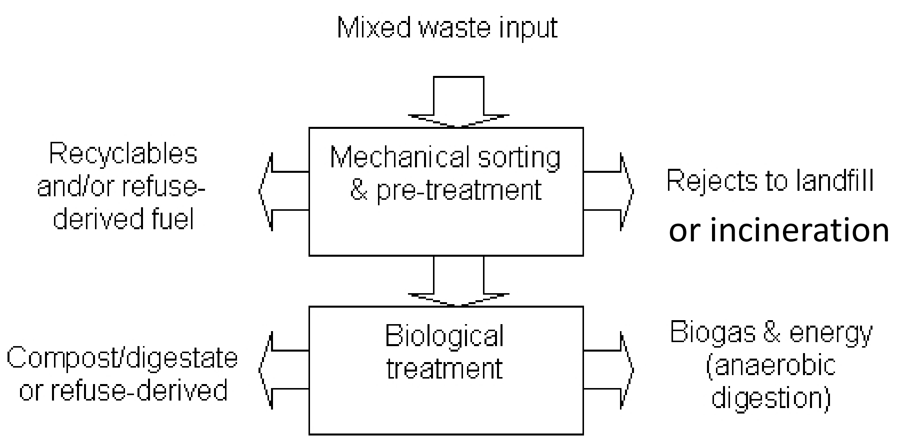
## Principle of biological residual waste treatment

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## Different types of residual waste

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## Technologies and design of waste treatment plants

The design of a waste treatment plant is defined by:

- The composition and structure of the input waste
    - Number of different components in the waste
    - The particle size distribution
    - The degree and kind of contamination being possible
    - Which components shall be recovered
    - How purified the recovered components should be

- All this information should be available before starting to plan a waste treatment plant. But even then the system should be robustly designed as waste composition and regulations may change quickly.



# Dry fermentation

## Príncipes of dry anaerobic digestion systems

- Dry Digestion in full scale application can be performed in a continuous or discontinuous system.
- Typical feedstock is structure rich material (e.g. municipal organic waste, yard waste, manure fibers, straw, …)
- Compared to liquid fermentation dry AD systems have quite simple process technology and are therefore in most cases cheaper



## Advantages for dry digestion systems

- Very tolerant system for contaminants (sand, fibres, large particles, …)
- Less complex system compared to wet AD systems
- Less maintenance required
- Less critical equipment (pumps, agitation systems, feeding equipment)
- Operation costs may therefore be less compared to wet systems
- Possibility of mobile biogas plants (containers)

# Disadvantages for dry digestion systems

- Special technologies for loading and unloading of the digester necessary
- Not totally mixed
- In discontinuous systems the microbial process has to started for each batch
- In many case lower methane yields compared to wet AD systems (BUT not in every case)
- In many cases large quantities of structure material is required (a lot of digester space is consumed for structure material)



# Dry fermentation - System Overview

- Dry Digestion Systems
  - Discontinuous
    - Percolation digester
    - Retention digester
    - Pile up digester
  - Continuous
    - Percolation digester
    - Plug flow digester
    - Silo digester

# Dry fermentation - Technologies

**Discontinous systems**

- Percolation systems
  - Bekon
  - Bioferm / Eggersmann
  - Loock
  - 3A-Process
- Retention systems
  - Ratzka
- Pile-Up systems
  - BAG Budissa
  - Ratzka

**Continous systems**

- Solid phase percolation
  - ISKA
- Plug flow processes
  - Kompogas
  - Strabag (Linde KCA)
- Silo-process with external recirculation
  - ATF
  - Dranco



# Percolation digester systems

- Usually boxes or garages
- At minimum 3 – 4 Boxes
- Feeding (loading) by loaders or filled cages
- Premixing with digestate for inoculation
- Aerobic starting phase
- 4 - 6 weeks anaerobic phase (retention time)
- Irrigation with percolate (leachate)

