CO2 Capture Project®

ADVANCING CCS TECHNOLOGY DEPLOYMENT AND KNOWLEDGE FOR THE OIL AND GAS INDUSTRY

The CO_2 Capture Project (CCP) is focused on applications in refining operations, natural gas combined cycle (NGCC) power generation and natural gas extraction.

NOVEL CAPTURE TECHNOLOGY ASSESSMENTS

Following successful completion of Work Packages (WP) 1 and 2 with CCP partner Laboratorio Energia e Ambiente Piacenza, Milan, (LEAP), the theme of novel capture technology continues in WP3. LEAP is undertaking a methodology and delivering the results of a techno-economic assessment of 5 molal (5m) piperazine (PZ) as a new potential baseline solvent for carbon capture from NGCC and is based on the most recent findings from University of Texas at Austin research activities.

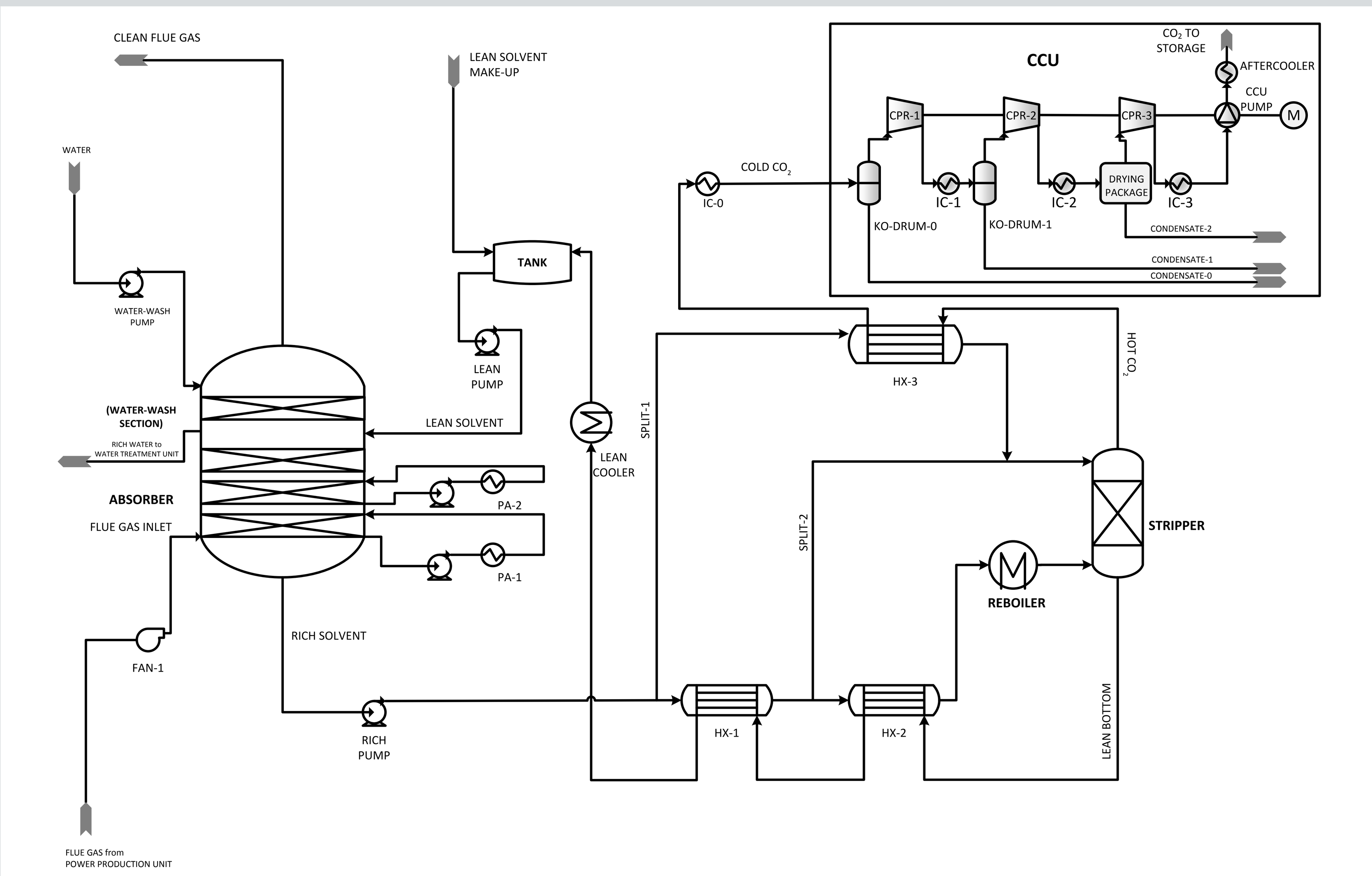


Fig. 1. Simplified process flow diagram (PFD) for the 5 molal piperazine process (courtesy: LEAP)

