**Integration of hydrothermal liquefaction in wastewater treatment plants: Biogas vs Bio-crude**

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**Highlights**

* Bio-crude is a viable option for sludge treatment, competing with current biogas.
* WWTP is particularly suitable for HTL treatment.
* Primary sludge filtration increases HTL economic feasibility.

**1. Introduction**

The concept of wastewater has seen in recent years a major change; rather than a mere waste that is expensive and tedious to treat, new approaches are regarding it a valuable source of energy and resources. Furthermore, given the current energy paradigm they cannot be ignored.

Typical wastewater treatment plants (WWTP) comprise a pre- and primary treatment, followed by an aerobic and secondary treatments. Besides the treated effluent, a mixed sludge (which is in reality the combination of several stages’ sludges) comes as a by-product. Typically, the sludge is anaerobically digested (producing biogas), followed by dewatering and final disposal, like landfill, incineration or eventually used as a fertilizer.

A major drawback to this conversion path is the carbon potential wasted, with 70 to 75% of the original carbon content being converted, and released as CO2. Only the remaining 25 to 30% is converted to methane. This requires the use of more efficient processes that are able to capture the intrinsic quality of wastewater. In a recent publication [1], the use of biomass as a filtration media for sludge treatment has shown the potential to increase the solid content of sludge, which in turn increases hydrothermal liquefaction performance and subsequent bio-crude yield. At the same time, it reduces the amount of biological oxygen demand (BOD) to be treated in the aeration step, dramatically reducing the electricity need of this step which is responsible for a substantial share of the total electricity consumption.

The focus of this work is, given a wastewater composition and flow, finding the optimal set of solutions that for a certain investment, minimize operating costs and implicitly, the environmental impact. For the sake of simplicity, the choice is given between biogas or bio-crude production.

The sludge used in hydrothermal liquefaction (HTL) was considered to have between 20 and 25% total solids, mainly due to the filtration step. Bio-crude is sold after HTL step and no upgrade was considered inside the WWTP facility.

**2. Methods**

Based on [2], a MILP formulation was applied for optimal utility selection. The main objective is to minimize the operational costs, while constraining investment values (ε-constraints), subject to a set of constraints for the mass and energy balances (heat cascade included). Furthermore, binary variables are considered for the units’ use and continuous variables are associated with their size.

**3. Results and discussion**

The optimization procedure is able to choose, considering the mathematical formulation, the combination of units that minimize the operating cost. Figure 1 shows the flowsheet implemented.

A reference scenario considering the conventional wastewater destination for biogas production was considered. The extended model including the HTL unit allows operational savings between 10 and 30% variations are due to different scenarios assumptions, in particular the bio-crude market value and sludge water content.



**Figure 1.** WWTP with HTL unit including mass and energy connections.

**4. Conclusions**

Hydrothermal liquefaction inserted in a wastewater facility in combination with a biomass-aided filtration is a promising solution for the increasing amounts of sewage sludge. Bio-crude can be directly sold to an upgrading facility or used as fuel for internal consumption, reducing the overall costs in a WWTP. The integration in a WWTP is especially suitable, as HTL water phase can be used as wastewater input. Furthermore, HTL is flexible enough to handle different inlet sludge compositions, even tolerating the presence of components (like plastics) that are inadmissible when anaerobic digestion is considered.

As identified in the flowsheet, a huge potential for CO2 capture and utilization is available, in particular by making use of renewable power, especially in periods of excessive production.

**References**

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