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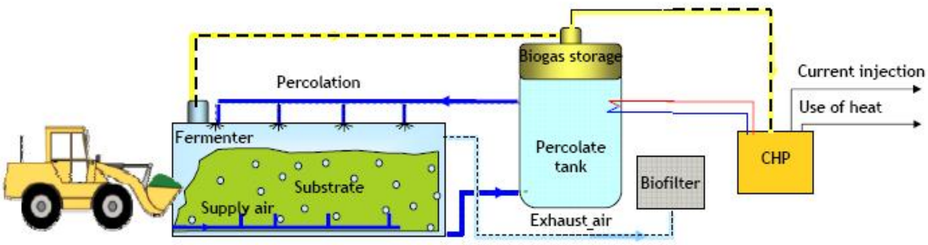
## Garage anaerobic digestion system





## Garage anaerobic digestion system

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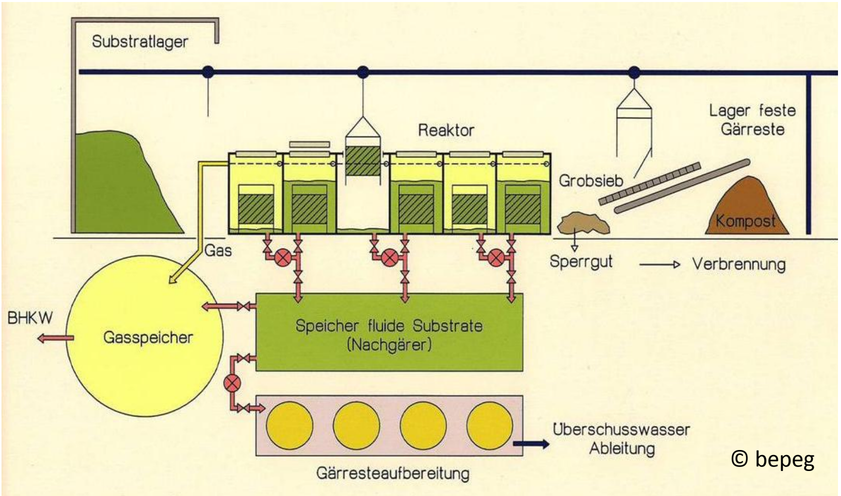
# Box system

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# Loading the digester

- Preconditioning of the feedstock material
  - Substrate treatment
  - Mixing with structure material (if necessary)
- Mixing with digestate (up to 85 % !!!)
  - Inoculation (percolate often not sufficient)
  - Buffering (initial acidification)
- Loading the digester/cages (loaders, cranes, …)

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# Loading the digester



# Aerobic starting phase

- After closing the compartment / box / garage oxygen from the ambient air is consumed by respiration of aerobic and facultative anaerobic microbes
- A small portion of the easy accessible compounds is respirated.
- $CO_2$ and heat is produced (partial initial heating)
- anaerobic conditions are generated

# Hydrolyses

- Microbes from the inoculum (digestate initially added) and the percolate start to degrade the organic compounds to organic acids

- Depending on feedstock composition fast production of organic acids (danger of acidification)

  ⇒Percolate from fresh filled compartments is directed to older ones (strong population of methanogens and good buffer system).

  ⇒An optimum mixture of inoculum has to be found



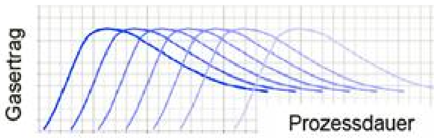
# Digester facts

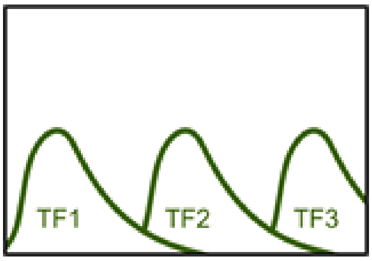
- The digesters are usually heated with the percolate (external heat exchanger for this liquid fraction)
- Other possibilities for heating
  - Initial aeration
  - Wall and floor heating
- The biogas is collected and stored in an external gas dome

