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CORDIS Results Pack on renewable fuels

A thematic collection of innovative EU-funded research results

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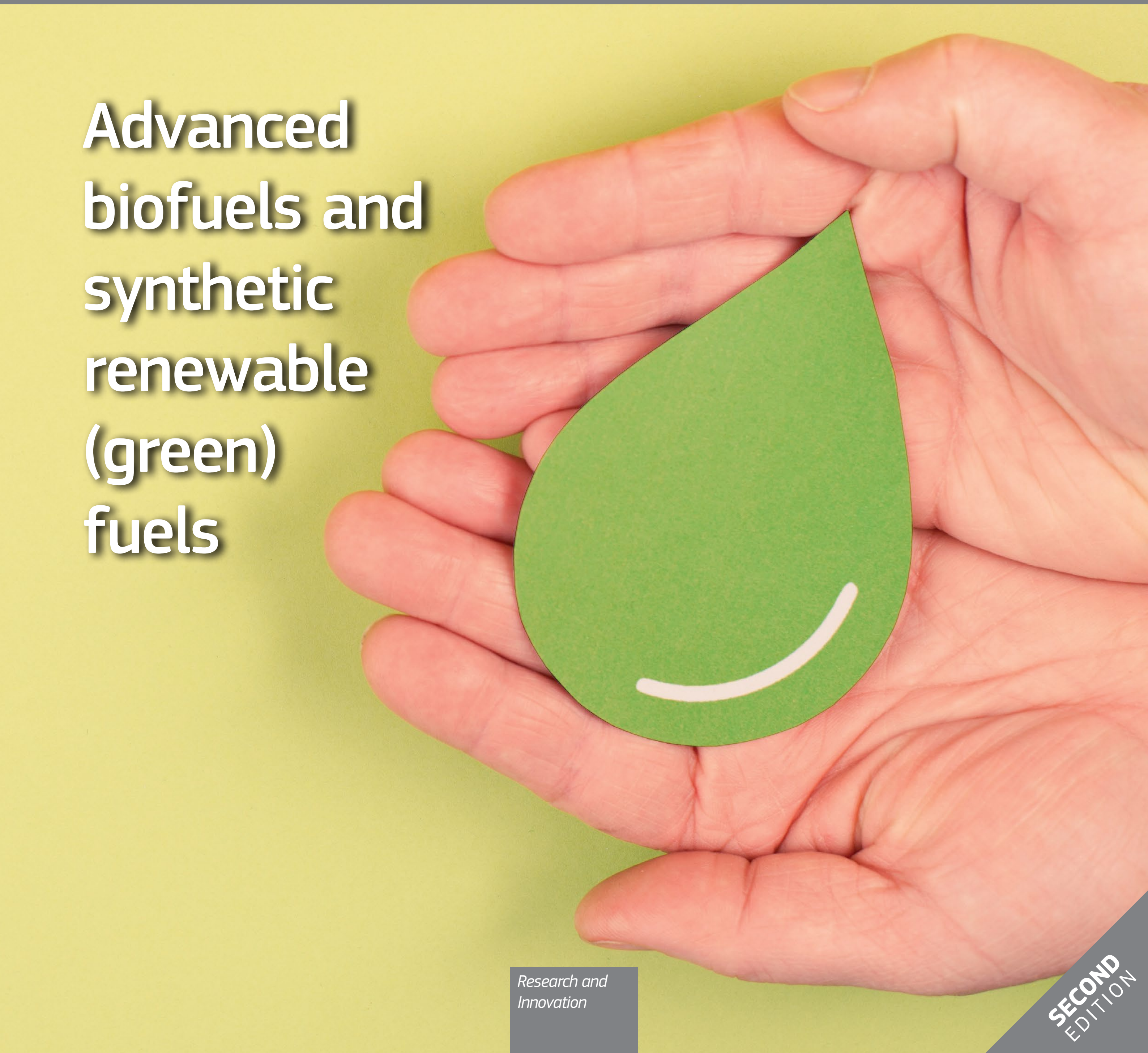
Advanced biofuels and synthetic renewable (green) fuels



Research and Innovation

SECOND EDITION

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Editorial

Transportation fuels are among the largest sources of greenhouse gas (GHG) emissions in the EU. In line with the European Green Deal's goal of achieving climate neutrality by 2050, 15 EU-funded projects are introducing renewable fuel technologies that will support the clean energy transition in the transport sector and help EU's energy independence.

Transportation accounts for a large share of the total energy consumption in Europe and contributes to approximately one fourth of global direct CO_2 emissions from fuel combustion. Advanced biofuels are a promising alternative that could significantly reduce the carbon footprint of the sector fast.

Europe has taken significant steps towards transport decarbonisation with initiatives such as the European Green Deal "Fit for 55" package. For the uptake of sustainable fuels, special provisions are proposed for the aviation and shipping sectors, which are among the most difficult to decarbonise and rely on renewable fuels in the long-term: ambitious targets on sustainable aviation fuels have been set (a share of at least 5 % in 2030 and 63 % in 2050), and guidelines for reduction in the GHG content of the energy supplied to ships have been laid down (at least 6 % in 2030 and 75 % in 2050 from the 2020 average).

Specific transport targets are foreseen in the proposal for the Renewable Energy Directive revision for advanced biofuels and biogas (a share of at least 2.2 % in 2030) and renewable fuels of non-biological origin (a share of at least 2.6 % in 2030), as well as for GHG intensity reduction (at least 13 % in 2030). This will help in the short term to decarbonise all transport sectors, including heavy road transport, through renewable fuels.

In order to rapidly reduce the EU's dependence on fossil fuel imports, the REPowerEU Plan proposes to increase the target of renewable energy in the EU final energy consumption in transport by an additional 4 % in 2030 through increasing also the shares of renewable fuels of non-biological origin to 5.7 % and of GHG savings to 16 %. This also implies that the demand for the supply of renewable fuels will be further increased.

This expectation is confirmed by the recent provisional agreement on specific transport targets for advanced biofuels and renewable fuels of non-biological origin in the Renewable Energy Directive revision trilogues.

Moreover, the Net Zero Industry Act establishes the framework of measures for innovating and scaling up the manufacturing capacity of net-zero technologies in the EU. It names renewable fuel from non-biological origin and sustainable alternative fuel technologies among the net-zero technologies.

The SET Plan Conference in Barcelona planned for 13 and 14 November 2023 will further strengthen Europe's plans towards the development of low-carbon, cost-competitive technologies that will also accelerate the transition towards green transportation.

Decisive steps towards carbon neutrality in the transport sector

This Results Pack on Renewable Fuels aims to showcase the contribution of novel technologies in replacing fossil fuels in line with "Fit for 55" and REPowerEU.

The 15 Horizon 2020 projects featured in the Pack will show how advanced biofuels and synthetic renewable fuel technologies can help pave the way towards energy security and autonomy, placing Europe in the lead of the net-zero industrial revolution.

Cost-effective biofuels production could slash transport's global warming potential

Biomass conversion technology has boosted the yield of biocrude oil production and decreased its cost. The blended diesel and gasoline fuels resulting from the refineries' upgrade could significantly enhance the transport sector's sustainability.

Transport is a major contributor to greenhouse gas (GHG) emissions. Advanced biofuels derived directly from living matter including agricultural and forestry residues and wastes have a key role to play in Europe's low-carbon energy landscape.

Their combustion can decrease GHG emissions more than 80 %, they can be sustainably produced from waste, and they can improve our energy security. The EU-funded COMSYN project, coordinated by the VTT Technical Research Centre of Finland, set out to increase the adoption of biomass-to-biofuel technologies.

Flexible feedstock and small-scale primary conversion

A key component of the COMSYN concept is local, small-scale conversion of biomass feedstock to biocrude oil. Compatible feedstocks include demolition wood, forest residues, forest industry by-products and straw. "The smaller scale lowers the investment costs significantly, which lowers the investment risk and makes the concept more attractive. The biomass flexibility minimises seasonal impacts associated with food crops and enables the primary conversion units to be located throughout Europe, enhancing energy security," says Johanna Kihlman, senior scientist and COMSYN project coordinator.

