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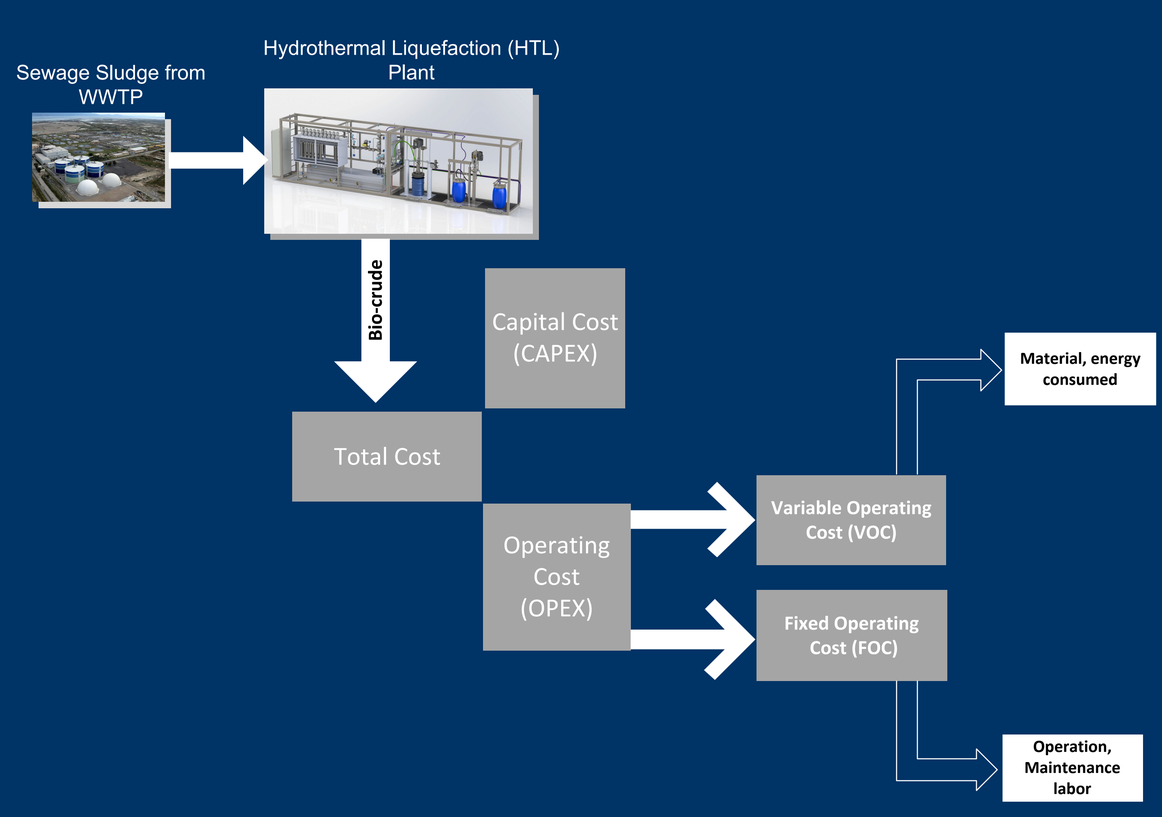
INTRODUCTION

- **Hydrothermal liquefaction (HTL)** is an efficient thermochemical process used to convert biomass into bio crude at sub- or supercritical temperatures, 280–400°C and pressures 10–35 MPa.
- HTL shows an economic friendliness due to the ability to process wet feedstock, saving energy and economy of a pre-drying step.
- Increasing sludge production and disposal challenges restrict the use on agricultural land due to potential risk of pathogens and transmission of contaminations and plastics. Sewage Sludge (SS) is a potential candidate for resource efficient circular valorization by HTL.

OBJECTIVES

- To investigate the conversion efficiency of SS to bio-crude through HTL process.
- To investigate the techno-economic feasibility of the HTL process utilizing SS as a feedstock for producing bio-fuels.

