Improving the quality of producer gas is one of the major steps to be taken for integrating biomass gasification in the energy system and to allow the use of synthesis gas in the production of fossil–free biofuels and bio-chemicals. For this reason, it is important to develop effective and low-cost gas upgrading solutions, in particular to reduce the tar content of producer gas. Tar is mostly made up of aromatic substances and it is a problematic contaminant, as it forms deposits that may damage or compromise components. The use of residual gasification char for the removal of tar and upgrading of producer gas represents a convenient solution. Char is generated as a solid residue by gasifiers and it is an inexpensive waste material. In some cases, it features suitable properties to be used for adsorption and conversion of tar species. This study has focused on the residual char generated by TwoStage “Viking” gasifier at DTU, Risø Campus. The Viking char is known for being highly porous and thermally stable, therefore it is well suited to the task, even for high temperature applications.

This work was aimed at understanding and optimizing the use of char for the upgrading of producer gas. The main objective was to investigate the interaction between the surface of char and tar species, in order to design and operate a char-based gas cleaning unit for the upgrading of producer gas with a high tar load. As a first step, laboratory experiments were conducted with the purpose to compare the performance of residual gasification char with other chars and commercial active carbon. Experiments were designed to estimate the ability of small char beds at different temperature to remove aromatic compounds by adsorption or cracking.

Following positive experimental results, a char-based gas upgrading unit was designed and constructed. The unit combined a zone for partial oxidation, via sub-stoichiometric air injection, with a fixed bed of char. Residual char from the Viking gasifier was used. Producer gas with a high tar load was generated by the 100 kWth Low Temperature – Circulating Fluidized bed (LT-CFB) gasifier operated at DTU, Risø Campus. Gas and tar analysis up- and downstream of the unit revealed that, in presence of a char bed, tar conversion could be as high as 98%. At the same time, the product gas was enriched with H₂ generated by reforming reactions. Char itself participated in steam reforming reactions, but was consumed at a slow rate. The durability of the effect on the gas quality was demonstrated with a 5 hours long experiment, after which the gas upgrading unit was still working and delivering a clean producer gas. Detailed chemical and structural characterization of char samples revealed the interesting properties of the Viking residual char before and after being used as a substrate for gas cleaning and suggested possible end-life application such as biochar. The experimental activity produced valuable knowledge about the interaction between char and tar species and demonstrated the feasibility of achar-based solution for the upgrading of producer gas.