Simplified syngas 'cleaning' and intensified biocrude production

The synthesis gas produced by biomass gasification must be cleaned rigorously to remove impurities before it is fed into the Fischer-Tropsch synthesis reactor. There, recombination reactions yield hydrocarbons for centralised refining to transport engine-compatible fuel.

COMSYN simplified the cleaning process, significantly reducing associated costs. The scientists increased the output of Fischer-Tropsch synthesis with process intensification, which also lowers the cost of the final product. The production rate of a large-scale reactor was predicted to increase from 0.25 barrels per day (bpd) to 20 bpd, a nearly 100-fold increase. Multiple intensified modular reactors can be used together to further increase production.

COMSYN's primary conversion process was piloted at VTT. The results of the pilot campaigns were used to create northern and central European case studies. Techno-economics of potential sites were analysed considering the options for: integration with local industry including a pulp mill and a sawmill; different feedstocks such as wood, forestry residues and by-products and straw; and energy integration in the form of electricity, district heating and on-site consumption of electricity and steam.

From biocrude to functional fuel: considerable global warming reduction

"Within the first 2 years, our gas ultra-cleaning unit went from lab to pilot scale; we constructed the new unit in the gasification pilot facilities and integrated the gasification and gas cleaning process with the Fischer-Tropsch synthesis unit," says Kihlman. This remarkable technical success was the prerequisite to upgrading the biocrude product to blended diesel and gasoline fuels at refineries, verification of the biofuels' functionality, and a techno-economic analysis.

The blended biodiesel and biogasoline produced by COMSYN technology are suitable for normal vehicle engines without excessive costs.

"For the average consumer, the dilemma is often how to cut personal carbon footprint without extra costs and/or changing personal lifestyle. The blended biodiesel and biogasoline produced by COMSYN technology are suitable for normal vehicle engines without excessive costs. Technologies like COMSYN's make the transition towards a carbon-neutral Europe easier," concludes Kihlman. Techno-economic and life cycle assessment outcomes demonstrate an impressive global warming potential decrease (based on GHG emissions) of greater than 80 %.

PROJECT
COMSYN – Compact Gasification and Synthesis process for Transport Fuels

COORDINATED BY
VTT Technical Research Centre of Finland, Finland

FUNDED UNDER
Horizon 2020-ENERGY

CORDIS FACTSHEET
cordis.europa.eu/project/id/727476

PROJECT WEBSITE
comsynproject.eu/

From domestic sewage waste to your gas tank: advanced biofuels from sewage

Naturally renewable, carbon-rich biogenic waste is turned into drop-in fuels for transport in the first industrial-scale demonstration of the process and product.

@ Fraunhofer UMSICHT

In 2021, fossil fuel-powered cars and vans accounted for 92 % of light-duty vehicle sales globally. Despite the accelerating adoption of electric and hybrid vehicles, these vehicles and many more will be on the road for at least a couple of decades, so a sustainable interim solution for greener transport is needed.

Carbon-rich biowaste such as sewage sludge is an excellent source of energy and energy carriers. It is renewably and locally produced with no geopolitical boundaries. Today, most of it is landfilled, incinerated or used in agriculture. The EU wants to convert it into energy. The EU funded TO-SYN-FUEL project is making this possible.

TO-SYN-FUEL and its 13-member consortium demonstrated for the first time at a precommercial scale the conversion of sewage sludge into drop-in biofuels at a decentralised location. Abundant domestic sewage waste may soon be powering our cars rather than accumulating in landfills.

From sewage sludge to drop-in gasoline and diesel

First-generation biofuels are derived directly from starchy crops like corn, cereals and rapeseed. Advanced or second-generation biofuels enhance sustainability with feedstocks like residual and waste products from households and industry that are not in direct competition with food production.

"In the TO-SYN-FUEL project, crude oil was obtained via thermo-catalytic reforming (TCR®) technology from sewage sludge produced by wastewater treatment plants. The crude oil was converted via hydrogenation and distillation processes into drop-in biofuels that meet European standards for gasoline and diesel (EN 228 and EN 590, respectively)," explains project coordinator Robert Daschner of the Renewable Energy Department at Fraunhofer. TO-SYN-FUEL's gasoline and diesel have all the properties of fossil fuel-derived counterparts and can be used directly in unmodified vehicles.

TO-SYN-FUEL demonstrated for the first time on an industrial scale that biogenic residual and waste materials can be converted into thermally stable liquid bio-oils.

Sewage-derived biofuels go for a test drive

From 2017 to 2022, TO-SYN-FUEL converted more than 0.5 million kg of sewage sludge into approximately 50 000 l of oil, from which 40 000 l of gasoline, diesel and kerosene can be obtained. EU funding of the TO-SYN-FUEL supported the team in increasing efficiency through energetic and thermal process coupling and integrative products use and subsequent technology scaling.

While sewage waste was the focus of TO-SYN-FUEL, as its disposal is particularly problematic, the TO-SYN-FUEL process can convert almost any biomass, including the organic fraction of municipal waste, agricultural residues and garden waste, into gasoline and diesel. TO-SYN-FUEL's biofuel was on display throughout Europe. The team took an unmodified Volkswagen Passat for a road trip fuelled with biodiesel from the project's plant.

"TO-SYN-FUEL demonstrated for the first time on an industrial scale that biogenic residual and waste materials can be converted into thermally stable liquid bio-oils. Our high-quality drop-in biofuels will enable the substitution of fossil carbons with a wide range of petrochemical products obtained from biogenic residues via conventional refinery processes," states Daschner. The team is now working on demonstrating its technology for other biomass feedstocks.

Sewage sludge prepares to take flight

A Bavarian refinery is planning the first industrial application of the technology. Sustainable aviation fuel will be derived from processing up to 400 000 metric tonnes of sewage sludge (100 000 metric tonnes of dry matter) by 2030, around 40 % of Bavaria's total sewage volume. 'Renewable' sewage could soon be powering vehicles on land, air and sea.

PROJECT

TO-SYN-FUEL - The Demonstration of Waste Biomass to Synthetic Fuels and Green Hydrogen

COORDINATED BY

Fraunhofer Society for the Advancement of Applied Research, Germany

FUNDED UNDER

Horizon 2020-ENERGY

CORDIS FACTSHEET

cordis.europa.eu/project/id/745749

PROJECT WEBSITE

tosynfuel.eu/

Steel plant CO_2 fuels the shipping sector with greener methanol

CO_2 in steel plant residual gases has been recycled to sustainably produce methanol for the shipping industry, contributing to decarbonisation of both sectors.

Finding ways to abate emissions is a priority to achieve the EU's climate-neutrality (net-zero greenhouse gas emissions) goals for 2050. In 2018, global emissions generated by the shipping sector accounted for approximately 3 % of human activity-related emissions. Steelmaking is an energy-intensive and carbon-intensive process. Likewise, the steel industry generates about 5 % of CO_2 emissions in the EU and 7 % globally.

The EU-funded FReSMe project found a way to decarbonise both industries to a significant extent by connecting one's output to the other's input, all with little need for new equipment or plants. The team developed and optimised an innovative combination. CO_2 capture technology to capture CO_2 from steel plant blast furnace gas was coupled with emissions-to-liquids (ETL) methanol production to produce fuel for the shipping industry.

CO_2 capture coupled with methanol production

In Europe, most steel is produced via the blast furnace-basic oxygen furnace route. In the blast furnace, the iron in iron ore is separated from oxygen via a reduction reaction, primarily using coke from coal as the reducing agent. As a result, in addition to steel, the steel production process generates significant residual blast furnace gas containing carbon monoxide, CO_2 and hydrogen (H_2).

Plans to reduce the steel sector's emissions increasingly focus on replacing these existing steel production processes with new steel plants based on the direct reduction of iron using H_2. However, this transition will take time and money.

FReSMe turned to the sorption-enhanced water-gas shift (SEWGS) process for CO_2 capture and H_2 production, developed approximately a decade ago largely through the previous EU-funded CACHET and CAESAR projects. FReSME successfully demonstrated that SEWGS is a technology especially well-suited for carbon capture in steel production processes.

