

Overview

The iron and steel industry is responsible for around 7% of global energy-related CO₂ emissions, with blast furnaces contributing about 80% of primary production emissions. Direct Reduction of Iron (DRI) offers a more sustainable alternative, yet currently relies on methane reforming.

BioH₂Steel develops and demonstrates the integration of biomass/waste sorption-enhanced gasification (SEG) with the DRI process. The dual fluidized bed (DFB) oxy-SEG process converts biogenic residues (e.g., sewage sludge) into H₂-rich bio-syngas, targeting TRL 6/7. Complementary green H₂ from electrolysis and utilization of the separated CO₂ stream support a fully integrated decarbonization pathway.

Circular economy & resource efficiency

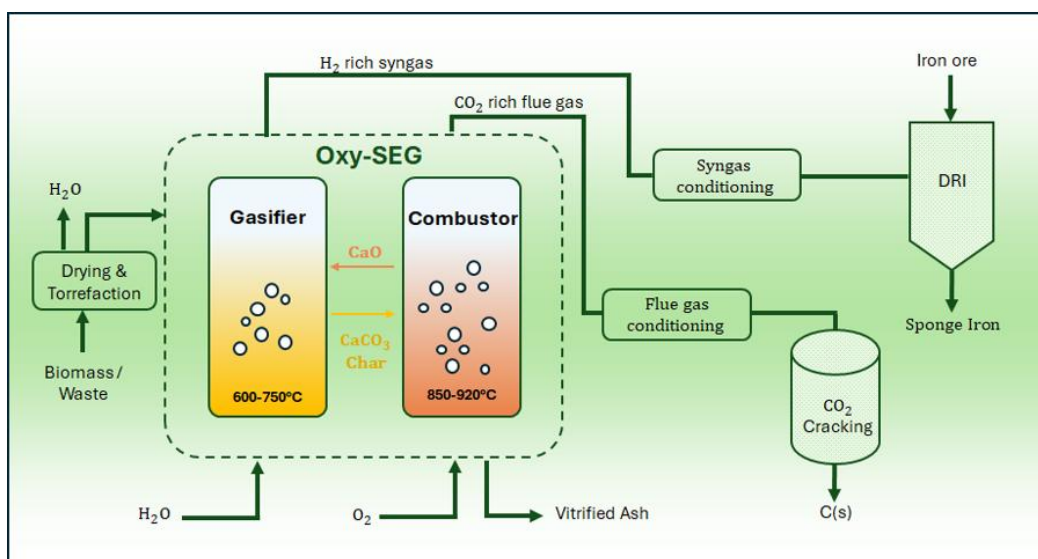
Residual waste streams are converted into H₂-rich bio-syngas. Deactivated CaO sorbent is reused as a fluxing agent in electric arc furnaces or cement production. Vitriified ashes are utilized in road construction and high-resistance composite materials.

Removing carbon emissions

Biogenic H₂-rich syngas replaces fossil reducing agents. Integrated CO₂ cracking produces solid carbon fines C(s) for use in steelmaking or the chemical industry, enabling negative-emission potential.

Technology status & goals

At the University of Stuttgart (IED), oxy-SEG has demonstrated H₂ concentrations of 60–70 vol.% and CO₂ flue-gas concentrations of 80–90 vol.% at TRL 6. The project now tackles remaining challenges - waste feedstock handling, high-ash operation, and bio-syngas impurities (tar, sulfur, chlorine, ammonia) - by combining oxy-SEG with plasma-supported reforming and electrochemical gas cleaning to meet DRI purity requirements.



Partners

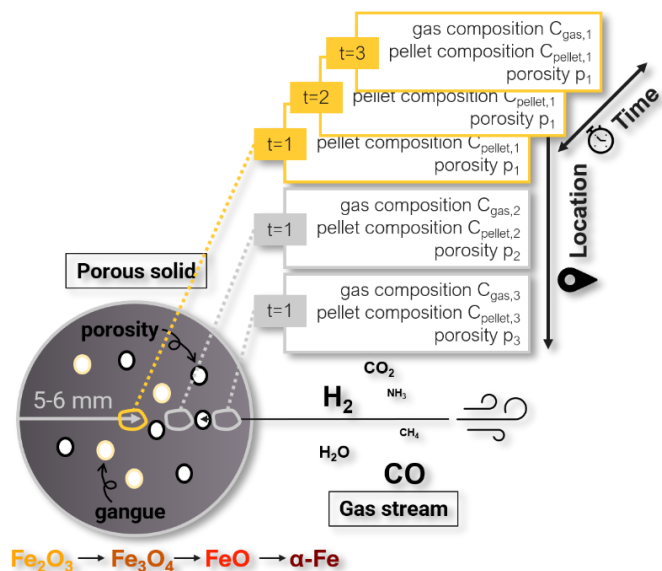
University of Stuttgart (USTUTT) – Institute for Energy Process Engineering and Dynamics in Energy Systems (IED)



USTUTT has considerable experience concerning the thermal utilization of gaseous, liquid and solid fuels (coal, biomass and alternative fuels) and excellent know how in designing and operating lab- and pilot scale test facilities for high temperature gasification and combustion processes. USTUTT will coordinate the project and lead the experimental investigation of the oxy-SEG for DRI process chain using both 20 kW and 200 kW DFB gasification facilities. The figure shows a part of USTUTT's TRL 6 test facility for the sorption enhanced gasification (SEG) process for the production of H₂-rich bio-syngas, which will be used in the direct reduction of iron (DRI).

