The Billund Biorefinery - Transforming organic waste streams into valuable products

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INTRODUCTION

Billund Vand A/S is a public utility company, owned by the municipality of Billund, that provides drinking water and sewerage services along with the treatment and disposal of wastewater and organic household wastes. Over the course of four years, what was once a regular activated sludge wastewater treatment plant (WWTP) combined with a mesophilic anaerobic co-digestion plant, has now been transformed into an integrated biorefinery - the Billund Biorefinery (BBR). In the BBR, multiple streams of organic wastes are received and transformed into energy, heat, recovered nutrients and reclaimed water. This is an example of circular economy that was achieved by combining existing and cutting edge technologies. An interesting aspect is that the transformation into the BBR was performed by inserting process units into the already existing facility, thus making the transformation process applicable to any other WWTP. The BBR project was a public-private partnership between Billund Vand A/S and Krüger Veolia A/S.
The BBR currently combines source separated household wastes, various organic industrial wastes and sludges from the WWTP to produce various products such as electricity, heat, organic manure and cleaned water and has the possibility to expand its product portfolio.

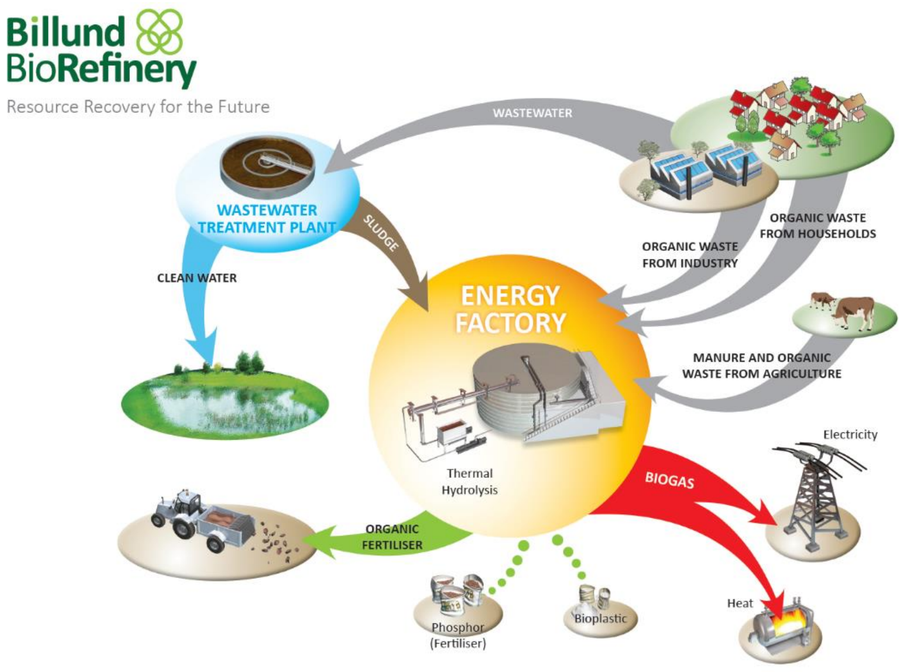
METHODS

The main aims of the BBR are:

1. To serve as a demonstration plant
2. To include new waste streams into the resource recovery cycle
3. Maximise the recovery of energy and nutrients
4. Improve and maintain the quality of the cleaned water
5. To have flexibility in the process line such that new products can be derived based on the business case.

A few of the process units and upgrades that were introduced are as follows:

1. Exelys™ thermal hydrolysis unit along with a new thermophilic digester to form the Digester Lysis Digester (DLD) process
2. Hydrotech filter, a disk filter, installed at the outlet of the wastewater treatment plant to improve the quality of the effluent
3. ANITA™Mox, an Anammox process was installed to treat reject water, thus reducing the load of Ammonia on the wastewater treatment plant
4. STAR Control ®: Advanced online control for the WWTP



RESULTS

Effects of the various process units:

