2synfuel Newsletter

Turning sewage sludge into fuels and hydrogen

Issue 3 / October 2020

The TO-SYN-FUEL consortium is delighted to introduce its third newsletter edition

This newsletter reports the latest news and developments of the project that have occurred up to October 2020.
The H2020 To-Syn-Fuel project will demonstrate a new integrated process combining thermo-catalytic reforming (TCR®), with hydrogen separation through pressure swing adsorption (PSA), and hydrodeoxygenation (HDO), to produce a fully equivalent gasoline and diesel substitute (compliant with EN228 and EN590 European standards) and green hydrogen from sewage sludge and to help de-carbonise the transport sector.

Contents:

1. To-Syn-Fuel project activities progress

Dr.-Ing. Robert Daschner, Head of the Renewable Energy Department at Fraunhofer UMSICHT and Project Management Officer, presented "To-Syn-Fuel Project to Convert Sewage Sludge into Value-Added Products" during the virtual edition of the e-EUBCE 2020 (link: https://www.eubce.com/) in July.

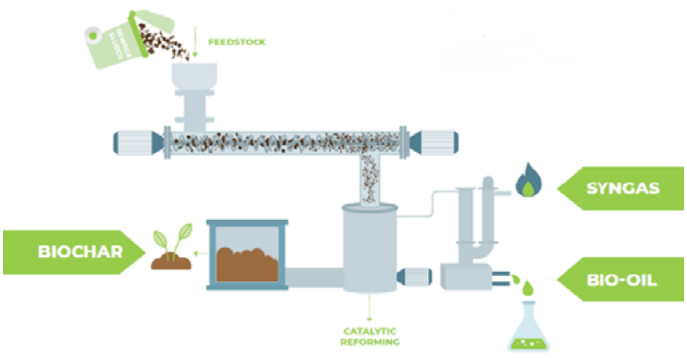
This presentation discussed the progress of the project activities, which are focused on the integration of new technologies to produce renewable drop-in liquid bio-fuels capable of directly replacing fossil fuels.

For the conversion of biogenic residues to sustainable advanced biofuels, Fraunhofer UMSICHT invented a novel technology several years ago named Thermo-Catalytic Reforming (TCR®), an intermediate pyrolysis based process.

Starting from tests at lab-scale through to fuel production demonstrated at a pilot scale, the TCR® technology was then scaled-up to a 300 kg per hour plant to convert sewage sludge at an industrial rate. This was financially supported by the Bavarian State Ministry of Economic Affairs, Infrastructure, Transport and Technology.

The ongoing step of a pre-commercial scale technical demonstrator is the primary aim of To-Syn-Fuel. The operational capacity is designed for 500 kg per hour of dried sewage sludge and will be run for 5000 hours and result in more than 200,000 litres of bio-crude oil for distillation into transport fuels. The project completes in September 2022.

The development process of this novel technology has also shown a high potential in the utilization of many other types of biomass and residues, not just sewage sludge.



Process flow diagram.
Credit: To-Syn-Fuel project.

Dr.-Ing. Robert Daschner confirmed as follows:
"In this project we want to produce advanced biofuels from waste, which in this particular case will be sewage sludge. We are building-up the plant and we will operate and demonstrate the technology in operation. By the end of the project we want to have a business case for sustainable green fuels in order to support the targets of the European Commission".

The assembly and the manufacturing of the demonstrator are progressing well. The location is in Bavaria, near Fraunhofer UMSICHT institute, in the south of Germany. Assembly has started, the hydrogen storage has been implemented at the demonstrator plant, as well as the PSA unit, which mean the hot phase of the assembly is up-and-running. The rest of the assembly is ongoing and the commissioning of this integrated unit will be finalised within the coming months.

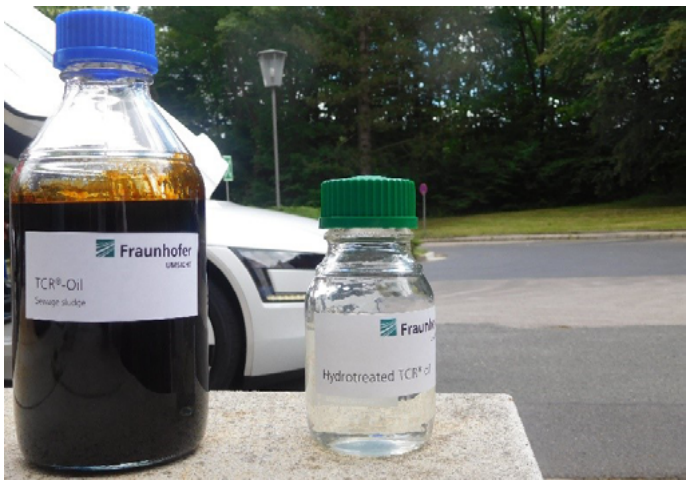
2. New informational video available

A new informational video (see link below) from our outreach partner, WRG Europe Ltd, shows how TCR® is integrated with Pressure Swing Adsorption (PSA) and Hydro-De-Oxygenation (HDO) processes to create the advanced biofuels and green hydrogen from the To-Syn-Fuel technology.