GTT-Technologies

In BioH₂Steel, GTT is developing a thermodynamically consistent **kinetic model of a DRI shaft furnace** capable of simulating the reduction of iron oxide pellets with varying chemical compositions, pellet sizes, and initial porosities under mixed-gas atmospheres. The model accounts for bio-syngas with variable H₂/CO ratios, with and without impurities, while considering coupled heat and mass transport at process temperatures. The model is intended to enable the optimization of bio-syngas quality by evaluating the effects of different H₂/CO ratios and impurity levels on the reduction process.



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Cyclize GmbH

The company Cyclize developed a novel and patented plasma process to convert hydrocarbons into syngas with variable ratios. Within the EXIST-research-transfer funding by the German Federal Ministry for Economic Affairs and Climate Action the Cyclize GmbH was founded in 2023, with a substantial financing round in 2024 to scale from a pilot plant (TRL 5) to a demo plant in a chemical park (TRL 7) and cover development costs. Cyclize has a growing interdisciplinary team of experts to develop non-thermal plasma processes converting hydrocarbons into syngas, including plasma reactors, plasma drivers and plant constructions.

ArcelorMittal

As a world leader in steel production, ArcelorMittal operates Europe's only Direct Reduced Iron (DRI) plant in Hamburg, Germany, focusing on sustainability and low-emission technologies. In the BioH2Steel project, ArcelorMittal is involved in several key tasks, including material characterization, experimental testing of the oxy-SEG process, integration studies for the DRI furnace, and business case analysis for bio-syngas utilization. The project initiative is in line with the company's commitment to promote low-emission technologies and support the transition to a circular economy.

BEST – Bioenergy and Sustainable Technologies GmbH



At BEST the Area of Syngas Platform Technologies will, for the first time, perform SEG with their 1 MW_{th} gasifier at the Syngas Platform Vienna and investigate the effects on downstream gas cleaning. The Area Sustainable Supply and Value Cycles will conduct a Life Cycle Assessment (LCA)

and assess the socio-economic impacts. BEST will apply its expertise in results communication, dissemination and exploitation.



This research was funded by CET Partnership, the Clean Energy Transition Partnership under the 2025 joint call for research proposals, co-funded by the European Commission (GA N°101069750)



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Aichernig Engineering GmbH

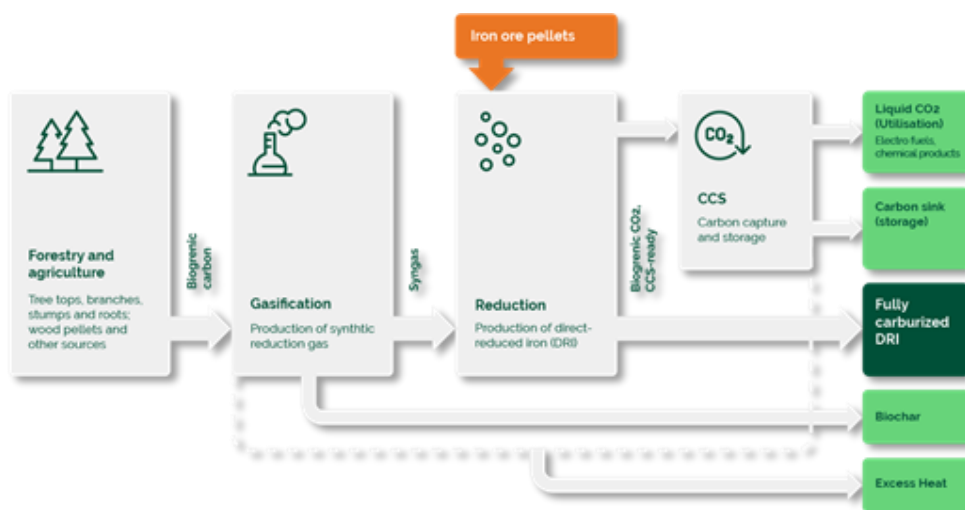
The highly specialized small engineering company focuses on planning bioenergy plants. It achieved a breakthrough in biomass gasification with the Biomass Gasification CHP Plant in Güssing, Austria, in 2001. The company is also involved in optimizing bioenergy processes, including synthetic natural gas, 2nd generation biofuels, green H₂, and mixed alcohols production via thermal gasification of biomass. Aichernig Engineering will mainly contribute its expertise in designing medium and large-scale industrial bioenergy plants to scaling-up concept and techno-economic analysis of bio-syngas and CO₂ utilization.

KTH Royal Institute of Technology – group of energy and furnace technology

The main focus of KTH in the project is catalytic cracking of biomass and bio-syngas, producing bio graphite and hard carbon from biomass for application in batteries, steelmaking plants and primary aluminium production. KTH has developed an e-reformer concept for cracking the gas. A preliminary test facility for catalytic cracking of CO₂ into solid carbon is available but needs further improvement and optimization. In the BioH2Steel project, KTH will work on the experimental study of CO₂ to solid carbon and assessing the application of carbon for battery and steel plant application.

