

## Annex 1 - Application form EUDP

# Sludge2Fuel

### Summary

**Sludge2Fuel** is a comprehensive demonstration project to validate the **world's first full scale implementation** of the direct conversion of wet wastewater sludge to sustainable fuels. Key is an innovative modular technology for decentralized Hydrothermal Liquefaction (HTL) of wastewater sludges to produce liquid fuels and fertilizer. Sludge2Fuel spans the full value chain from wastewater sludge to the use of the refined fuels. Innovative new solutions to integrate the HTL technology into existing fuel refining operations are implemented at full scale thereby fast tracking the launch of the technology to the commercial market and allowing modern fuel refineries to become a key part of the green transition.

HTL conversion of wet waste streams, e.g. wastewater sludge, into a renewable biocrude, is a key step towards implementing a circular economy and will contribute to making Denmark independent of fossil fuels. At the same time, the technology can prevent harmful substances such as microplastics pathogens and residual pharmaceutical compounds entering the environment. The production of liquid fuel using HTL is favorable to competing technologies. The resulting biocrude contains 7-8 times the amount of energy that is consumed to produce it, has a >80% reduced carbon intensity compared to fossil fuels, and are cost competitive in many cases even to fossil fuels. HTL implementation at the wastewater treatment plants (WWTP) will be commercially favorable due to reduced sludge disposal costs as well as providing an income in sale of the biocrude to the refinery, which will benefit financially from the price premium for green fuels to customers. Furthermore, the project will show how this product is upgraded to transportation fuel in a modern refinery using green hydrogen, thereby providing a commercially attractive pathway to operate renewable oil refineries.

The project will create the foundation for the commercialization of this technology both in Denmark and internationally. Modular, decentral HTL plants will be produced and sold by Bio2oil either directly or via service providers. The produced biocrude will provide the sustainable feed for the next generation refineries like Shell, who see a large potential in upgrading with green hydrogen to provide sustainable fuels for the market, and thus help to meet the requirements set forward in the EU RED II agreements. Implementation and integration knowhow of the HTL technology at WWTP's will be a major future business opportunity for Krüger both nationally and abroad through the global distribution of Veolia Business units.

## Resumé (dansk):

**Sludge2Fuel** er et omfattende demonstrationsprojekt til validering af verdens første fuldskaalimplementering af direkte omdannelse af vådt spildevandsslam til bæredygtige brændstoffer. Det centrale element er en innovativ modulær teknologi til decentraliseret hydrotermisk forflydning (HTL) af spildevandsslam til fremstilling af flydende brændstoffer og gødning. Sludge2Fuel omfatter hele værdikæden fra spildevandsslam til brug af raffinerede brændstoffer. Innovative nye løsninger til at integrere HTL-teknologien i eksisterende brændselsraffineringsoperationer implementeres i fuld skala og accelererer dermed introduktionen af HTL-teknologien på det kommercielle marked og gør det muligt for moderne brændselsraffinerier at blive en vigtig del af den grønne overgang.

HTL-konvertering af våde affaldsstrømme, f.eks. spildevandsslam, til et bæredygtigt grønt transportbrændstof, er et vigtigt skridt i retning af implementering af en cirkulær økonomi og den igangværende proces med at gøre Danmark uafhængigt af fossile brændstoffer. Samtidig kan teknologien reducere, eller helt forhindre, skadelige stoffer som mikroplast og medicinrester i miljøet. Produktionen af flydende brændstof ved hjælp af HTL er favorabel sammenlignet med konkurrerende teknologier. Indeholdende Processen giver 7-8 gange den mængde energi, der kræves for at producere det, yderligere giver det en 80% reduktion kulstofintensitet sammenlignet med fossile brændstoffer, og en konkurrencedygtig produktionspris i forhold til fossile brændstoffer. HTL-implementering på rensningsanlæg vil være kommercielt fordelagtigt på grund af reducerede bortskaffelsesudgifter til slam samt indtægter ved salg af bioråolie til raffinering. Dette vil yderligere forstærkes af prispræmien for grønne brændstoffer. Yderligere vil projektet vil demonstrere, hvordan bioråoliens opgradering til transportbrændstof ved hjælp af grøn brint i et moderne raffinaderi og vil skabe en kommercielt attraktiv vej til drift af bæredygtige olieraffinaderier.

Projektet skaber grundlag for kommercialisering af HTL-teknologien både i Danmark og internationalt gennem produktion og salg af modulære, decentrale HTL-anlæg enten direkte af Bio2oil eller via underleverandører. Den producerede bioråolie vil give det basis til næste generations raffinaderier som Shell, der ser et stort potentiale i at opgradere med grøn brint til produktion af bæredygtige brændstoffer til markedet og dermed bidrage til at opfylde kravene i EU RED II aftaler. Yderligere vil implementering og integration af HTL-teknologien på rensningsanlæg vil være en vigtig fremtidig forretningsmulighed for Krüger både nationalt og i udlandet gennem den globale distribution af Veolia forretningsenheder.

## 1 Project description and state-of-the-art

### 1.1 Purpose of the project:

The objective of Sludge2Fuel is to demonstrate the world's first full scale integration of a modular HydroThermal Liquefaction (HTL) unit in a modern Waste Water Treatment Plant (WWTP) and to validate the potential for full scale upgrading of the produced biocrude using green hydrogen. The project will cover the full value chain from wastewater sludge to transport fuel and will validate the vast potential as a commercially and environmental attractive technology in the energy sector.

HTL is a thermochemical process in which water suspensions of biomass are subjected to temperatures and pressures below the critical point of water (374°C, 220 atm) in order to promote a process in which a large part of the oxygen in the biomass is eliminated, whilst retaining most of the energy content [1]. The main product from mixed biomass is a black viscous oil not unlike fossil crude oil. In fact, this process mimics in