The video shows how the semi-dried sewage sludge is processed by TCR® technology into 3 main outputs: char, bio-crude oil, and syngas. The hydrogen from the hydrogen-rich syngas is used to hydro-treat the bio-oil, which can then be distilled readily into EN equivalent petrol and diesel fuels.

The hydrogen is separated from the TCR® syngas using pressure swing adsorption, developed by our project partner Hygear. The clean hydrogen flows out of the PSA unit into a buffer tank and is further compressed before entering a large storage cylinder. The hydrogen is then at the correct pressure for use in the HDO process.

In the HDO process, developed by our project partner VTS, clean PSA hydrogen and TCR® bio-crude oil are mixed and heated before entering a reactor, where the hydrogen together with the bio-oil (black coloured -see figure) is converted into hydrotreated bio-oil (colourless -see figure). It is a thermally stable oil, therefore can be directly processed with the hydrogen. The oxygen, the sulphide and the nitrogen are rejected to result in an almost pure hydrocarbon which can be fractionated in to diesel and gasoline fractions.



TCR® bio-oil (black coloured) and hydrotreated TCR® bio-oil (colourless). Credit: ETA-Florence Renewable Energies.

This oil, and the whole value chain explained above has already been demonstrated to be effective. For example, Fraunhofer UMSICHT has already produced sufficient quantities of this green fuel at lab and pilot scale to show that it can work in different kinds of vehicles using tests with its own cars at the institute. Notably, the electric/diesel hybrid XL1 vehicle from Volkswagen has been driven for many miles already using the To-Syn-Fuel diesel. However, the To-Syn-Fuel project will also undertake long-term, dedicated engine performance tests and measurements to fully quantify the effects of the fuels on engine performance and emissions.

Technologies integration video released: **"TCR® integration with PSA and HDO to create refined bio-oil for distillation"** available on the project website (link: https://www.tosynfuel.eu/) and on the YouTube channel (Link: https://www.youtube.com/watch?v=JnJ6M7F9i6M).

"The hydrogen from the hydrogen-rich syngas is used to hydro-treat the bio-oil, which can then be distilled readily into EN equivalent petrol and diesel fuels"

3. Construction of the first industrial-scale TCR® demonstrator plant

The fuel production plant is under construction in the Hohenburg area of Germany (district of Amberg-Sulzbach, Upper Palatinate).
The location offers numerous advantages. For example, there are many years of experience on site in drying and handling pre-treated sewage sludge.

Moreover, the quantities and quality of input material required in the project are readily available in Hohenburg. In fact, the service of the local supplier includes the daily and on-demand amount of dried and pre-treated sludge to the demonstration site.

Pilot plant for the To-Syn-Fuel project in Markt Hohenburg, district of Amberg-Sulzbach.
Credit: Fraunhofer UMSICHT.

The service also includes the feedstock-container including a sludge transport system up to the input of the TCR® sluice system. Furthermore, additional facilities for storage and maintenance of the demonstrator equipment are available.

The ground-breaking ceremony in the Hohenburg Industrial Park took place at the end of 2018. Since then, the procurement and construction of the demonstration plant has been in full swing after an intensive planning phase.

The pilot plant hall for the To-Syn-Fuel demonstration plant was completed in February 2020 and the first components such as the hydrogen storage tank and the combined heat and power plant are already onsite. The main plant components of the TCR® technology are being gradually set up and commissioned.

The sewage sludge from the drying plant in Hohenburg has already been tested in the pilot plant at Fraunhofer and can be implemented without further pre-treatment due to the optimized drying process.

This unit will be in operation from 2021 for around 5,000 hours and it will produce more than 200,000 litres of biocrude oil. TCR® will be combined with pressure swing adsorption (PSA) and hydrodeoxygenation (HDO) technologies in an integrated plant.

A demonstration visit of the working plant is expected to be organised for interested stakeholders and potential early adopters of the technology within a year.