# Gas production in discontinuos systems

- No costant gas production
- No constant as quality

=> BUT constand gas demand






# Unloading the digester

- Stop of percolation
- Collection of leachate
- Before opening the digester it has to vented /prevention of explosion danger)
- The vented air has to treated in a biofilter to degrade methane (very powerful green house gas)
- Unloading of digestate with a loader etc.
- Further treatment of the digestate (contaminant removal, composting, field application as bio-fertilzer, …)

# Plug flow systems

- Plug flow systems usually show the following characterisation
  - Lying cylindrical or rectangular digesters
  - Initial mixing with digestate (inoculation)
  - Horizontal (axial) agitator
  - Dewatering of the remaining fibres
  - Post digester

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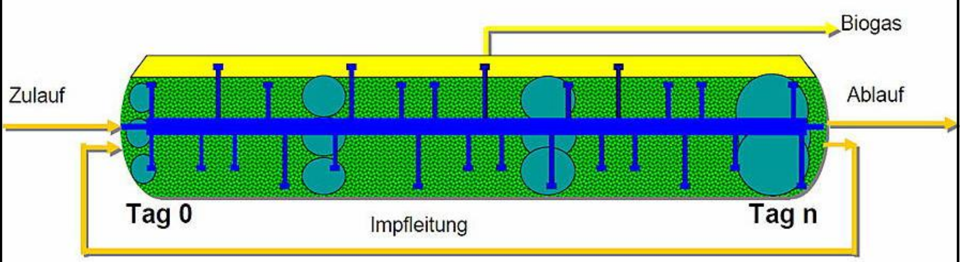
# Plug flow systems

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## Plug flow systems


## Plug flow systems

- Feedstock is usually stored in a hopper and fed to the digester with an auger system (screws)
- The fresh material is mixed with liquid digestate inside the reactor
- The substrate is continuously pushed forward by the fresh material
- A horizontal stirring shaft with paddles provides mixing and degassing

- In comparison to discontinuous process the biogas production and microbiology is more stable. Furthermore the process is better automated.
- Disadvantage is the greater demand of process technology as result of high forces on the agitation system

# Linde KCA process (Strabag)

- Feedstock is fed to the digester by an auger system or being premixed with liquid digestate to reach a pump able mixture and then pumped into the reactor
- The agitators are across to the flow direction in the digester
- The agitation direction is reversed periodically so the flow inside the reactor is just a result of the material fed to the digester
- At the backend of the digester the sludge is dewatered.
  - The liquid fraction is part wise recycled for mixing and inoculation of the fresh feedstock
  - The solid fraction and the not needed liquid are used as bio-fertilizer or are further processed



