# SYSTEMIC Living Lab panel conversation: Evaporation technology

*12/11/2020 11:00h CET – 11:45h CET – TEAMS online meeting*

Moderator: Marieke Verbeke (VCM, SYSTEMIC project)

*Extra information for literature inserted in this summary after the discussion.*

Expert Panel:

SYSTEMIC Demonstration Plants, Outreach Locations and Associated Plants

For more information check out:

https://systemicproject.eu/plants/demonstration-plants/

https://systemicproject.eu/plants/outreach-plants/

https://systemicproject.eu/plants/associated-plants/

## *How does one decide if the technology of evaporation is the best for your digestate treatment? What are the main drivers to install an evaporation technology as digestate treatment?*

### Biogas Plant in Flanders, Belgium:

At our plant, there are 3 parts in the process where they produce water/liquids:

- Liquid fraction of digestate (treated in biological nitrification-denitrification)
- Effluent of this biological nitrogen and COD removal step, has lower nitrogen levels however still contains a lot of salts (e.g. K)
- Evaporator produces ammonia water (condensed water vapours with ammonia and some Volatile Organic Compounds) and concentrated PK organic matter slurry/paste, process water

In total 90% of this water is re-used:

- process water for diluting the feedstock to optimal dry matter content
- process water to mix with polymers (flocculants) used in the dewatering of the digestate (slow turning screw presses)
- Heat from CHP engines can be transferred to the process water (steam or hot water) and used again: for this they get heat certificates (subsidies) and this payes back the investment of the evaporator

### Biogas Plant in Finland

In Finland, digestate (products) can only be spread on land a few months per year. So, the evaporator makes it possible to reduce the amount of liquid digestate (products) that need to be transported or stored. This because, condensate from the evaporated can be further treated in an reversed osmosis installation (RO) and the purified fraction can be clean enough to be discharged.

50% of the total input volume is reduced this way.

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Process water from the evaporator (not clean enough to be discharged), can again be used for dilution or making polymer solutions.

Biogas Plant in Flanders, Belgium:
Another reason for installing an evaporator could be that it can produce ammonia water.
*(Ammonium volatizes as ammonia in the evaporator, together with VOCs and water. When this is condensed, a solution of mainly water and ammonia; 10-20% pH 9-10; can be obtained) Read more about ammonia water as alternative to urea in NOx flue gas cleaning in incineration plants (SNCR process)- ANNEX II.6.3 in of "Market Research in Europe",2021*
https://systemicproject.eu/downloads/ →Project Deliverables > D 3.4 Market research in Europe (update 2021)

Biogas Plant in Flanders, Belgium:
Marketing of ammonia water is not always as straightforward as it seems.
*It is not possible to use as fertiliser, because the pH is very high and it volatizes immediately. The market as reductant in SNCR is getting smaller, when more biogas plants would start to produce it. In general, incineration plants would be able to be persuaded to use (lower quality) ammonia water for their flue gas cleaning (SNCR), if they can obtain it for a low price.*
*If only transport costs are taken into account, both parties (the biogas plant and the incineration plant) are reducing their costs (Market Study in Europe, 2020). However, transport cost of ammonia water can be high, because it is high risk (ADR) transport.*

*Ammonia can be prevented from volatizing in the evaporator by acidifying the input of the evaporator. The will then end up in the concentrate (cfr. NPK-organics concentrate slurry). Is this product easy to market as a fertiliser?*

Biogas Plant in Flanders, Belgium:
It is also important not to underestimate the cost of acidification (or a similar process like N-stripping-scrubbing to ammonium sulphate).

- It requires a lot of chemicals (i.e. acids)
- Transport costs of the voluminous liquid end products to where there is a demand.

Biogas Plant in Flanders, Belgium:
We had an evaporator in 2003, which was our first "blue print" machine, however it had a lot of problems at first. While working with it we gradually started to fix these problems.
Today we are in need of a new evaporator, with higher capacity, and because of the experience I had with the first evaporator I already knew what were the typical flaws and problems that an evaporator could have.
So you need to be sure about what specifications your evaporator needs to have, and what it should be able to do.
This is also very case specific.
For our business model, the best fit was a simple single-stage evaporator.
It does not recover heat that efficiently (like for example multistage or falling film evaporators, which are more expensive).

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However, it does provide is with the amount of process water we need and has a reasonable pay back.

I started looking on the market at the available technologies and had talks with other people that are experienced. However, there are not so many technology providers for evaporators.

It is also very important that the evaporator works on your product (digestate).
Don't automatically believe the technology providers when they say that it will perform the way they claim it will to. Each digestate is different and therefore, try to test somehow first if the evaporator works on your specific product.

## *For the operation of the evaporator, was there extra staff needed to be hired or trained?*

Biogas Plant in Flanders, Belgium:
We have 2 3-stage evaporators working in parallel on liquid fraction of digestate.
We need an extra staff member full time to follow up the evaporator when we were in start-up phase. We saw that in the first months, the more you follow-up on hourly base, the more efficient it can work, because you can prevent or quickly solve problems that could keep the evaporators from running.
It also depends on the type of digestate you treat in the evaporator. If there are more impurities, more organic material, this can make efficient performance of the evaporator more difficult and this will determine the amount of maintenance and cleaning for example and hereby the amount of staff hours.

Biogas Plant in Finland
In our experience, during start-up indeed a full time staff member is needed. However, after that, only cleaning once or twice per year should be necessary and the whole operation of the evaporator is included in the general work of the staff on the total process.