The next step was recycling this CO_2. Methanol is a versatile, low-carbon, hydrogen-rich chemical that is currently primarily produced from fossil fuels. Valorising the bigger amounts of captured CO_2 to produce methanol required augmenting the amount of H_2. "The pure stream of H_2 obtained from the SEWGS capture unit was combined with renewable H_2 produced through water electrolysis. The H_2 was reacted with SEWGS-captured CO_2 in the ETL unit to obtain fuel-grade, low carbon methanol, a clean burning fuel which meets the strictest emissions regulations," explains project coordinator David Cuesta Pardo of NTT DATA.

The pure stream of H_2 obtained from the [sorption-enhanced water gas shift] (SEWGS) capture unit was combined with renewable H_2 produced through water electrolysis. The H_2 was reacted with SEWGS captured CO_2 in the [emissions-to-liquids] (ETL) unit to obtain fuel-grade, low-carbon methanol, a clean burning fuel which meets the strictest emissions regulations.

From steel industry blast furnace gas to methanol for the shipping industry

FReSMe's methanol was successfully used to power a roll-on/roll-off cargo ship connecting Gothenburg in Sweden and Kiel in Germany, demonstrating that CO_2 can be recycled and contribute to a reduction in fossil fuel demand and emissions.

"Without EU financial support for piloting innovative technologies and fostering technology transfer, many technologies would not achieve meaningful impact. Thanks to EU funding of FReSMe, both SEWGS and ETL technologies performed flawlessly with the complex mixtures of blast furnace off-gases and are moving toward large-scale deployment," concludes Cuesta Pardo.

The versatility of SEWGS is now being demonstrated by producing ammonia from blast furnace gas, and the process is ready for scale-up. The ETL technology has reached commercial status, and the first large-scale plants have just entered operation. The project has reaffirmed the ability of circularity and industrial symbiosis to contribute to decarbonisation of an important part of the economy.

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PROJECT
FReSMe - From residual steel gasses to methanol

COORDINATED BY
I-Deals Innovation & Technology Venturing Services, Spain

FUNDED UNDER
Horizon 2020-ENERGY

CORDIS FACTSHEET
cordis.europa.eu/project/id/727504

PROJECT WEBSITE
N/A

Optimised approaches to biofuels production in existing refineries

A holistic study of diverse biomass transformation processes throughout the value chain has led to cost-effective commercial biofuels production via co-processing with crude oil.

The transport sector relies on fossil fuels more than any other sector and contributed [37 % of CO_2 emissions from end-use sectors] in 2021. Advanced biofuels are a promising alternative 'drop-in' fuel that could significantly reduce the carbon footprint of difficult to decarbonise sections of transport. These fuels replace the existing first-generation biofuels with non-food feedstocks. The solid feedstock is liquefied and processed to produce a bio-oil that is refined to yield advanced biofuels.

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Integrating these processes into existing refineries will play a key role in exploiting the potential of advanced biofuels. It will make use of existing refinery processes and infrastructure, allowing cost-competitive scale-up of fossil fuel alternatives. The EU-funded 4REFINERY project developed new biofuels production technology for diverse feedstock to facilitate effective and efficient implementation in existing refineries.

Primary conversion of diverse biomass feedstocks into bio-oil

Biomass differs from fossil fuel-based hydrocarbons, particularly in relation to its oxygen content and the fact that it is a solid feedstock. It requires a primary conversion step, liquefaction to a bio-oil, to enable upgrading in existing refineries. The most promising liquefaction routes are fast pyrolysis and hydrothermal liquefaction (HTL).

According to project coordinator Duncan Akporiaye of SINTEF, "4REFINERY evaluated several approaches to integration with refinery processes to optimise the efficiency and cost of primary conversion of forest residue, eucalyptus and straw using the complimentary fast pyrolysis and HTL technologies."

Bio-oil to bio-gasoline and biodiesel: co-processing at existing refineries

Harnessing existing refineries will include co-processing of bio-oil and crude oil. Fluid catalytic cracking (FCC) and catalytic hydrotreating (HDT) are important refinery processes that break down large petroleum fragments into lighter hydrocarbon streams. 4REFINERY explored all the major steps for co-FCC and co-HDT routes to bio-oils in refinery processes.

Key findings include that mildly treated pyrolysis oil could be integrated into the co-FCC route, but the co-HDT route required more severe treatment of the pyrolysis bio-liquids. Issues of HTL bio-liquids' compatibility in the co-processing with straight-run gas oil (SRGO) (produced by distillation before further conversion or processing) were found due to solubility issues. However, fractional distillation and use of the heavy distillates enabled complete miscibility in SRGO, suggesting it could still be a promising route for co-processing of bio-oils and fossil fuels.

4REFINERY was quite unique in that it was able to test a very wide range of alternative value chains, allowing the development of comprehensive models. The results of these studies have been implemented in a tool that can be used by refineries to evaluate the potential of different scenarios.

A tool to help refineries choose optimal processes

4REFINERY demonstrated that the existing fossil-based refinery processes have the potential to be reconfigured to produce advanced biofuels at commercial scale, avoiding the need to build completely new production units. This potential has been realised by project partner BTG Biomass Technology Group, which built a commercial unit in Sweden implementing the concepts developed in the project. In parallel, the consortium and other partners are now working on the scaling up one of the 4REFINERY value chains towards the production of aviation and marine fuels.

The project has enabled deeper understanding of the impact of different combinations of biomass feedstock and treatment processes on product characteristics, providing insight into synergetic effects. "4REFINERY was quite unique in that it was able to test a very wide range of alternative value chains, allowing the development of comprehensive models. The results of these studies have been implemented in a tool that can be used by refineries to evaluate the potential of different scenarios," concludes Akporiaye.

PROJECT
4REFINERY - Scenarios for integration of bio-liquids in existing REFINERY processes

COORDINATED BY
SINTEF AS, Norway

FUNDED UNDER
Horizon 2020-ENERGY

CORDIS FACTSHEET
cordis.europa.eu/project/id/727531

PROJECT WEBSITE
sintef.no/projectweb/4refinery/

From biomass residues and waste to drop-in aviation fuels

The transport sector guzzles liquid fuels. Hydrothermal liquefaction to produce feedstock-flexible advanced biofuels could slash global emissions.

Transportation is one of the largest generators of greenhouse gas emissions. It contributes approximately one fourth of global direct CO_2 emissions from fuel combustion. Advanced liquid biofuels could play a significant role in achieving the goals of the European Green Deal, particularly a 90 % reduction in transport emissions and climate neutrality by 2050.

The EU-funded HyFlexFuel project brought together 11 European partners with expertise throughout the biofuel production chain. The team successfully turned a wide variety of low-cost, abundant and sustainable feedstock into advanced biofuels. They also valorised organic and inorganic components in residual process streams, laying the groundwork for a circular and sustainable economy for the transport sector.

Hydrothermal liquefaction of biomass and waste to biocrude, flexibly and sustainably

Hydrothermal liquefaction (HTL) is an emerging biofuel technology that can produce renewable transportation fuels by converting a plethora of biomass types into crude-like bio-oil under moderate temperature and high pressure. Through a comprehensive experimental and theoretical campaign to industrial-scale pilots, the HyFlexFuel team successfully demonstrated the full fuel production chain.

According to Valentin Batteiger, "HyFlexFuel produced transportation fuels including gasoline, jet fuel and diesel via HTL conversion of diverse feedstock (sewage sludge, algae and wheat straw) and upgrading to drop-in fuels in an industrial environment." The demonstrations within the HyFlexFuel project included 48 hours of continuous HTL biofuel production and more than 300 continuous hours of upgrading via the appropriate choice of process design and catalysts. A blend of HTL kerosene and conventional jet fuel was successfully validated in a laboratory-scale gas turbine engine.

More than biocrude: biogas and fertiliser products

The integration of HyFlexFuel technology in wastewater treatment is particularly interesting as it can be used to destroy micropollutants, recover phosphorous and produce fuels, contributing to a circular economy.