# Strabag (Linde KCA)

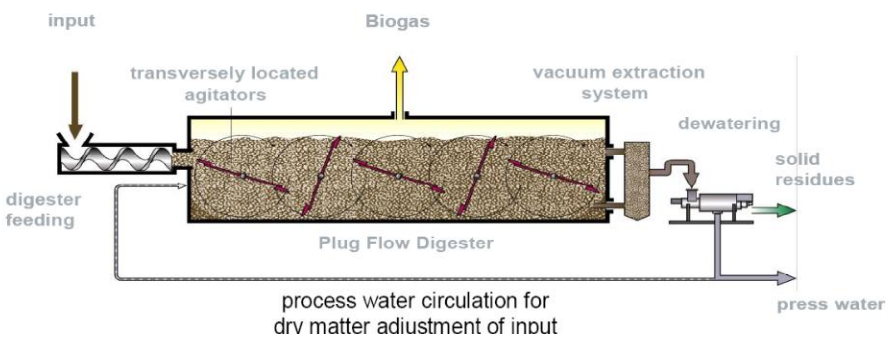


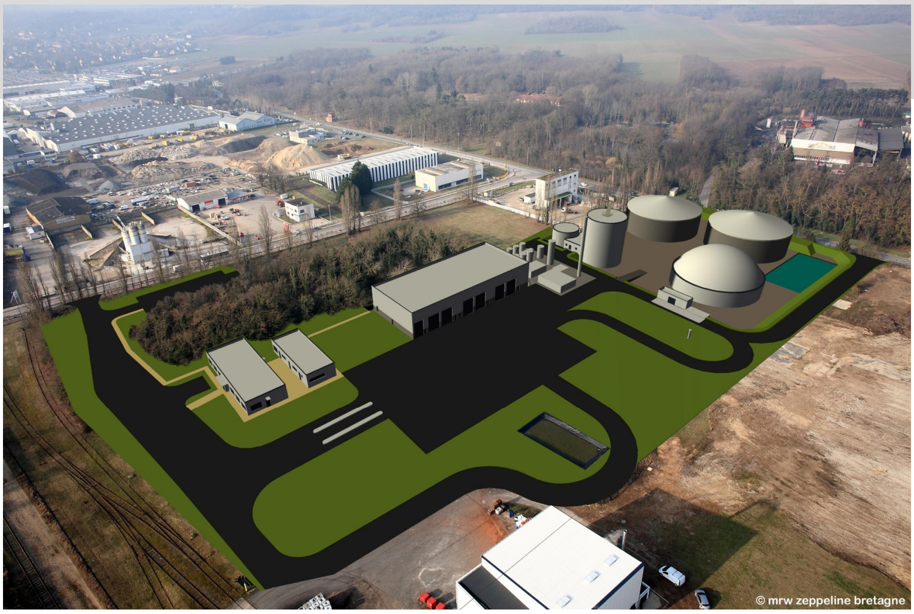

**Figure 1: Principle of the LARAN ® recumbent plug-flow dry digester**

# Wet fermentation

## Example 65.000 t/year

## AD-plant for food waste





## Material reception

## Substrate treatment

# Sanitation

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# Hydrolysis / Mixing tank

- Pre-acidification of feedstock
  - Faster gas production in fermenter
  - Biological - acidic treatment of feedstock
- Homogenisation
- Buffer tank (e.g. Weekends)
- Preconditioning (heating / cooling)

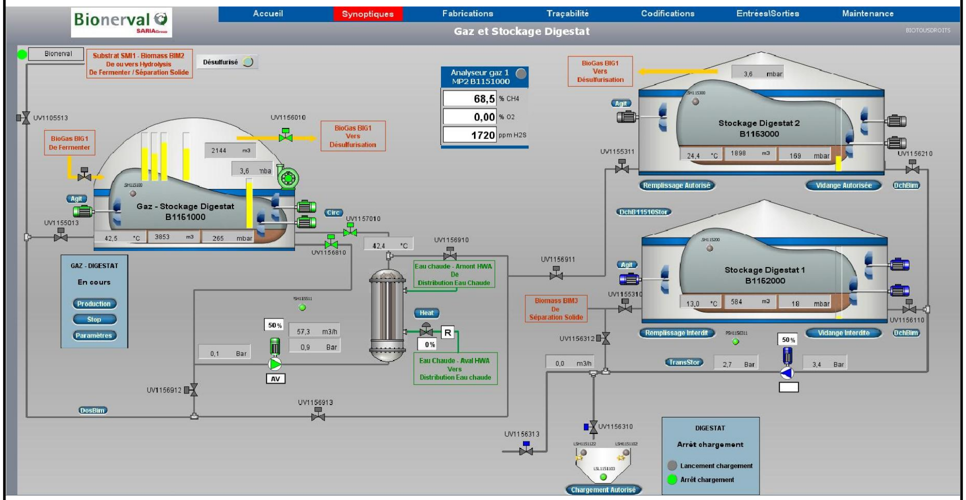
## Fermenter

## Post fermenter & gas storage

## Desulfurization & biogas dehumidification & digestate storage

## CHP Units

# Process control system / supervision



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from waste to value

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