Biogas Plant in Flanders, Belgium:
We have had 12 years' experience with optimizing our first evaporator.
2 years ago we bought our new one, and it took us another 1,5 year in optimisations before we could say that it works smoothly.
So it is correct that the start-up needs a full-time staff member, but even after that there is a long period of optimizations, finetuning and problem solving which requires technical staff.
Again, the simpler your machine, the faster and easier this gets.

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## *What are your experiences with foaming in the evaporator?*

Biogas Plant in Flanders, Belgium:

We had a lot of problems with foam in the beginning and we used a lot of anti-foam to prevent this . *(2,2-3,7€/kg)*

We changed some things process wise, so that now we have 70% less anti-foam consumption than before.

There are also many types of anti-foam products. Choosing the right product that works best on your digestate and finetuning the right dose will also highly impact the result.

Biogas Plant in Finland

In our case we had a $CO_2$ stripper before the evaporator, which seemed to cause the foaming in the evaporator. Because when we removed it, the foaming disappeared.

Volatile fatty acids can also be an important cause for foaming.

*When the pH is high (like in an evaporator, >9) this creates $K^+$ and $Na^+$ fatty acid salts (="soap"), which as surface tension lowering characteristics, creating foam.*

They are produced in the digester when the retention time is not long enough.

*Or when there an imbalance in micro-organisms. If the temperature in the digester is too low (34°C), there will be more acetogens than methanogens, creating VFA's, that cannot be converted to methane.*

These VFAs can also be a cause of blocking of RO membranes further down the process line.

*Also feedstock with high protein content or organic matter, that is not broken down enough in the digesters, can also cause foaming in the evaporator.*

So in general, the operation of your anaerobic digester can prevent foaming, as anti-foam can solve it (against a price).

## *How are the end products marketed in your case? And is this something you had foreseen?*

Biogas Plant in Flanders, Belgium:

Our aim is to remove the salts from our digestate (and thus the end products).

We have a very salty evaporator concentrate (NPK) and we pay an external company to process this (57€/m³).

Initially, the external processing was already calculated in the business case. However, we are looking for other ways to process the NPK concentrate internally and therefore hopefully cheaper.

One of the things we are investigating is struvite precipitation from the NPK concentrate. It seems like the ratios of minerals present in the concentrate are quite good for struvite precipitation.

*$Mg^{2+} + NH_4^+ + PO_4^{3+} + 6H_2O \rightarrow MgNH_4PO_4.6H_2O$ (mono-ammonium-phosphate or struvite)*

We will investigate this further next year, but again we will not invest in a struvite reactor if it does not have the ability to pay itself back.

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We also do composting of the solid fraction of the digestate, and because of this our compost is already kind of wet. This does not allow us to mix NPK concentrate in it, it would make it even more wet.

Biogas Plant in Flanders, Belgium:

The NPK (organic) concentrate from our evaporator is 20-25% DM and it costs a lot of money to dispose of it. We started giving it away for free, and now we are paying for it and we have seen the prices rise together with the P and N application limits getting more stringent. Therefore, we are also trying to find a solution to treat this internally, so we can cut this treatment costs.
The product is worthwhile as a fertiliser, but before use it has to be re-diluted to administer it in the right concentration to the crops. If applied directly, the salt content is too high for crops.

Biogas Plant in Finland

In Finland NPK concentrate can be used as nutrient for wastewater treatment in the forest industry.
*This is usually wastewater with a lack of macro-nutrients (N,P), which makes the biological waste water treatment not working optimally.*
Usually, sources of these macro-nutrients (N, P), *like urea or phosphoric acid*, are bought and supplied to the wastewater and these concentrates could therefore be cheap alternatives for this.
*Read more about the use of recovered nutrients as macro-nutrients in industrial biological wastewater treatment in ANNEX II.4 in of "Market Research in Europe",2021*
https://systemicproject.eu/downloads/ →Project Deliverables > **D 3.4** Market research in Europe (update 2021)

You can also use it as fertiliser, but you would need a special spreading or injection system because the amount per ha is very low (3-4 $m^3$/ha) to be able to stay within the Phosphorus application limits.
It can also be mixed with (solid fraction) of manure to increase its nutrient content.

Biogas Plant in Flanders, Belgium:

We will mix it with the dried digestate but we don't have the capacity to mix all our concentrate. Therefore, we are also working on a second route for internal treatment of NPK concentrate.
We are still starting up the evaporator, next week we will start producing ammonia water. We will mix it with compost in our composting installation. If this is not possible, we are going to try to market it as reductant for DeNOx in flue gas (SNCR).
The concentrate in our case, has only 1g N/kg *(1,5 % DM, 0,6 g P2O5/kg, 8,5 g K2O/kg)*, because it has been pre-treated in a dissolved flotation unit. We will not produce large amounts yet, so we will be able so spread it on the farmlands within a 10 km radius.

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## *Any advice for people who are thinking about investing in an evaporator?*

Biogas Plant in Flanders, Belgium:

Evaporation is not purifying technology; it is only way to concentrate a lot of impurities *(organic matter, minerals)* in a small amount of water.
It is only transporting your waste in a smaller volume, not purifying it.

Biogas Plant in Flanders, Belgium:

Next to ammonia water and (N)PK concentrate slurry, you also have the process water; which will also contain a small part of the nitrogen and VOC, and thus it is not clean enough to discharge or to use for certain process water applications.
To further purify this, you will need a biological treatment (nitrification-denitrification), an ammonia stripper-scrubber or/and RO.
Take into account that these are also complex technologies which cost a lot of money *and also need to fit in the business model.*

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