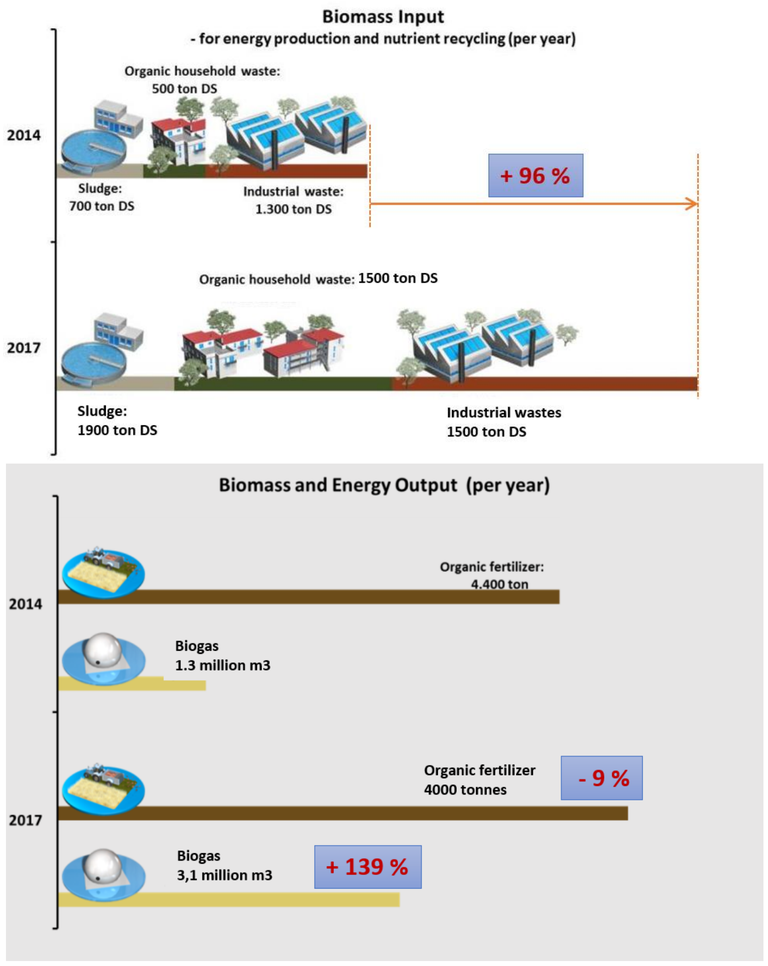
1. Exelys™ thermal hydrolysis unit: improves energy recovery by 50% [2], thus reducing the amount of the final solids.
2. Hydrotech filter: apart from reducing the suspended solids in the effluent, it reduces microplastic mass by 77% [1].
3. ANITA™Mox: removes up to 250 kgNH_4/day, which amounts to about 44 % of the entire loading to the WWTP.

BBR products (2017)

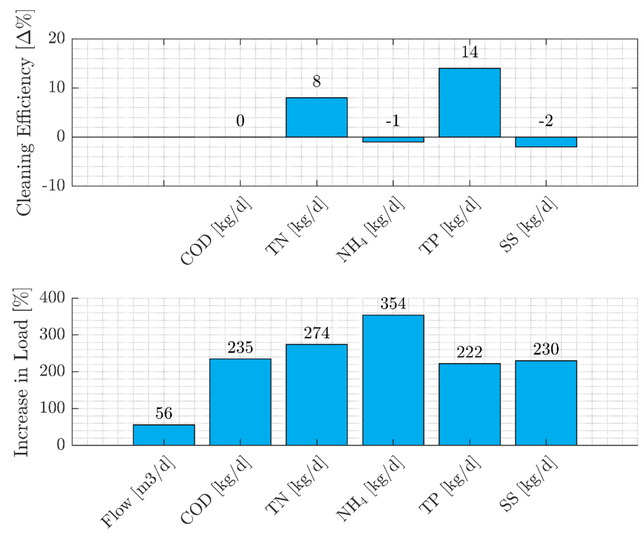
- Energy produced:
  - Power 6.7 GWH/y
  - Heat 14.7 GWH/y
- Energy utilized in the entire concern:
  - Power 3.8 GWH/y
  - Heat 8.8 GWH/y
- Energy production is **1.7** times more than what is used in the entire company
  This includes the supply of drinking water, sewerage, wastewater cleaning and the production of energy itself
- Cleaned water: 3.8 million m^3/y
- Nutrients
  - Organic Fertilizer (24 % DS) 4000 ton/y
    - Nitrogen 50 ton/y
    - Phosphorus 30 ton/y
    - Potassium 2 ton/y

DISCUSSION

The combined effect of the improvements made on the BBR can be seen in the changes in the biomass inputs and product outputs before and after BBR in the figure below.



The change can also be seen in the quality of the cleaned water, even though the load on the WWTP increased substantially. The figure below shows the difference in the cleaning efficiency for 2013 and 2017, along with the percentage increase in the influent loadings for those years. The quality of the cleaned water is defined by the Chemical Oxygen Demand (COD), Total Nitrogen (TN), Ammonia (NH_4), Total Phosphorous (TP) and Suspended Solids (SS).



CONCLUSIONS

The BBR has been a successful demonstration of upgrading an existing WWTP into an economically profitable resource recovery plant. The BBR process lineup is designed such that it has the possibility to recover resources in other forms that might be more desirable, for example- struvite, PHA and upgraded bio-methane among others.

New technologies such as the Exelys™ thermal hydrolysis process and the ANITA™Mox process have been tested and successfully implemented.

The main outcome has been a shift in the focus of the aim of the entire facility. The BBR functions as a resource recovery plant instead of being just a cleaning facility and redefines a waste stream as a valuable resource.

References: [1] Simon, M; Olesen, K.B; Liu, F; Vollertsen, J; Removal of 10 – 500 µM microplastics from wastewater effluent by disc filter, 2018, SETAC Europe 28th Annual Meeting, Rome, Italy
[2] Feng, Lu and Møller, H.B. 2018. unpublished data.

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