Carbon2Chem®

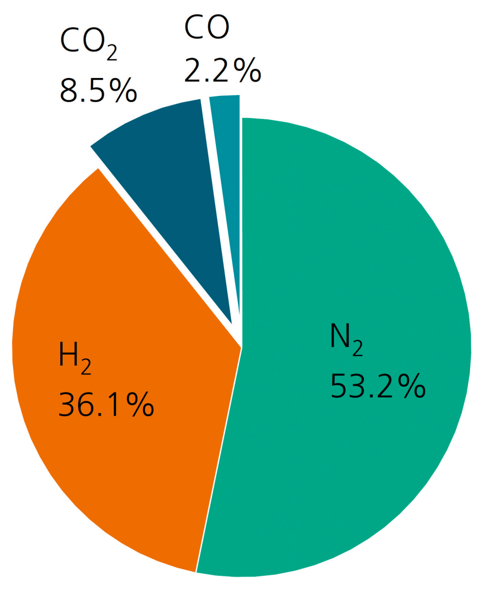
L-III | Recovery of Carbon-containing Gas Components from Purge Gas Streams

Fraunhofer Institute for Environmental, Safety and Energy Technology UMSICHT, Osterfelder Strasse 3, 46047 Oberhausen, Germany
Martin Peters, Phone +49 208 8598-1511, martin.peters@umsicht.fraunhofer.de

The reduction of carbon dioxide emissions from industrial sources is one objective of the Carbon2Chem® project. Beside the large emissions in steel mill gases, which are focussed in the project, also the innovative processes for steel mill gas utilization have smaller but significant emissions of carbon-containing gases. One example for emissions from the synthesis of value-added is the purge gas stream of a methanol plant utilizing blast furnace gas as a carbon source.

Purge gas composition of methanol synthesis from BFG

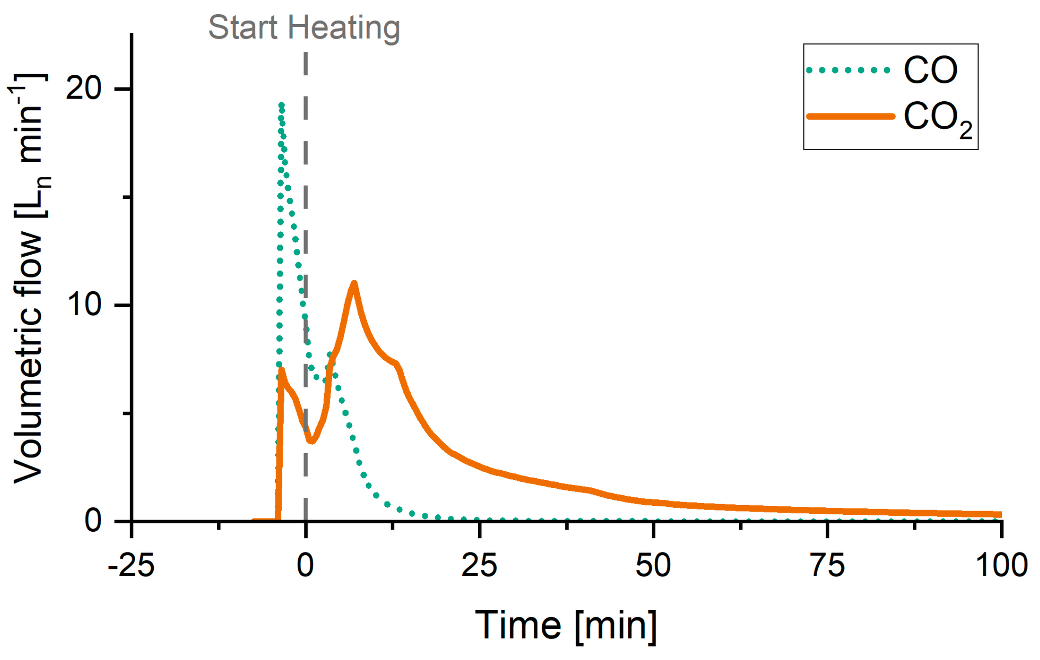
In the context of the Carbon2Chem® project BFG (blast furnace gas) has by far the largest Volume compared to coke oven (COG) and basic oxygen furnace gas (BOFG). Therefore, the utilization of BFG for producing value-added products like methanol, which is investigated in L-II, is a important scope of the project. The methanol synthesis has been investigated in a demonstration plant using synthetic gas mixtures to simulate composition of BFG at the Fraunhofer UMSICHT site. Currently the plant is fed with real BFG at thyssenkrupp site to demonstrate the technology.
One challenge with the utilization of BFG is the high concentration of nitrogen in the gas. Since the methanol synthesis uses gas recycling, the nitrogen must be purged to avoid accumulation and too high concentrations in the recycle stream. The purge gas composition has been measured and reveals that also significant amounts of hydrogen and carbon containing gases like carbon dioxide and monoxide will be released to tail gas treatment or even atmosphere.
From the points of efficiency and emission reduction the recovery of hydrogen and also carbon-containing gases can be a practical approach. The methanol synthesis as one exemplary technology brings useful requirements.



Volumetric concentration of major components in the purge gas stream from BFG methanol synthesis.

Recovery of carbon-containing components from purge gases with technology combination

The high reaction pressure of up to 60 bar_g enables the possibility of hydrogen recovery based on commercially available pressure swing adsorption (PSA) plants. The off-gas can also be utilized at elevated pressures. The residual mixture of N_2, CO and CO_2 can be separated by temperature swing. This enables the opportunity to keep the gases at pressures above methanol synthesis feed gas pressure. The Electric Swing Adsorption (ESA) technology is an efficient option to heat up the adsorbent and desorb N_2, CO and CO_2 subsequently based on their different adsorption isotherms.
One promising result was found during investigations of CO_2 adsorption from BOFG. Adsorption and desorption are carried out at equal pressure of 3.5 bar_a. For desorption, a purge gas flow of nitrogen was applied for analytical reason. The concentrations of the major components are different to the methanol synthesis purge gas.
Nevertheless, the diagram from ESA desorption measurements shows that for example CO can be well separated from CO_2. The adsorbed CO_2 is desorbed by heating up the fixed bed up to 150 °C while CO is purged out with the additional nitrogen.



Volumetric flows of carbon monoxide and dioxide during the ESA desorption at 150 °C and 5 L_n min^{-1} nitrogen purge.

A KEY BUILDING BLOCK FOR THE CLIMATE PROTECTION

SPONSORED BY THE
Federal Ministry of Education and Research

CO_2 reduction by cooperation of process industrial sectors