FerroSilva AB

The company has been formed to commercialise the FerroSilva process. Within this process bio-syngas made from residual products from forestry and agriculture is used for DRI production. This enables a drastic reduction in greenhouse gas emissions. The FerroSilva process has the potential to turn the



steel industry into a carbon sink, in an economically justifiable way without the need for large investments in new electricity production.

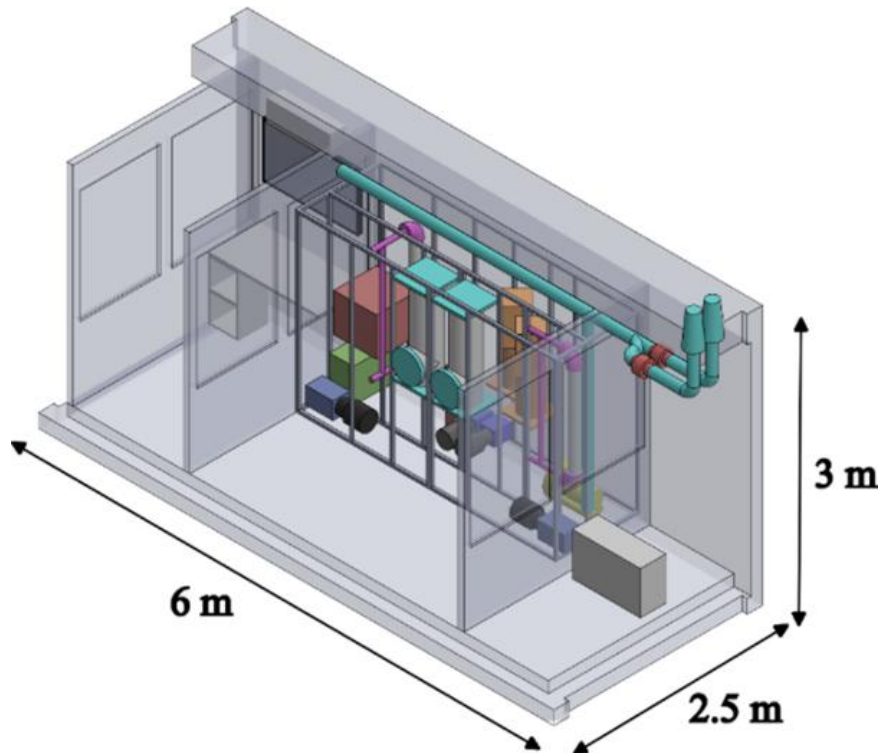


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Technical University of Denmark (DTU) – Department of Chemical and Biochemical Engineering

During the BioH₂Steel project, DTU's mobile electrochemical demonstration unit will be deployed to clean bio-syngas produced at the power plant operated by USTUTT. The technology uses electricity to remove sulfur compounds and other impurities from the bio-syngas, ensuring it meets the purity requirements for use in the BioH₂Steel DRI process. Unlike conventional gas-cleaning technologies, the electrochemical process achieves a high level of gas purification without consuming chemicals or generating toxic waste products.



Elplatek

Core business of Elplatek is electroplating on special equipment and on electrodes for H₂ production. Additionally, Elplatek has an ambitious plan for development of green energy business. This was the main driving force for EUDP funded projects for biogas upgradation (MeGa-StoRE), bio-gas to MeOH (BIO-ReFuel phase 1 and 2). Elplatek is specialized in development of technology, and in design and construction of modular containers for green processes. In this project, Elplatek will help DTU demonstrating the innovative e-cleaning process for gas impurity removal at USTUTT's pilot scale oxy-SEG facility.

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Wrocław University of Science and Technology (WUST)

WUST is represented by the Department of Energy Conversion Engineering, focusing on the characterization, torrefaction, combustion, and gasification of fuels. Main expertise of the team is in biomass and waste torrefaction (dry/wet HTC processes). The team also contributed to the “Negative CO₂ Emission Gas Power Plant” project, advancing plasma gasification and vitrification technologies. Two patents for biomass torrefaction and plasma processing are held by WUST.

WITI

Supervised by the Minister of National Defence of Poland, WITI is an independent R&D company, specializing in military and civil engineering for the Polish and EU markets. Its main activities include mine-barrier equipment, shelters, camouflage systems, and engineering machines, applying research to the needs of engineering forces. The institute’s experience in plasma technologies and project expertise will play a key role in utilizing vitrification products for fortification, diagnostics, and hazardous material disposal.

Metalerg Serwis

Metalerg Serwis Sp. z o.o. has over 12 years of experience in modernization, commissioning, and installation of biomass boilers, dryers and exhaust gas treatment equipment. Our experience is based on a qualified engineering and specialist staff. We have both the infrastructure and extensive technical resources necessary to complete a wide range of tasks. Existing torrefaction reactor installation to produce homogeneous material for gasification reactor will be demonstrated.

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