Further information available here:

Link:https://www.umsicht-suro.fraunhofer.de/en/press-and-media/press-releases/2018/Groundbreaking_demonstration_plant.html

Link:https://www.umsicht-suro.fraunhofer.de/en/press-and-media/press-releases/2020/H2-Tank_TO-SYN-FUEL.html

4. PSA delivered to To-Syn-Fuel plant site

The liquid bio-oil resulting from the To-Syn-Fuel technology is refined to drop-in transport fuels using the hydrogen from the produced TCR® gas fraction. However, this hydrogen needs to be purified first. Hydrogen is separated from other species, like carbon monoxide, carbon dioxide and methane using the technology of project partner HyGear: Pressure Swing Adsorption (PSA). The separation is based on variation of adsorption capacity of an adsorbent as a function of operating pressure. The cleaned hydrogen is compressed and redirected to the hydrodeoxygenation (HDO) reactors or can be used for other applications, like fuel cells. The required purity of the hydrogen can be controlled by the PSA settings.

The existing PSA technology has been modified to meet the specification of the TCR® gas combined with recycled hydrogen out of the HDO part of the To-Syn-Fuel plant. Several technology improvements have been implemented to reduce the size and cost of the PSA.
The hardware has been designed and assembled at HyGear in Arnhem, in the Netherlands. The PSA is fully automated and can run safely without human intervention. The system is CE certified and installed in a container for easy handling and for in- and outdoor use.

In mid-June 2020, the PSA construction was finalized, the software loaded and the container ready for shipment to the To-Syn-Fuel plant in Hohenburg in Bavaria, Germany. The system has been installed during this summer. The commissioning phase is ongoing.

Installed To-Syn-Fuel PSA.
Credit: Hygear.

5. Environmental performances from LCA applied to biofuels from sewage sludge

Experts of CIRSA, the Inter-Departmental Centre for Research in Environmental Sciences of the University of Bologna, are the project group committed to evaluating environmental performances and sustainability of current sewage sludge management and to comparing it with the innovative solutions investigated in the project. Preliminary results from the life cycle assessment (LCA) methodology have been reported during the Advisory Board meeting, analysing the first encouraging results related to the climate change parameters.

Filippo Baioli, University of Bologna, reported To-Syn-Fuel LCA preliminary results at Ecomondo 2019.
Credit: ETA-Florence Renewable Energies.

As Serena Righi and Filippo Baioli, University of Bologna, reported also during national and international events last year, the sustainability of the TCR®-PSA-HDO integrated system is being analysed by means of LCA according to ISO 14040 and ISO 14044 and calculation of Greenhouse gases (GHG) emission savings according to Renewable Energy Directive (RED). The system boundaries analysed include the entire life cycle of the biofuel from source to usage, which considers sewage sludge collection, biofuel production by TCR®-PSA-HDO, and the distribution and use phases of the biofuel.

The Greenhouse Gases Emission of biofuel produced by the TCR®-PSA-HDO integrated system is evaluated and compared with conventional fuel (diesel and gasoline). The results are encouraging in accordance with the sustainability objectives defined by the Renewable Energy Directive. However, the primary contributor to carbon dioxide equivalent emission is the sewage sludge drying. For this reason,

several alternative scenarios are being evaluated. Furthermore, sewage sludge represents a large share of the biodegradable waste generated in the EU, and recent restrictions in some member states on its use as fertiliser and soil conditioner have resulted in increased disposal problems.

More than 8 Mt in terms of dry solids were produced in EU in 2014, of which approximately: 7% was disposed of in landfill; 28% was recycled in agriculture; 38% was incinerated; 15% was composted; 12% was disposed of with other treatments.

Therefore, environmental performance and sustainability of current sewage sludge management are evaluated and compared with the innovative solutions investigated in the To-Syn-Fuel project.

Through the LCA methodology the environmental impacts associated with products, processes or activities are assessed during its entire life cycle and measured by means of various indicators.

The use of sewage sludge to produce biofuels appears encouraging, in particular with respect to some impact categories such as Climate Change, Acidification, Freshwater Eutrophication and Ionizing Radiation, Ozone Depletion and Photochemical

"The Greenhouse Gases Emission of biofuel produced by the TCR®-PSA-HDO integrated system is evaluated and compared with the conventional fuel"

The consortium with 11 partner organisations has brought together some of the leading researchers, industrial technology providers and renewable energy experts from across Europe, in a collaborative, committed and dedicated research effort to deliver the overarching ambition. Partners include: Engie Services Netherlands NV, HyGear Technology and Services BV (The Netherlands), Fraunhofer UMSICHT, Verfahrenstechnik Schwedt GmbH, Martech GmbH (Germany), Alma Mater Studiorum – University of Bologna, Eni SpA, ETA–Florence Renewable Energies (Italy), University of Birmingham, WRG Europe Ltd (UK) and LEITAT (Spain). The project has a total duration of 65 months from May 2017 to September 2022 and will be funded by the European Union under the Horizon 2020 programme.

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