Biocrudes are not the only HTL product. Typically, 90 % of the throughput of an HTL plant is process water containing a significant amount of minerals and organics. HyFlexFuel investigated the methane production from the organic content and produced biogas from the process water. These gases could be used, for example, for on-site electricity and heat generation. The project also recovered nitrogen and phosphorous from the process water and solids and phosphorous from the HTL of sewage sludge.

"The integration of HyFlexFuel technology in wastewater treatment is particularly interesting as it can be used to destroy micropollutants, recover phosphorous and produce fuels, contributing to a circular economy," notes Batteiger.

Accelerating the transition to sustainable transportation

Process models helped to evaluate the economic and environmental performance of HTL fuel production. In the case of sewage sludge conversion, near-competitive production costs and greenhouse gas reductions of more than 80 % can be achieved. However, although the corresponding market value exceeds EUR 1 billion, only a small fraction of European fuel demand can be covered. Therefore, further research should focus on the conversion of more abundant advanced feedstock, such as manures and straw, as well as more resource efficient conversion schemes, e.g. by coupling with green hydrogen production.

To support sustainability and a road forward, the project also quantified and mapped the availability and density of residues and waste streams across Europe to identify suitable locations for HTL plants.

HyFlexFuel has achieved an advanced biofuel breakthrough that could make a substantial contribution to the European Green Deal and carbon neutrality by slashing the transport sector's substantial emissions. Insights and experience from HyFlexFuel will also contribute to the Horizon Europe-funded project CIRCULAIR that investigates aviation fuel production from manures and straws via HTL.

PROJECT
HyFlexFuel – Hydrothermal liquefaction: Enhanced performance and feedstock flexibility for efficient biofuel production

COORDINATED BY
Bauhaus Luftfahrt, Germany

FUNDED UNDER
Horizon 2020-ENERGY

CORDIS FACTSHEET
cordis.europa.eu/project/id/764734

PROJECT WEBSITE
hyflexfuel.eu/

Exploiting available land to promote sustainable bioenergy in Europe

Freely accessible digital tool assesses the environmental, social and economic sustainability of producing biomass on marginal, underutilised and contaminated European lands, and finds great potential.

Bioenergy will play an important role in meeting EU climate targets. For example, the Renewable Energy Directive has established that 32 % of Europe's energy production shall come from renewable energy sources until 2030.

To meet these and other climate goals, bioenergy must be produced sustainably. The availability of sustainable biomass resources is a key prerequisite for further developing advanced biofuels and penetrating the market.

MUC lands, a viable option in producing bioenergy

One effective measure to support sustainable bioenergy expansion is using marginal, underutilised and contaminated (MUC) lands to produce biomass. For the most part, these lands cannot be used anymore for food/feed production or for recreational and conservation purposes. However, in some cases, MUC lands have the potential to produce biomass feedstock that is suitable for bioenergy production.

Furthermore, using these lands for biomass production could have several positive environmental and socioeconomic benefits. These include restoring soil productivity, increasing biodiversity, promoting rural economic development and boosting household income.

Sustainability tool for bioenergy production

To expand the production of sustainable biomass and bioenergy, the EU-funded BIOPLAT-EU project developed a digital platform. It mainly incorporates a tool that uses global information system (GIS) maps. Available in English, French, German, Hungarian, Italian, Romanian, Spanish and Ukrainian, this web-based GIS tool visualises MUC lands on an interactive map that covers Europe and neighbouring countries.

Relevant stakeholders, such as farmers, landowners and investors, can search MUC land plots and discover what type of biomass can be grown on them. To decide whether to proceed or not, they assess a set of environmental (e.g. soil quality), social (e.g. bioenergy sector jobs) and economic (e.g. net energy balance) sustainability indicators for selected bioenergy value chains.

"This mapping provides first insight into the value chain's viability and sustainability performance and serves as a support tool for decision making," explains Rainer Janssen of WIP Renewable Energies, the German renewable energy consultancy company that coordinated BIOPLAT-EU. "The actions can be performed online without the need for extensive research, expertise or funding." A how to manual, video and online Helpdesk are available for assistance.

Valuable information on Europe-wide availability of MUC lands

Project partners carried out an assessment to test the web-based GIS tool's ability to find suitable MUC lands for sustainable oil crop production in Europe. "When combining the tool's information on MUC lands and the crops' suitability, there is a lot of potential throughout Europe, especially in the eastern and southern parts," states Janssen.

The results showed that the tool is technically applicable and simple to use for mapping potential value chains. Prospective MUC areas for oil crop production can be found for market actors who want to evaluate further their options and start developing more comprehensive bioenergy value chains. The pan-European assessment found rapeseed and sunflower oil to have the most potential.

For the first time, a concise, user-friendly overview of MUC lands throughout Europe became available based on scientific data.

"For the first time, a concise, user-friendly overview of MUC lands throughout Europe became available based on scientific data," concludes Janssen. "Thanks to BIOPLAT-EU, end users can take advantage of the tool and explore opportunities to develop value chains for sustainably producing biomass on these lands."

PROJECT
BIOPLAT-EU – Promoting sustainable use of underutilized lands for bioenergy production through a web-based Platform for Europe

COORDINATED BY
WIP Renewable Energies, Germany

FUNDED UNDER
Horizon 2020-ENERGY

CORDIS FACTSHEET
cordis.europa.eu/project/id/818083

PROJECT WEBSITE
bioplat.eu/

Innovative technologies provide high-performance, low-emission biofuel

Fully compatible and fully renewable: Europe's first standards-compliant biofuel has arrived.

Drop-in fuels are key to bioenergy development. Derived from biomass, they can be blended with fossil fuels and even replace them without modification to existing equipment. Funded by the EU, the REDIFUEL project has developed a drop-in fuel with the same name.

After exploring several biomass options for REDIFUEL, the team selected wood residues as the most promising large feedstock for their research. Completely renewable, REDIFUEL is designed to help the EU reach its target for reduced greenhouse gas (GHG) emissions by 2050.

According to project coordinator Thorsten Schnorbus: "REDIFUEL's ambition is to develop new technologies, solutions and processes to reach high conversion efficiencies for fleet compatible renewable fuel production."

The road transport sector contributes the majority of GHG emissions. While electric vehicles will help to alleviate the problem, heavy transport will continue to rely on liquid fuels for some time to come. Developing biofuels with low GHG emissions is not only a sustainable solution; it is an imperative one.

A cascade of innovative processes

The process to transform a feedstock into a high-combustion, low-emission biofuel involves many steps. The initial feedstock must be gasified, pollutants must be removed, and then the gases must undergo the Fischer-Tropsch synthesis. The production of REDIFUEL uses an innovative catalytic process developed by the Spanish National Research Council (CSIC). Commonly the implementation of the Fischer-Tropsch process requires large facilities and massive quantities of biomass. However, the compact design of the reactor developed by the partner, German-based e-fuel company INERATEC, allows for high efficiency and fine-tuned control of the process.

The second key stage to developing REDIFUEL involves transforming the high share of olefins, a type of hydrocarbon molecule implicated in GHG emissions, into bio-alcohols using the processes of hydroformylation and hydrogenation. The success of the REDIFUEL project in this regard led to a high share of bio-alcohols, a key factor in meeting EN 590 fuel standards.

A well-to-wheel winner in the making

Through the application of innovative technologies, REDIFUEL meets many of the criteria set out in the project. It is a low-emission, high-performance fuel that can replace up to 100 % of petroleum-derived diesel. Well within the requirements of EN590 fuel standards, REDIFUEL can be put into diesel engine vehicles and distribution sites without modification of infrastructure or software.

Because REDIFUEL can be produced using a variety of feedstocks (including green hydrogen and air captured CO_2), it has the potential to provide a sustainable solution over the long term. The technical innovations that produced REDIFUEL can also be used in a PtX-based production strategy, converting renewable electricity into biofuel.

As yet, the production of REDIFUEL does not reach the cost-competitive target set by researchers. The catalytic process produced the desired high share of carbon-rich olefins. However,

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this result was paired with a low productivity rate, and target productions in the pilot stage could not be met. Further research is necessary to make REDIFUEL cost-competitive by 2030, the target date identified by the researchers.