In this work, three different case studies have been considered relevant from a preliminary literature analysis. The three evaluated configurations are (i) conventional F-class NGCC coupled with the conventional absorber configuration with a direct contact cooler (DCC), (ii) conventional F-class NGCC coupled with an advanced absorber configuration (no DCC – flue gas cooling integrated within the absorber) and (iii) high efficiency, state-of-the-art H-class NGCC, coupled with the advanced absorber configuration. The process flow diagram for a single CCS train for configuration (i) is shown in Fig. 1. The full results from the work will be presented at GHGT-14 in the paper entitled 'Techno-economic assessment of novel vs. standard 5m piperazine CCS absorption processes for conventional and high-efficiency NGCC power plants'.

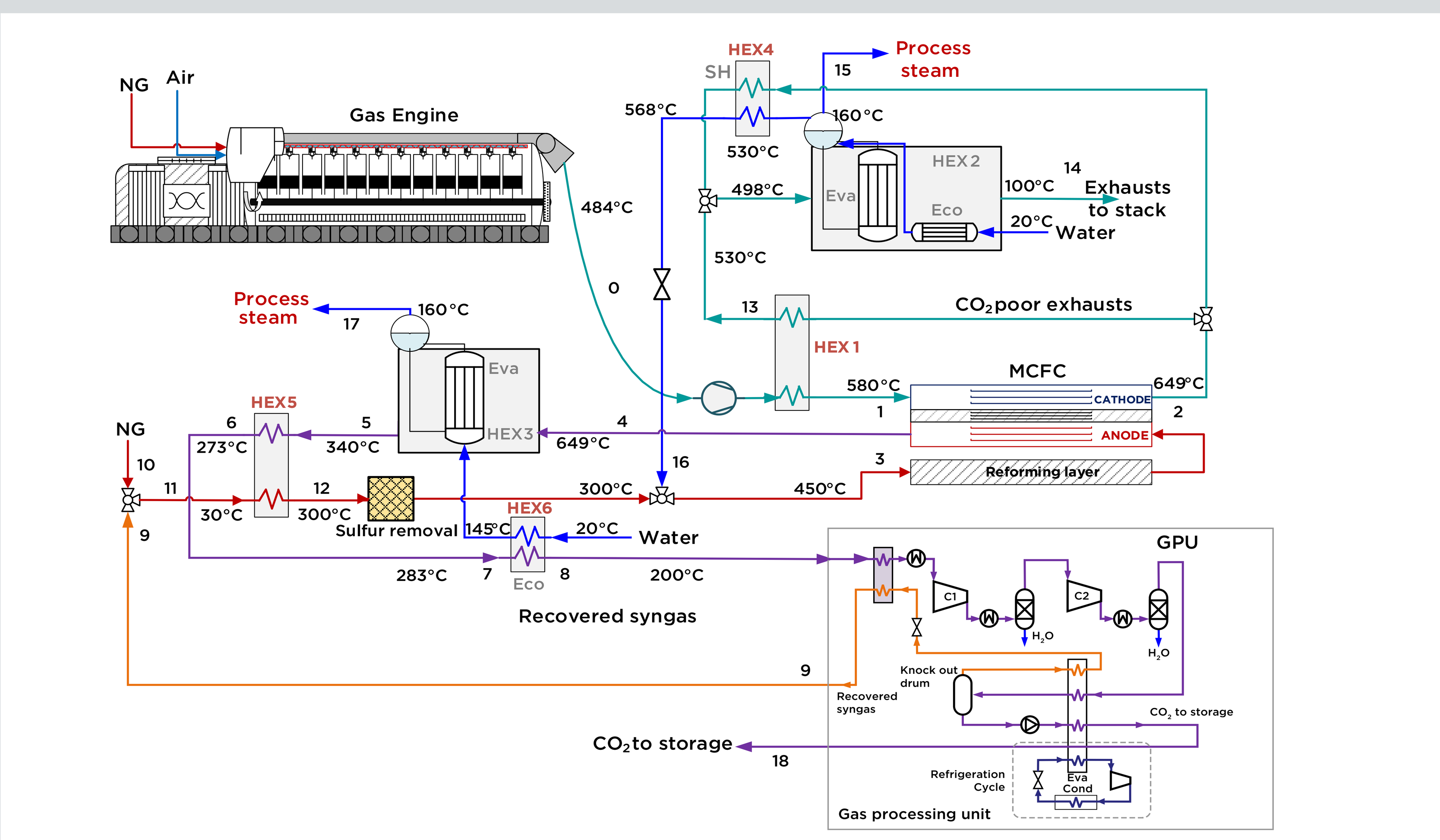


Fig. 2. Layout of the ICE+MCFC integrated option: Scheme A with unconverted fuel separation and recycle.

