Vapogant digestate evaporator

Energy-efficient, novel digestate reduction with nitrogen recovery
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Advantages of digestate evaporation

Vapogant

Our plant prepares the digestate of the biogas plant to produce a usable, concentrated fertiliser: We remove the water from the digestate through vacuum evaporation using waste heat from the CHPS. At the same time, volatile nitrogen is bound, minimising loss during distribution and making the nitrogen available as ammonium sulphate solution (ASS). The goal is to use the available exhaust heat to thicken or process 100 % of the digestate produced in the biogas plant.

The benefits:

Storage
- The thickened digestate has much less volume and saves up to 70 % of digestate storage capacities.
- Digestate evaporation as an alternative to building additional digestate stores.
- No additional digestate storage problem due to the amended ordinance on installations that handle substances hazardous to water (VAwS) and the fertilisation ordinance.

Transport
- Reduced volume means fewer drives (less impact on roads and population)
- Fewer passes over fields due to concentrated nutrients
- The weather risk is reduced and the impact of spreading increased.

Nutrient management
- Upgrading the digestate to ammonium sulphate solution (ASS) that is worth being transported and concentrated fertiliser.
- Less nitrogen loss through ammonia emissions on the field, hence savings to purchase nitrogen
- Improved nutrient management: Thanks to the separate nutrient fractions, nutrients can be applied much more selectively and efficiently.

Use of heat
- Efficient heat use throughout the year
- CHP bonus guaranteed through efficient fertiliser production
- Integrates easily with existing plants (also for partial heat use)
A mechanical separation takes place before digestate evaporation where the digestate passes through a fine-mesh screen (e.g. 0.75 mm) and is separated in a liquid and a solid phase.

The solid matter (solid phase) is put out on a suitable area for intermediate storage and can be used for targeted fertilisation as needed. During the time where no fertiliser is spread, it can be stored on open areas or in bunker silos. The liquid phase is introduced into the process of digestate evaporation.

Inside the installation, the liquid phase is heated and put under a vacuum. In this step, part of the liquid phase evaporates, thereby thickening and concentrating the digestate. This step is repeated in another evaporator where heat recovery enables energy-efficient evaporation and multiple heat use.

Inside the vapour cleaner, the gas phase that is produced through heat and vacuum is stripped of ammonia by adding sulphuric acid. In this process, ammonia is converted into ammonium sulphate and concentrated. The ammonium sulphate solution (ASS) can be stored in separate containers.

The vacuum required for energy-efficient evaporation is generated by a vacuum pump. This pump is connected at the pressure side of the gas compartment of the biogas plant; thus, residual gases emerging from the liquid phase are safely fed back into the biogas plant. There they are either metabolised microbially (e.g. H₂S that is converted into sulphur) or burnt in the CHPS (CH₄).

At the end of the process, the concentrate (the thickened liquid phase of the digestate) exits the process under vacuum. This digestate is now concentrated and contains all nutrients also found in untreated, non-dried digestate, with the exception of ammonia. This slightly volatile substance is added in the form of ammonium sulphate solution (ASS). The ASS is subsequently stored in one or more separate tanks.

**Evaporation capacity of the plant:**

The digestate evaporator has a modular design. The evaporation capacity is up to 2.5 litres per kWtherm, depending on the flow temperature, temperature difference and dry matter content in the inlet and outlet of the plant.

The vapour produced in this process, which has been stripped of ammonia, is condensed to water (distillate) in heat exchangers and the recovered heat is used. The distillate is transported to storage tanks for intermediate storage. After the distillate has cooled down in the dry or wet cooling tower, it is used as a cooling liquid e.g. in the condenser heat exchangers. The plant is sealed hermetically, resulting in a low-emission process.

**Evaporation process description:**

*Concentration and vapour cleaning*
Composition of the digestate

1) Digestate from digester
2) Solid material through separation
3) Liquid phase after separation
4) Distillate: the water removed from the digestate for inlet, evaporation or use as process water
5) Liquid phase as concentrate
6) Ammonium sulphate solution (ASS)
Distillate use

Customers may use the vapour-cleaned distillate obtained from the evaporation process as needed:

Using the distillate for operation purposes

There are different options to use the distillate for operations: Storing the water to be used as washing water for stables and areas, as thinning water for pesticides and liquid fertilisers, etc.

Evaporation of the distillate through the wet cooling tower

As a cooling unit is needed to operate the plant, part of the water may also be evaporated continuously through a cooling tower. Additionally, the cooled water is used as a cooling medium.