The environmental and societal aspects are taken into account by a biomass-to-wheel analysis showing that the overall CO_2 reduction compared to fossil fuels is tremendous and beyond that of conventional biodiesel.

Regardless of the challenges posed, the REDIFUEL team has demonstrated an impressive degree of innovative problem solving that will no doubt yield breakthroughs in the near future. According to Schnorbus: "The environmental and societal aspects are taken into account by a biomass-to-wheel analysis showing that the overall CO_2 reduction compared to fossil fuels is tremendous and beyond that of conventional biodiesel." A low-emission and high-performance biofuel is just what is needed for heavy transport in Europe, and REDIFUEL delivers.

PROJECT
REDIFUEL – Robust and Efficient processes and technologies for Drop In renewable FUELs for road transport

COORDINATED BY
FEV EUROPE GMBH, Germany

FUNDED UNDER
Horizon 2020-ENERGY

CORDIS FACTSHEET
cordis.europa.eu/project/id/817612

PROJECT WEBSITE
redifuel.eu/

Retrofitting EU industries for bioenergy

Case studies in five energy-related industries shine a light on how companies can meet environmental goals without sacrificing financial gains.

Bioenergy retrofitting refers to the implementation of new state-of-the-art equipment into existing facilities. It is one of the fastest and most cost-effective ways to increase Europe's use of renewable energy.

The EU-funded BIOFIT project worked with industry partners in paper and pulp, first-generation biofuels, fossil fuel refineries, power stations and combined heat and power (CHPs) to design bioenergy retrofitting proposals that meet both environmental and economic objectives. Bioenergy retrofitting incorporates new technology and equipment into older facilities in order to increase fuel efficiency, especially with respect to bioenergy.

According to project coordinator Patrick Reumerman of BTG Biomass Technology Group BV: "A key characteristic of BIOFIT is that it was implemented in very close cooperation with companies." In conversation with industry partners, Reumerman and the BIOFIT team realised that there was a lot of enthusiasm around retrofitting but identifying best practices and barriers to implementation was essential to success.

Best practice focus

A major product of BIOFIT was the design of 10 proposals for retrofitting, 2 for each of the targeted industries. In order to create the proposals, BIOFIT worked to identify best practices. They gathered information about bioenergy retrofits that had already occurred, surveyed individuals employed in the targeted industries about attitudes and perceptions around retrofitting and produced a comprehensive but accessible handbook to guide companies in the process of adopting new ideas in retrofitting.

The BIOFIT philosophy was that in cooperation with actual market players, the real problems of implementing bioenergy retrofits could be identified.

While the proposals developed by BIOFIT vary greatly, all highlight the importance of biofuels. Industry examples include using paper and pulp residues as biomass for producing biofuel, retrofitting fossil fuel industries to produce hydrotreated vegetable oil, and using biomass fuels instead of coal in power plants and CHPs.

BIOFIT's focus on best practices and enhancing communication between constituencies has led to the successful implementation of some of the proposals. For example, the Austrian company AustroCel Hallein converted a by-product into a second-generation transport biofuel. Second-generation biofuels are fuels produced from biomass residue or waste, which distinguishes them from first-generation biofuels, which are produced from crops, like rapeseed.

A focus on the future

Despite strong motivation to retrofit, many industries have struggled to follow through. According to Reumerman: "The BIOFIT philosophy was that in cooperation with actual market players, the real problems of implementing bioenergy retrofits could be identified." Specifically, companies are understandably concerned about managing costs. However, analysis of retrofitting shows that most initiatives are financially sound and ultimately increase a company's productivity.

According to survey results, one of the biggest deterrents to retrofitting is the rapidly changing and complex set of regulations applied to industries throughout the EU. Complicating things further, different member states have different regulations as well as different criteria as to what constitutes a biomass residue.

As EU markets lean towards the future, market players, policymakers and consumers will need to inform themselves and connect with one another to determine the wisest course of action. Clearly, biomass resources are at the heart of biofuel

production, but this is a finite resource. BIOFIT has set a good example for how to assess best practices, design viable proposals for change, and encourage essential communication in our ever-changing world.

PROJECT
BIOFIT - Bioenergy retrofits for Europe's industry

COORDINATED BY
B.T.G. BIOMASS TECHNOLOGY GROUP, Netherlands

FUNDED UNDER
Horizon 2020-ENERGY

CORDIS FACTSHEET
cordis.europa.eu/project/id/817999

PROJECT WEBSITE
biofit-h2020.eu/

Breakthrough biotechnology enables engineered bacteria to churn out sustainable biofuels

EU-funded researchers altered the genetic make-up of *Escherichia coli* to produce biofuel using three renewable and naturally abundant source ingredients: water, CO_2 and solar/wind-generated electricity.

Renewable energy sources such as solar and wind power can help reduce CO_2 emissions into the atmosphere. Sometimes, these sources produce great amounts of power but not necessarily when usage is high. Traditional power plants cannot yet be fully displaced owing to the lack of viable solutions for storing such excess electricity. Furthermore, vast CO_2 amounts produced by industry, for example in steel production, are not upcycled.

> *Our sustainable production chain converts CO_2 emissions and renewable electricity into easy-to-handle formic acid, which is then fed to engineered microbes for producing renewable hydrocarbon fuels and other biomaterials.*

Bringing together researchers and companies across Europe, the EU-funded eForFuel project addressed all these issues at once.

Tiny microorganisms riding to the rescue

eForFuel's groundbreaking concept relied on using excess electricity from renewable sources, waste emissions from industry and lab-grown bacteria to produce valuable, ready-to-use biofuels. "Our sustainable production chain converts CO_2 emissions and renewable electricity into easy-to-handle formic acid, which is then fed to engineered microbes for producing renewable hydrocarbon fuels and other biomaterials," notes Laura Martinelli, CEO and founder of IN SRL Impresa Sociale and project coordinator.

The first step involved using renewable electricity to directly reduce CO_2 into a liquid product. CO_2 and water were fed into an electrolyser, creating an acid most notably found in ants, the so-called formic acid. The latter was then transferred into a fermentor, a vessel where bacteria can be grown. This hosted a special strain of engineered *Escherichia coli* (*E. coli*) able to digest the formic acid and produce hydrocarbon gases that can be converted into fuels for use in transport.

New pathway to the use of CO_2 for advanced biofuels

"CO_2 is unlimited, might be captured from air or from point sources, and can be transformed into a plethora of products, including advanced biofuels. The technology is still in its infancy and poses several challenges, such as the cost-efficient reduction of CO_2 into a viable carrier and its successive transformation into advanced fuels via an engineered microorganism," remarks Martinelli.

The metabolic pathway that efficiently converted CO_2 and formic acid into fuel was constructed by the reverse glycine cleavage reaction. Glycine and serine, universal precursors of one-carbon compounds, were produced from formate and CO_2 through a reductive route. "We were the first to engineer the fully synthetic reductive glycine pathway, enabling *E. coli* to grow on formic acid and CO_2 as the sole carbon sources. It turned out to be the most energy-efficient aerobic formate assimilation pathway, suitable for industrial scale-up," highlights Martinelli.

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Adaptive laboratory evolution (ALE) further optimised the strain for rapid growth and increased biomass yields. Furthermore, ALE experiments adapted the strain to growth at lower CO_2 concentrations, similar to those found in industrial off-gases.

"The development of efficient technological solutions such as microbial strains that can grow and produce using one-carbon sources is crucial for establishing a sustainable and scalable bioeconomy. Several research groups have already replicated the engineering of the reductive glycine pathway in other organisms, and multiple projects are underway to build on the work initiated by eForFuel," remarks Martinelli.

"Proof-of-concept studies have advanced the engineered *E. coli* strain to grow on methanol, another reduced one-carbon compound, that results in a smaller CO_2 footprint. This may render it a more suitable carbon source for use in the bioeconomy," concludes Martinelli.

In memory of Arren Bar Even who left prematurely, who was the inventor behind eForFuel's innovative technology. Special thanks to Steffen Lindner from the Charité – Universitätsmedizin Berlin who is also continuing his pioneering work.