LEAP have also undertaken a techno-economic assessment of a molten carbonate fuel cell (MCFC) technology for capturing CO_2 from a group of reciprocating gas engines. In this configuration, the CO_2-rich effluents discharged by the Internal Combustion Engine (ICE) are sent to the MCFC working temperature (580 °C) in a regenerative heat exchanger, before entering the fuel cell cathode side. The hot side of this heat exchanger is fed with a fraction of the MCFC cathode outlet stream, from which most of the CO_2 is removed as a result of the cathode reaction (see stream 1 in Fig. 2.), which shows the migration of CO_3^{2-} ions across the cell electrolyte from the cathode to the anode. The results of this work will be published in due course.

The final piece of analysis to be undertaken in WP3 was an assessment of C-Capture solvent processes. A techno-economic assessment of this solvent based on the preliminary performance information available from laboratory tests indicated that the regeneration energy of the novel solvent was about 1.5 GJ/tonne CO_2, although additional electrical energy will be required in the regeneration process. The preliminary analysis indicated that the CO_2 avoided cost of the C-Capture process was lower than the MEA base used in WP1. The results of this work will be published in due course.

PILOT-SCALE TESTING OF PZ SOLVENT

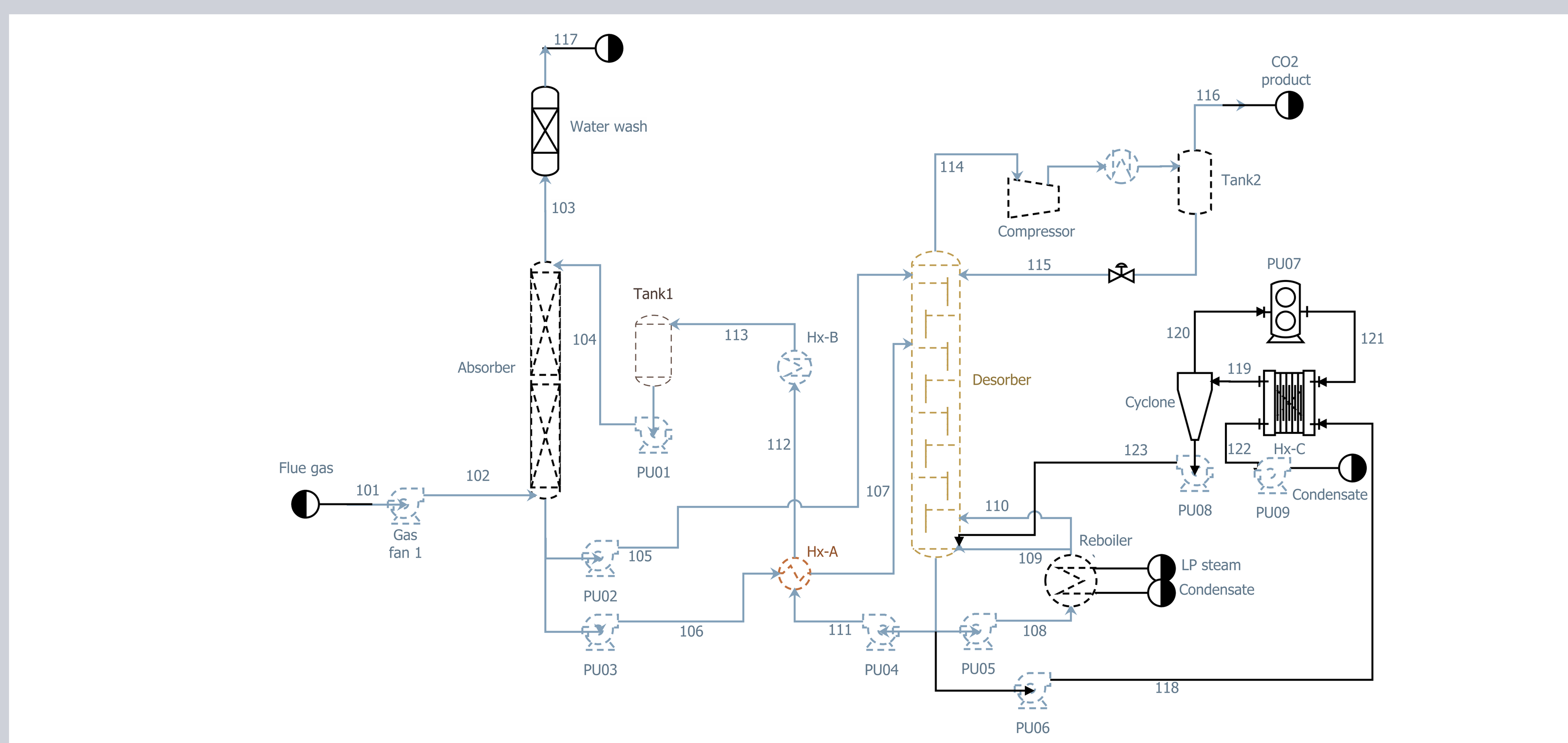
The CCP collaboration with University of Texas at Austin is aimed at demonstrating the application of an aqueous piperazine solution-a second-generation solvent-in a pilot plant. The goal is to test CO_2 separation from synthetic flue gas representative of the exhausts from natural gas-fired combined cycle power plant (i.e. ~4 mol% CO_2). The low CO_2 concentration in NGCC flue gas is considered to be a challenge for many capture technologies. This work tested the performance of 5m piperazine in the pilot plant (Fig. 3) at a range of operating conditions, including solvent loadings, gas and liquid flow rates, assessing two different absorber configurations.

