# Full-Chain Demonstration of Methanol Synthesis from Co-Gasification of Plastic Waste in a Pilot Scale HTW-Gasifier

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## Abstract

Reducing $CO_2$ emissions is one of the major challenges of our time. Polygeneration concepts based on gasification that utilize waste streams to generate valuable base chemicals and electricity on demand are very promising approaches to close the carbon cycle while also allowing to incorporate fluctuating power production from renewable sources.
Since 2015, numerous test campaigns for HTW gasification with different feedstocks have been successfully completed at the 500 $kW_{th}$ pilot scale gasifier of the Institute of Energy Systems and Technologies, TU Darmstadt. In 2020, the pilot plant was extended with a pilot scale gas treatment to convert the raw gas stream into a syngas for a lab scale synthesis test rig and to test different gas treatment equipment. In February and April 2021, the pilot plant with all new treatment units was successfully commissioned and the full process chain from the feedstock, comprising plastic waste and coal, to methanol derived from syngas was demonstrated.
In the pilot plant, the raw gas from the atmospheric gasifier is cooled down in a commercial type raw gas cooler. The subsequent gas treatment consists of an atmospheric and a pressurized section. Within the atmospheric section, entrained particles are filter from the gas stream with mineral fiber candles. A water scrubber and quench unit removes halides and other water-soluble contents. After compression, the COS and HCN is converted in a hydrolysis unit and then sent to an innovative BTX removal unit that utilized fatty acid methyl ester (i.e. biodiesel) as a solvent in two absorber columns. The first column uses a water-biodiesel-mixture for gas cooling. The second column removes BTX components from the gas stream. The last process unit within the gas treatment is an amine based acid gas removal. A partial stream is sent to a synthesis test rig, which was equipped with a methanol catalyst.
During first demonstration, stable operation was achieved in all units. The mineral fiber candles showed excellent particle retention with no notable slip. The innovative BTX removal achieved good performance. Especially, the decantation tank for separation of water and biodiesel worked as intended and a good demulgator was found. A significant amount of raw benzene could be extracted from the syngas stream. The acid gas removal worked as designed and reduced the $CO_2$ content to the desired 1.5 %. First tests for dynamic loading of the absorption system were conducted. Eventually, methanol was produced form the treated gas stream.
The gas treatment pilot plant will be used in further research projects. In the currently ongoing research projects VERENA, Lig2Liq, and CLARA the full scale demonstration for other feedstocks (biogenic residues, waste) and gasification technologies (dual fluidized bed and chemical looping gasification) will be conducted.