PROJECT
eForFuel - Fuels from electricity: de novo metabolic conversion of electrochemically produced formate into hydrocarbons

COORDINATED BY
IN_society, Italy

FUNDED UNDER
Horizon 2020-ENERGY

CORDIS FACTSHEET
cordis.europa.eu/project/id/763911

PROJECT WEBSITE
eforfuel.eu/

Highly efficient conversion of wet and dry biogenic waste into fuels

Researchers have demonstrated a chemical efficiency of 61 % and a carbon conversion of 53.5 % for a process based on novel Fischer-Tropsch and aqueous phase reforming technologies.

Transportation fuels are responsible for a large portion of the final energy consumption in Europe. The source of this energy is largely from fossil fuel imports, which is harmful to the environment and Europe's security. EU policy strives to transition to greener solutions.

Proposing such a solution is the EU-funded Heat-To-Fuel project. It set out to deliver the next generation of biofuel production technologies, supporting the decarbonisation of the transportation sector. "Our main objectives were to achieve competitive prices for biofuel technologies, below EUR 1 per litre, while delivering higher fuel qualities and significantly reduced life-cycle greenhouse gas (GHG) emissions," explains project coordinator Richard Zweiler. This is in addition to the targets of energy production savings by 20 % and enhancing the EU's energy security, amongst other goals.

Contributing to a circular economy

The project's objectives were achieved thanks to the integration of novel technologies with innovative activities on design, modelling, development of hardware and processes, testing and life cycle analysis of a fully integrated system in a single machine.

"Specifically, using a novel Fischer-Tropsch (FT) milli-structured reactor and aqueous-phase reforming (APR), a highly integrated process has been developed, which is in the position to convert a wide range of biogenic residues into FT products and biocrude," outlines Zweiler. The process consists of a dry route and a wet route. In the dry route, straw/bark mixtures, for instance, are gasified. The syngas is then converted via the milli-structured reactor into FT products. During the wet route, feedstocks such as lignin are converted through the combination of hydrothermal liquefaction and APR.

"Gasification experiments have also been carried out in a series of small- and large-scale process development units. CO_2 gasification technology was developed further, and detailed fundamental results on ash agglomeration behaviour have been published," notes Zweiler. Three different structured FT-reactors have also been developed in the project within an iterative process in close combination with catalyst development.

The comparison with other biofuel technologies such as gasification plus FT and fermentation showed energy savings in the 44-58 % range.

"The development in the project shows that up to 100 % of CO_2 can be reused as gasification agent, where a chemical efficiency of 61 % and carbon conversion of 53.5 % can be reached in the full integrated Heat-To-Fuel process," confirms Zweiler.

Using this process, the GHG footprint can be reduced by 70 % compared to the fossil scenario. "The comparison with other biofuel technologies such as gasification plus FT and fermentation showed energy savings in the 44-58 % range," adds Zweiler.

Supporting local economies with the Heat-To-Fuel biorefinery

The installation of a biorefinery plant using the project's process will create synergistic business opportunities in other sectors, hence fostering economic development at the local and regional levels, driven by an efficient and conscious use of local resources.

Looking towards the future, Zweiler confirms: "All partners are committed to contributing to further activities. Consortium members have already scheduled participation in Horizon Europe clustering activities and workshops organised by other Horizon projects."

At the end of the project, 18 active members from industry, investors and associations have continued promoting the project's technology further. "One dedicated goal is to find funding for increasing the TRL to demonstration phase, which should allow fast uptake from the industry and implementation of the project's technology into biorefineries and industry," concludes Zweiler.

PROJECT
Heat-To-Fuel - Biorefinery combining HTL and FT to convert wet and solid organic, industrial wastes into 2nd generation biofuels with highest efficiency

COORDINATED BY
GUSSING ENERGY TECHNOLOGIES GMBH, Austria

FUNDED UNDER
Horizon 2020-ENERGY

CORDIS FACTSHEET
cordis.europa.eu/project/id/764675

PROJECT WEBSITE
heattofuel.eu/

Molten salts improve transport biofuel production

An EU-funded project has developed a novel molten-salt-based process for obtaining sustainable biofuels from waste biomass that is cheaper and with higher yields.

Lignocellulose – a polymer containing cellulose, hemicellulose and lignin – is one of the most powerful weapons in our fight against climate change. Waste streams of lignocellulose are a by-product of various industrial sectors such as agriculture (corn stover, straw) and forestry (paper mill discards). Converting this raw material into energy, for example in the form of biofuels, helps reduce reliance on fossil fuels.

Overcoming the barriers to commercial use of biofuels

The ability to use lignocellulose as a raw material for advanced biofuel applications has been constrained by the conversion technology itself. Extracting sugars (simple monosaccharides) from lignocellulosic biomass and synthesising them into fuels is challenging as lignocellulose is designed by nature to resist breakdown. Economic technologies for this conversion are needed to boost biofuel uptake.

The EU-funded ABC-SALT project has found a more efficient method to deconstruct lignocellulosic biomass by treating the biomass with molten salts – salts that are solid at room temperature but enter the liquid phase at elevated temperatures.

"ABC-SALT demonstrated an innovative route to the production of sustainable middle distillates from biomass, leading to higher hydrocarbon yields," notes project coordinator Erik Heeres. "Biomass-derived fuels have been obtained using several lignocellulosic waste streams including lignin-rich ones. The use of such waste streams, which are abundantly available at low prices, will help overcome any feedstock limitations while keeping short supply chains." Middle distillates are important fuels in transport, both for road (diesel) and air transport (jet fuel).

ABC-SALT demonstrated an innovative route to the production of sustainable middle distillates from biomass, leading to higher hydrocarbon yields.

A promising path from biomass to middle distillates

The advanced thermochemical conversion process implemented by ABC-SALT involves the following fundamental steps. First, proper molten salts are used to dissolve biomass. Then, biomass is fed into a hydropyrolysis machine, where it is quickly heated without oxygen. A catalytic hydrodeoxygenation step helps remove the oxygen from the biomass streams after hydropyrolysis.

"Molten salts hold great potential for use as liquefiers since they maximise the liquid fraction in fast hydropyrolysis and act as catalysts. Besides their ability to easily dissolve biomass, the selected molten salts presented high heat capacity, thermal conductivity and low vapour pressure," explains Heeres.

Another challenge has been to select a molten salt with a melting point low enough to avoid producing ash or char but high enough to liquify biomass. Furthermore, high thermal stability played a critical role in preventing salt decomposition at high temperatures.

Samples of oils derived from lignin hydropyrolysis were successfully hydrotreated in batch and

continuous set-ups. High carbon yields were obtained (up to 90 %), while the majority of the hydrocarbon products fell into the middle distillate range.

Raising the maturity of the technology

The integrated concept was demonstrated at lab scale in a dedicated bench scale unit. This will serve as the prototype for a future fuel production system in an industrial environment, moving the technology beyond TRL 4.

"The scientific knowledge generated by ABC-SALT will allow key stakeholders in the biofuels arena (e.g. policymakers, regulatory authorities, industry) to frame strategic choices concerning future energy technologies and integrate them in the current and future energy systems. We are currently investigating the possibility to set up new projects based on the acquired knowledge and bring the technology to TRL 5-6," concludes Heeres.

PROJECT
ABC-SALT - Advanced Biomass Catalytic Conversion to Middle Distillates in Molten Salts

COORDINATED BY
University of Groningen, Netherlands

FUNDED UNDER
Horizon 2020-ENERGY

CORDIS FACTSHEET
cordis.europa.eu/project/id/764089

PROJECT WEBSITE
abc-salt.eu/

Synthetic kerosene from renewable sources could power the transition to zero-emission flying

Hydrogen and electric flight propulsion might not be the best bet to lower carbon emissions significantly for long-haul flight. Attempts to go green are getting a boost from an inconceivable place: carbon-neutral fuel pulled from thin air.