METHODOLOGY



RESULTS

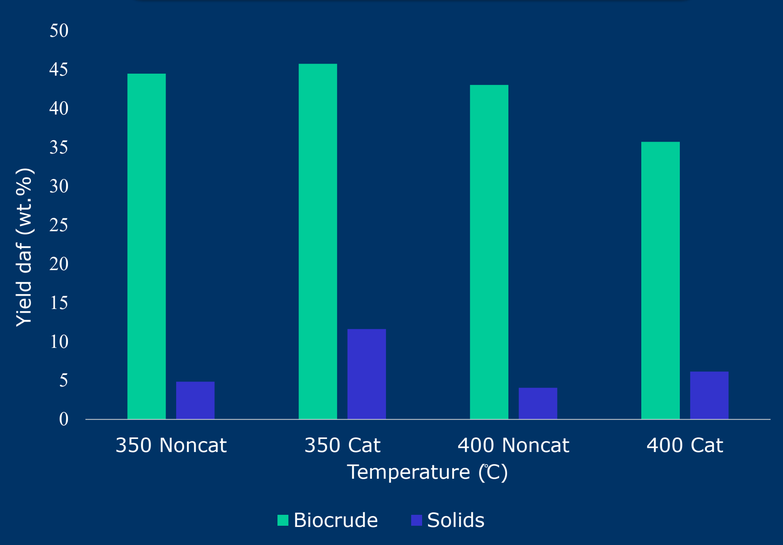
SS Characteristics

Moisture (%)	78.6
Dry Matter (%)	21.4
Ash (%)	23.2
C	35.7
H	5.9
N	5.7
O*	29.5
Crude Protein (%)	35.4
Crude Fat (%)	4.5
HHV (MJ/Kg)	22

*by difference (daf basis)

The potential for energy recovery from sludge is a function of its composition and energy content, depending mainly on volatile solid content that can be subdivided into readily degradable organics. i.e. 50% in sewage sludge.

Product Yield



The maximum bio-crude yield 45.73 wt% at 350 ℃ with the addition of K_2CO_3 catalyst, while approximately same trend was observed at 400 ℃ without catalyst with minimum solid formation.

Economic Assessment

General Assumptions	Parameter	Base cost	Source
	Plant Lifetime [years]	20	[2]
	Feedstock	Sewage Sludge	
	Feed rate [dry, ash free sludge]	95 ton/day	
	Plant Operation time [days/ year]	330	
	Bio crude yield, [daf]	44.46 %	
Parameters Variation			
CAPEX	HTL Oil Production Plant Capital Cost [Million Euro]	17.93	[1]
VOC	Sewage Sludge Credit [€/ton]	-63.6	[3]
	Electricity and other utilities [€/L]	0.015	[1]
	Thermal (Gas) cost [€/L]	0.063	[1]
	Water disposal	2.5% of VOC	[2]
FOC	Fixed operating Cost	17.5% of VOC	[2]
	Bio crude production cost [€/L]	1.0	

The calculated production cost of HTL Bio-crude at plant scale is 1.0 EUR/L. Production cost mainly affected by feedstock cost, equipment cost, energy consumption, electricity and thermal energy utilization cost.

CONCLUSIONS

- The maximum yield of bio-crude was 45.73 wt% in the addition of K_2CO_3 accompanied with maximum solid formation.
- The catalyst cost can be saved and solid formation can also be reduced at 400 ℃ condition.
- The production cost of bio-crude can be reduced by reducing operating cost, labor and thermal energy cost.

FUTURE WORK

- Model improvement and sensitivity analysis.
- Process Modeling and economic evaluation of HTL with bio-crude upgrading plant and whole product chain.
- Investigation of technical feasibility of water phase recirculation to enhance the bio-crude yield.
- Effect of integration with district heating grid on minimum fuel selling price MFSP.

REFERENCE

[1] Snowden-Swan LJ, Zhu Y, Jones SB and Elliott DC, Hydrothermal liquefaction and upgrading of municipal wastewater treatment plant sludge: A preliminary techno-economic analysis. Pacific Northwest National Laboraty PNNL, Tech.Rep., Richland, Washington (2016).

[2] Thomas Helmer Pedersen, Nick Høy Hansen, Oscar Miralles Pérez, Daniel Esteban Villamar Cabezas, Lasse A. Rosendahl, Renewable hydrocarbon fuels from hydrothermal liquefaction: A techno-economic analysis. Biofuels, Bioprod. Bioref. 12:213–223 (2018).

[3] Wastewater treatment plant Aalborg Kloak A/S, www.aalborgkloak.dk.