Fig. 3. Pilot-scale testing site of the PZ solvent at the University of Texas, Austin

DEVELOPMENT OF NOVEL C-CAPTURE SOLVENT AND PILOT TESTING

CCP initially in participation with the UK Government-funded project under the Department for Business, Energy and Industrial Strategy (BEIS) Energy Entrepreneurs Fund Phase 5 (EEF5) with C-Capture Ltd. and SINTEF AS to develop and evaluate novel low-energy solvents for post-combustion CO_2 capture and latterly with additional funding through the Norwegian RD&D CCS programme (CLIMIT), and partners C-Capture Ltd. SINTEF AS and Biobe AS to undertake a pilot scale demonstration of a new generation transformational solvent technology for CO_2 capture from power plants and industrial processes ("CAPSIN") under Gassnova. Several solvent compositions will be prepared by varying the amounts of the capture agent, reactivity moderator and solubilizing agent. The goal is to evaluate the solvents at 1 kg/h scale and perform pilot tests of promising solvents at 0.2 tonne/day scale and ultimately, optimize and validate the process at 1 tonne/day scale. An example of a simplified process flow diagram for the C-Capture Process is shown in Fig. 4.

Fig.4. A simplified process flow diagram (PFD) for the C-Capture Process (C-Capture Ltd)



SORBENT-BASED CAPTURE USING NOVEL 3D-PRINTING

Partly funded by European Commission and the ERA-NET ACT Program, the objectives of the 3D-CAPS project are two-fold: first to achieve a 10-fold productivity increase (i.e., increasing flow and/or productivity of materials) for two sorbent-based technologies in CCS and secondly to optimize sorbent shapes with Computational Fluid Dynamics (CFD) and other modeling tools, with direct realization in 3D-printed objects for testing under relevant conditions. The scope of work includes manufacture of adsorbents and pre-pilot testing of CO_2 capture from post-combustion flue gas and pre-combustion syngas conditions. This will be carried out at medium temperature (300-500°C) for pre-combustion conditions using the Pressure Swing Adsorption (PSA) technology employing alkali-promoted hydrotalcite adsorbents, and at low temperature (40-130°C) for post-combustion conditions using temperature swing (TSA) technology employing amine-functionalized silicas and immobilized amine adsorbents. This will be followed by optimization of structure configuration and processes through modeling. Other partners in the project include TNO, SINTEF, Aker Solutions, 3D-Cat and UBB.

The ACT 3D-CAPS project # 271503 has received funding from RVO (NL), RCN (NO), UEFISCDI (RO), and is co-funded by the CO_2 Capture Project (CCP) and the European Commission under the Horizon 2020 programme ACT, Grant Agreement No 691712.

PARTICIPANT ORGANIZATIONS

The CCP is a group of major energy companies working together to advance the technologies that will underpin the deployment of industrial-scale CO_2 capture and storage.

For further information on CCP and its projects, visit www.co2captureproject.org