This alternative to fossil-derived jet fuel may seem far-fetched, but it is a concept that the EU-funded KEROGREEN project proved experimentally and partially at scale. "When using renewable energy and CO_2 from the atmosphere, we have a closed carbon loop for the production of hydrocarbon-based fuels. We can thereby continue using the existing storage and distribution infrastructure and, importantly, the same aircraft engine technology," notes project coordinator Adelbert Goede.

Synthetic jet fuels like kerosene, which can be used directly today's aircraft engines, can be formed from syngas, a mixture of carbon monoxide (CO) and hydrogen.

However, the goal of KEROGREEN has been to produce a green, carbon-neutral form of syngas that does not create additional carbon emissions. "This problem has been tackled by converting water and air (CO_2) into high-energy-density fuels powered by renewable electricity," highlights Goede.

An unconventional route to converting CO_2 into fuel

The idea of extracting CO_2 from the atmosphere and converting it into fuel is simple. At plasma conditions, CO_2 is efficiently split into CO and oxygen (O_2), the most energy-intensive step of the process. Mixed with water, syngas is formed via the well-known water-gas shift reaction and subsequently converted into liquid hydrocarbons (kerosene) via the well-established Fischer-Tropsch process.

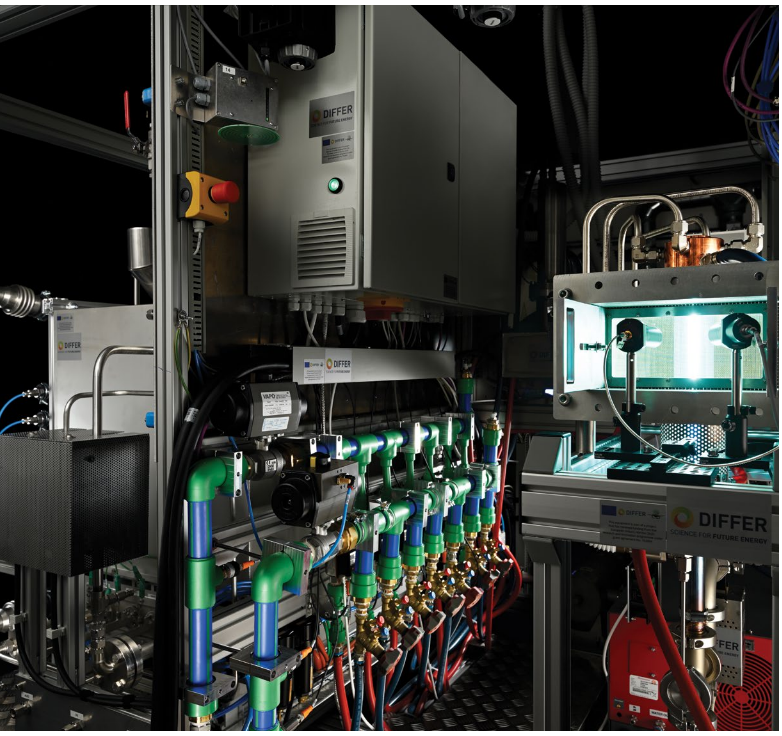
High-temperature electrolysis and plasmolysis are commonly used for CO_2 conversion. However, both methods present pros and cons when used separately.

For example, high-temperature electrolysis is highly energy efficient, directly separates CO and O_2 but relies on the use of scarce electrode materials that degrade with time. Conversely, plasmolysis uses more abundant electrode materials, instantly switches on and off, responding well to the intermittent nature of renewable electricity. However, it requires an additional step to separate O_2 from CO and CO_2.

When using renewable energy and CO_2 from the atmosphere, we have a closed carbon loop for the production of hydrocarbon-based fuels. We can thereby continue using the existing storage and distribution infrastructure and, importantly, the same aircraft engine technology.

KEROGREEN offers a sustainable route for CO production by combining these two methods. In this coupled process, the CO_2 plasmolysis gas mixture is supplied to a solid oxide electrolyser cell (SOEC) to separate the product gases. O_2 is transferred to one side of the SOEC, where it is removed. The remaining CO and CO_2 are transported to a chemical plant for liquid fuel synthesis.

Results show that the product stream of the coupled plasma-electrolysis process contains 91 % less O_2 and 138 % more CO than those supplied by plasmolysis alone. In addition, durability tests (~100 h) show better stability of the perovskite electrode material for the coupled process than for CO_2 electrolysis alone.



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Energy density plays an important role in determining the flight range. "Sustainable, high-energy-density fuels are crucial for long-haul flight. We deem that synthetic kerosene made from water and CO_2 with the help of renewable energy will be a more proper alternative for powering future aircraft. Hydrogen alone (even in its liquid form) is too bulky, and batteries add too much weight to aircraft," remarks Goede. Furthermore, synthetic green kerosene emits no sulfur and less soot, whilst nitrogen oxide emissions are minimised.

Ideal for decentralised systems relying on renewable energy

"KEROGREEN's innovative technology fitting into a shipping container is modular, scalable and well suited to small-scale distributed production plants sited in remote areas, for example, an off-shore wind park or a solar farm in the desert," states Goede.

All steps of CO_2 conversion via the plasma-electrolysis process have been demonstrated at TRL 3. Researchers will work to further scale the O_2 separator in a follow-up project.

PROJECT

KEROGREEN – Production of Sustainable aircraft grade Kerosene from water and air powered by Renewable Electricity, through the splitting of CO2, syngas formation and Fischer-Tropsch synthesis

COORDINATED BY

Foundation for Dutch Scientific Research Institutes, Netherlands

FUNDED UNDER

Horizon 2020-ENERGY

CORDIS FACTSHEET

cordis.europa.eu/project/id/763909

PROJECT WEBSITE

kerogreen.eu/

Advanced process makes biodiesel greener, cheaper and competitive

Four newly developed technologies enhance the efficiency and effectiveness of biodiesel production from waste biomass through a biomethanol route.

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The 2030 Climate Target Plan proposes to cut greenhouse gas (GHG) emissions by at least 55 % by 2030. This will greatly contribute to Europe's ambitious goal of becoming climate neutral by 2050.

Biomass grows by absorbing CO_2 from the atmosphere. It can be converted into biofuels that lower GHG emissions. Of all biofuels, biodiesel currently accounts for around 80 % of total green fuel production in the EU.

Sustainable alternative to fossil fuels

Nowadays, biomass is seldom used to produce biodiesel because the procedure is complex and costly. To be sustainable, biofuel production should be based on secondary biomass and waste streams. On that account, a solution is needed to efficiently produce methanol, which is a required intermediate step for producing green biodiesel. Advanced technologies can make the use of biomass in biodiesel production more competitive.

The EU-funded CONVERGE project validated a state-of-the-art process for green methanol production. "It is more efficient and less expensive than existing technology, giving it a competitive advantage over fossil fuels," explains project coordinator Giampaolo Manzolini, professor at Politecnico di Milano's Department of Energy. The number of operations needed to complete this conversion is also reduced.

Effective conversion of residual biomass into green methanol

This process takes advantage of breakthrough technologies that were developed and tested over hundreds of hours by the

CONVERGE team. Specifically, they designed four innovative components to convert secondary biomass into biodiesel. These components can be combined or implemented separately at a biodiesel facility.

First, a new type of catalyst converts condensable hydrocarbons collectively known as tar into high-value aromatic components such as benzene, toluene and xylene. After separation, these valuable products are available for use by the chemical industry.

The sorption-enhanced reforming combines methane recovery with CO_2 separation in a single technology. It enhances the conversion of methane and carbon monoxide into hydrogen and CO_2. The CO_2 is separated from the hydrogen. Only the CO_2 necessary for the methanol reaction is kept. The CO_2 can be stored or used for additional processes in the carbon capture, utilisation and storage industry.

The electrochemical hydrogen compressor pressurises and purifies hydrogen in a single unit. This reduces the steps required for pure hydrogen feed production and the energy consumption of traditional processes.

Lastly, the membrane reactor improves methanol production by removing the product from the reaction and pushing for a single-step conversion of the reactants. This reduces recirculation and off-gas management requirements.

By introducing CONVERGE's process and technological solutions in various procedures, industry stakeholders will be able to make their systems more efficient and less complex.