Indirect or direct distillate introduction

The water is introduced continuously to a receiving stream, combined with an upstream distillate processing module if necessary, or it can be allowed to drain.
Cold fogging of the distillate using a mist blower

A high-pressure pump atomises the water and sprays it into the air. Cold fogging can also be programmed to start at specific times. It is advantageous when other distillate uses are not feasible.

Substrate flow

Mass balance

Reference values from the mass balance of digestate evaporation at different heat consumption levels

<table>
<thead>
<tr>
<th>Heat:</th>
<th>Digestate/waste water</th>
<th>Solid matter</th>
<th>Concentrate</th>
<th>Distillate</th>
<th>ASS</th>
<th>Sulphuric acid</th>
</tr>
</thead>
<tbody>
<tr>
<td>300 kW</td>
<td>1.5 m³/h</td>
<td>0.19 m³/h</td>
<td>0.54 m³/h</td>
<td>0.71 m³/h</td>
<td>39 l/h</td>
<td>9.7 kg/h</td>
</tr>
<tr>
<td></td>
<td>12.000 m³/a</td>
<td>1.600 m³/a</td>
<td>4.400 m³/a</td>
<td>5.800 m³/a</td>
<td>320 m³/a</td>
<td>79 t/a</td>
</tr>
<tr>
<td>350 kW</td>
<td>1.5 m³/h</td>
<td>0.19 m³/h</td>
<td>0.42 m³/h</td>
<td>0.83 m³/h</td>
<td>46 l/h</td>
<td>11 kg/h</td>
</tr>
<tr>
<td></td>
<td>12.000 m³/a</td>
<td>1.600 m³/a</td>
<td>3.400 m³/a</td>
<td>6.800 m³/a</td>
<td>370 m³/a</td>
<td>92 t/a</td>
</tr>
<tr>
<td>400 kW</td>
<td>1.5 m³/h</td>
<td>0.19 m³/h</td>
<td>0.29 m³/h</td>
<td>0.95 m³/h</td>
<td>52 l/h</td>
<td>13 kg/h</td>
</tr>
<tr>
<td></td>
<td>12.000 m³/a</td>
<td>1.600 m³/a</td>
<td>2.400 m³/a</td>
<td>7.700 m³/a</td>
<td>420 m³/a</td>
<td>105 t/a</td>
</tr>
</tbody>
</table>
Setup example: operational building on the left, Vapogant digestate evaporator on the right.

Sulphuric acid store

Sulphuric acid is added to the process. It binds the ammonia and produces ammonium sulphate (ASS).
ASS storage or addition to the digestate

The ammonium sulphate produced by the plant can be used further as customers see fit.

Direct addition to the digestate

The ASS is added directly to the digestate (thickened liquid phase): Very easy integration into the system at full nitrogen benefit.

Separate storage

The ASS is stored in separate storage tanks (e.g. 100 m³ horizontal) to be spread subsequently using a sprayer. Ideal to supply plants with the amount of nitrogen they need.
Site plan

The digestate evaporator is installed next to the CHP5 building. The system is set up in a frost-proof container fully pre-assembled from the factory. The cooling tower is located outside of the container: see illustration.

Technical Data

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intake volume flow</td>
<td>up to 2000 l/h at 40 °C *</td>
</tr>
<tr>
<td>Dry matter content</td>
<td>max. 6 %</td>
</tr>
<tr>
<td>Particle size in digestate</td>
<td>&lt; 0.5 mm</td>
</tr>
<tr>
<td>Concentration level in dry matter content</td>
<td>up to 13 % **</td>
</tr>
<tr>
<td>Distillate capacity</td>
<td>approx. 2.5 l/kWh&lt;sub&gt;th&lt;/sub&gt; ***</td>
</tr>
<tr>
<td>Distillate flow</td>
<td>approx. 1250 l/h</td>
</tr>
<tr>
<td>Flow temperature</td>
<td>86 °C</td>
</tr>
<tr>
<td>Return temperature</td>
<td>up to 73 °C</td>
</tr>
<tr>
<td>Heat consumption</td>
<td>up to 500 kW</td>
</tr>
<tr>
<td>Dimensions L x W x H in m</td>
<td>16.5 x 4 x 6.4</td>
</tr>
</tbody>
</table>

* Digestate from biogas plants fed with agricultural feedstock

** At more than 13 % to max. 25 % concentration of solid matter, the performance data are lower.

*** The value is reduced accordingly when heat is extracted.
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