Most promising biomass supply chains

Project partners delivered a methodology to identify biomass supply chains for the four technological solutions. Case scenarios were applied to the Central European, Mediterranean, North Sea and Scandinavian regions. They identified five supply chain case scenarios and related business cases in 69 districts that have the most potential. In addition, the project team assessed the environmental impact of the entire process in these regions.

"By introducing CONVERGE's process and technological solutions in various procedures, industry stakeholders will be able to make their systems more efficient and less complex," concludes Manzolini. "The lower cost of biofuels, improved efficiency of renewable energy production and positive environmental impact of biofuels will be reflected on the final customer and society as a whole."

PROJECT
CONVERGE - CarbON Valorisation in Energy-efficient Green fuels

COORDINATED BY
The Polytechnic University of Milan, Italy

FUNDED UNDER
Horizon 2020-ENERGY

CORDIS FACTSHEET
cordis.europa.eu/project/id/818135

PROJECT WEBSITE
converge-h2020.eu/

Microorganisms transform waste gas into sustainable fuel

An innovative process based on microorganisms is set to help minimise greenhouse gas emissions from the steelmaking industry by turning waste streams into ethanol.

Greenhouse gas emissions from the industrial sector pose a significant burden on the atmosphere, contributing to the global carbon footprint. Efforts towards a circular use of carbon that doesn't produce any net addition of CO_2 to the atmosphere are urgently needed for climate change mitigation.

Fermentation of steelmaking waste gases

Steelmaking produces gas emissions rich in carbon monoxide (CO), carbon dioxide (CO_2) and hydrogen (H_2). The EU-funded STEELANOL project uses this gas mix as raw material for generating sustainable ethanol. Ethanol serves as an eco-friendly vehicle fuel and is also used in the chemical industry for the production of plastics.

The process is similar to making wine, where microbes convert sugar into ethanol, but in this case, the sugar is replaced by CO/CO_2 gas.

The STEELANOL innovative technology uses gas fermentation, whereby the generated industrial waste gas is sent to a bioreactor. The technology, developed by LanzaTech, uses a biocatalyst (microbes) to ferment the gases emitted from the steel plant and convert CO and CO_2 into ethanol with high productivity.

"The process is similar to making wine, where microbes convert sugar into ethanol, but in this case, the sugar is replaced by CO/CO_2 gas and the process is continuous, not batch-based," explains Wim Van der Stricht, project coordinator and ArcelorMittal CTO, lead on Carbon Capture and Utilisation technology.

Demonstration plant

The STEELANOL project has constructed Europe's first-ever commercial-scale production facility of sustainable ethanol from waste gases produced during the steelmaking process. In collaboration with the TORERO project, waste wood can serve as a feedstock for ethanol production by being first converted to bio-coal.

The demonstration plant has been commissioned and ethanol was first produced in June 2023. An industrial run for ethanol production was successfully performed at the end 2023. The ramp-up to full capacity is ongoing, where the plant is expected to produce around 80 million litres of ethanol per year by 2025.

Reducing waste streams from the steelmaking industry

According to Van der Stricht: "The most significant achievement of the project was the establishment of a creative pathway to produce sustainable fuels by introducing innovative technology and connecting several industries towards climate mitigation."

It must be noted that while other renewable sources, such as water and wind, can be used to create electricity, fuels require carbon and thus cannot be created without a carbon-rich source.

The consortium envisages further implementation of this technology in other steel plants and expansion of the output product ethanol to other chemicals and sectors.

Life cycle assessment studies indicate that the STEELANOL technology has the potential to cut greenhouse gas emissions by over 80 %. STEELANOL will produce 64 000 tonnes of ethanol per year which can be valorised as an alternative to gasoline, saving 135 000 tonnes per year of CO_2 emissions in the transport sector.

PROJECT

STEELANOL – Production of sustainable, advanced bio-ethANOL through an innovative gas-fermentation process using exhaust gases emitted in the STEEL industry

COORDINATED BY

ArcelorMittal in Belgium

FUNDED UNDER

Horizon 2020-ENERGY

CORDIS FACTSHEET

cordis.europa.eu/project/id/656437

PROJECT WEBSITE

steelanol.eu/en

Converting waste wood into biofuel from steelmaking

Predominantly used as a local fuel source, waste wood can now be exploited for biocoal and bioethanol production due to an innovative technology.

© ArcelorMittal Belgium N.V.

There is an urgent need to find green sources of energy and to reduce fossil fuel reliance. Waste wood, including demolition wood and waste furniture, is an untapped resource that could provide an alternative energy feedstock.

Production of biocoal from waste wood

The EU-funded [Torero](#) project introduces a novel concept of using waste wood products that cannot be recycled and would otherwise be incinerated. The technology, developed and adapted by consortium partner [TorrCoal](#), relies on [torrefaction](#) – a thermochemical process that takes place at high temperatures (up to 350 °C) but in the presence of low oxygen, thereby decreasing the water and volatile content from biomass.

"Torrefaction converts wood waste into biocoal, replacing fossil coal, which is one the main sources of greenhouse gas emissions in steel production," explains Wim Van der Stricht, project coordinator and ArcelorMittal CTO.

Torrefaction converts wood waste into biocoal, replacing fossil coal, which is one the main sources of greenhouse gas emissions in steel production.

The innovation behind Torero is that the generated biocoal can be utilised to replace the fossil fuel within the blast furnace in steelmaking industrial installations. The waste wood is collected, appropriately processed, and submitted to torrefaction before it is transported to the blast furnace instead of fossil coal.

In collaboration with the [STEELANOL](#) project, the waste gas emissions from the steelmaking plant, by incorporating biocoal in the blast furnace, can then be converted into bioethanol using a microbe-based fermentation process. Waste wood, in essence, therefore, generates a competitive input feedstock for the production of a biofuel, thus creating an additional value chain in the transport sector.

Torero pilot plant

"Torero is an add-on technology that can be used to upgrade existing facilities of the steel sector, an industry that is actively scouting for technological solutions to make its production processes more sustainable," emphasises Van der Stricht.

The pilot was commissioned at the end of 2023 and the first batches of biocoal have been produced from waste wood. Production will be ramped up to full capacity throughout the course of 2024 and is estimated to produce 37 500 tonnes of biocoal per reactor per year. Following plant and technological optimisation, this is expected to reach 50 000 tonnes per year by 2025, which translates into 150 000 tonnes less CO_2 released into the atmosphere per year via the replacement of fossil coal with biocoal in the steelmaking process. Moreover, the fermentation process of steelmaking waste gases will produce 80 million litres of biofuel, which will also contribute to the reduction of greenhouse gas emissions.

Towards climate neutrality

Torero has connected several sectors, including the steel industry, the waste wood chain and the recycling waste industry, in the production of renewable fuels through its innovative technology. The consortium further envisages implementing the technology in other steel plants and expanding the feedstock from waste wood to other types of biomass and waste.

Importantly, the Torero production process is compliant with the UN sustainability goals with respect to industrialisation and combating climate change. In addition, it can help reduce net greenhouse gas emissions and meet the European Commission targets for advanced biofuels in the transport sector. Through a circular economy approach, it has the potential to support climate neutrality.

PROJECT
Torero - TORrefying wood with Ethanol as a Renewable Output: large-scale demonstration

COORDINATED BY
ArcelorMittal, Belgium

FUNDED UNDER
Horizon 2020-ENERGY

CORDIS FACTSHEET
cordis.europa.eu/project/id/745810

PROJECT WEBSITE
torero.eu/

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PROJECTS INFO PACK ON INNOVATIVE BIOMETHANE FOR REPOWEREU

Europe’s energy security is under pressure from climate change, domestic and international energy policy, and conflict. Biomethane offers a reliable, drop-in fuel that can meet the energy needs of citizens. This CORDIS Projects Info Pack showcases 15 groundbreaking projects being carried out to grow Europe’s biomethane industry, cutting dependence on fossil fuel imports and helping to deliver on the EU’s ambitions for a competitive, low-carbon economy.

Check out the Pack here:
data.europa.eu/doi/10.2830/530396

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