IEAGHG 8th Post Combustion Capture Conference

16th to 18th September 2025 Marseille, France

DMX™ Demonstrator: Reliability Analysis of Experimental Data

David Albarracin-Zaidiza[a], Vincent Carlier[a],Céline Bertino-Ghera[a], Martin Pfeiffer[b],
Maxime Caillot[b], Hugo Vandezande[c], Stephane Jouenne[d] *

[a]IFP Energies Nouvelles, Rond-point de l'échangeur de Solaize, BP3, F-69360 Solaize, France
[b]AXENS 89, boulevard Franklin Roosevelt F-92500 Rueil-Malmaison, France
[c]ArcelorMittal France , 3031 rue du Comte Jean, F-59381 Dunkerque, France
[d]TotalEnergies, CSTJF EB 437Avenue Larribau 64018 Pau Cedex, France

Abstract

Over the past two decades, carbon capture by amine scrubbing has been extensively developed for sectors with large, fixed CO_2 emissions owing to its robustness and compatibility with the CO_2 value chain (capture-transport-storage). Reducing energy penalties, as well as limiting solvent emissions and degradation, remain among the most significant challenges for developers aiming to industrialize this technology. Demonstrators large enough to be representative for scaling-up and treating actual gases to evaluate the solvent stability over time, are an essential tool for validating improvements in these areas. However, with increased complexity comes a proliferation of uncertainties, which can hinder progress. Consequently, the operation and analysis of demonstrator results must prove that uncertainties are smaller than the improvements they claim to achieve. Despite this, uncertainties are rarely presented or discussed in detail, with error bars often omitted. This study aims to address this gap by presenting our approach to managing uncertainties, based on the last 2500 hours of operation of the DMX™ demonstrator in ArcelorMittal, Dunkirk, France.

The DMX™ process involves a solvent that exhibits liquid-liquid separation (i.e. demixion) of its organic compounds under temperature, offering low regeneration energy and high CO_2 absorption capacity. In addition, since the regeneration of the solvent can be performed at a relatively high temperature (130-160°C), the DMX™ process produces a high purity and relatively high-pressure CO_2 effluent (2-5 barg). These characteristics have the potential to bring about significant energy and investment cost savings [1, 2, 3].

Since September 2022, the DMX™ process developed by IFPEN has reached a significant milestone with the operation of its 0.5 ton/h CO_2 capture capacity demonstrator. This facility was located at the ArcelorMittal France (AMF) site in Dunkirk (France) and was connected to the blast furnace gas network [4]. During the last 2500 hours of operation in 2024, about 90 parametric tests (in steady state) were performed in this demonstrator. The experimental plan of these tests is illustrated in Figure 1. The CO_2 compositions in raw gas for Power Station and Waste-to-Energy applications ranged between 8 to 14 %vol, significantly lower than the 22 %vol observed in the Blast Furnace application. Consequently, the unit had to operate at nearly half of its designed capture capacity for these applications

---

* Corresponding author. Tel.: +33 4 37 70 33 40, *E-mail address:* david.albarracin-zaidiza@ifpen.fr

by using recycle lines to dilute inlet CO_2 concentration to lower levels.

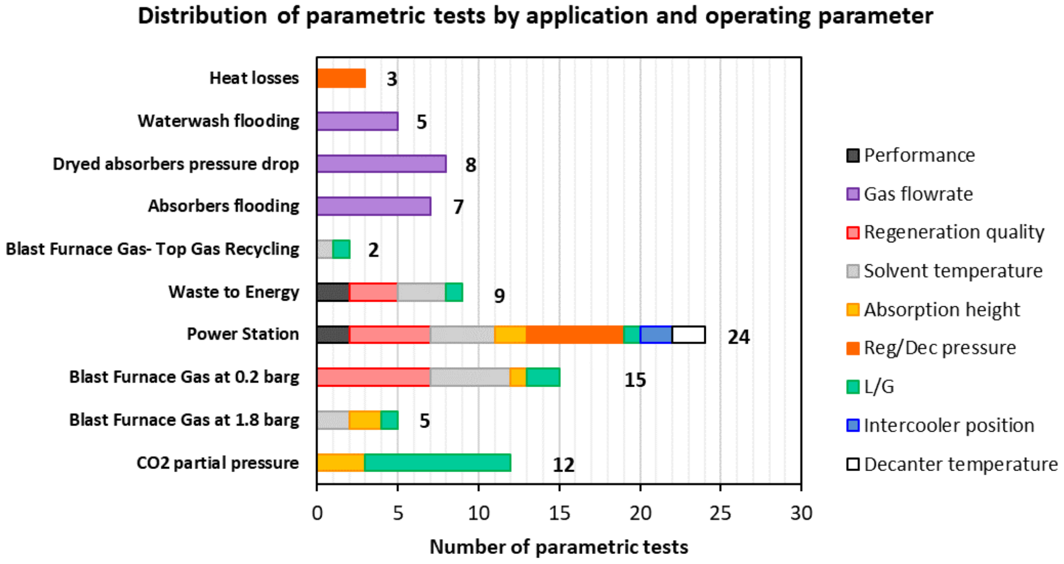

Figure 1 Experimental plan for the last 2500 hours of operation of the 3D demonstrator

Energy penalty involves two kinds of quantifications: mass of CO_2 captured and energy input of the system. To assess its uncertainty, we have quantified the uncertainties of both mass and heat balances as follows:

- Three primary contributors to mass balance errors have been identified: 1) the inherent uncertainty of the instrument (typically around 10% of full scale), 2) the variability of the measurement during steady-state operation (often 2-3 times standard deviation) and 3) discrepancies between different measurement strategies (gas flowmeters around absorption or regeneration, solvent mass intake, … required to compute mass-balances). The CO_2 mass balance uncertainties obtained for the parametric tests are illustrated in Figure 2a as functions of the unit capacity. The observed trend of increasing uncertainty with decreasing unit capacity is primarily attributed to CO_2 gas flowrate measurements falling below 10 % of full scale. Parametric tests with CO_2 mass balance uncertainties exceeding 10% require careful analysis. However, the overall quality of operation is demonstrated by an average mass balance error of approximately 6 %. These values were calculated considering only the third contribution, as the authors believe it to be the most significant.
- For thermal balance errors, two additional factors have been considered: 1) mass balance errors affecting enthalpy balances and 2) thermal losses from the facility to the environment. The first factor was assessed by reconciling the measured mass balances through a degrees-of-freedom analysis. Thermal losses were quantified during a specific campaign using demineralized water to eliminate uncertainties related to the solvent's thermodynamic model. The contributions of these factors are depicted in Figure 2b as a function of the unit capacity. Heat balance uncertainty is predominantly influenced by thermal losses rather than mass balance errors. Accounting for thermal losses reduces heat balance uncertainty from 18 % to 2 % overall. Thermal losses measured at the 3D demonstrator range from 30-50 kW, depending on weather conditions, and are comparable to those observed in similar pilot facilities (10-40 kW, PZAS at NCCC [5]).

The impact of mass and thermal balance uncertainties on several key parameters of the DMX™ process—such as CO_2 capture ratio, L/G (liquid-to-gas ratio), and decanter performance—will be analysed and compared to predictions from in-house simulators. This comparison serves to validate the quality of the process's scale-up.

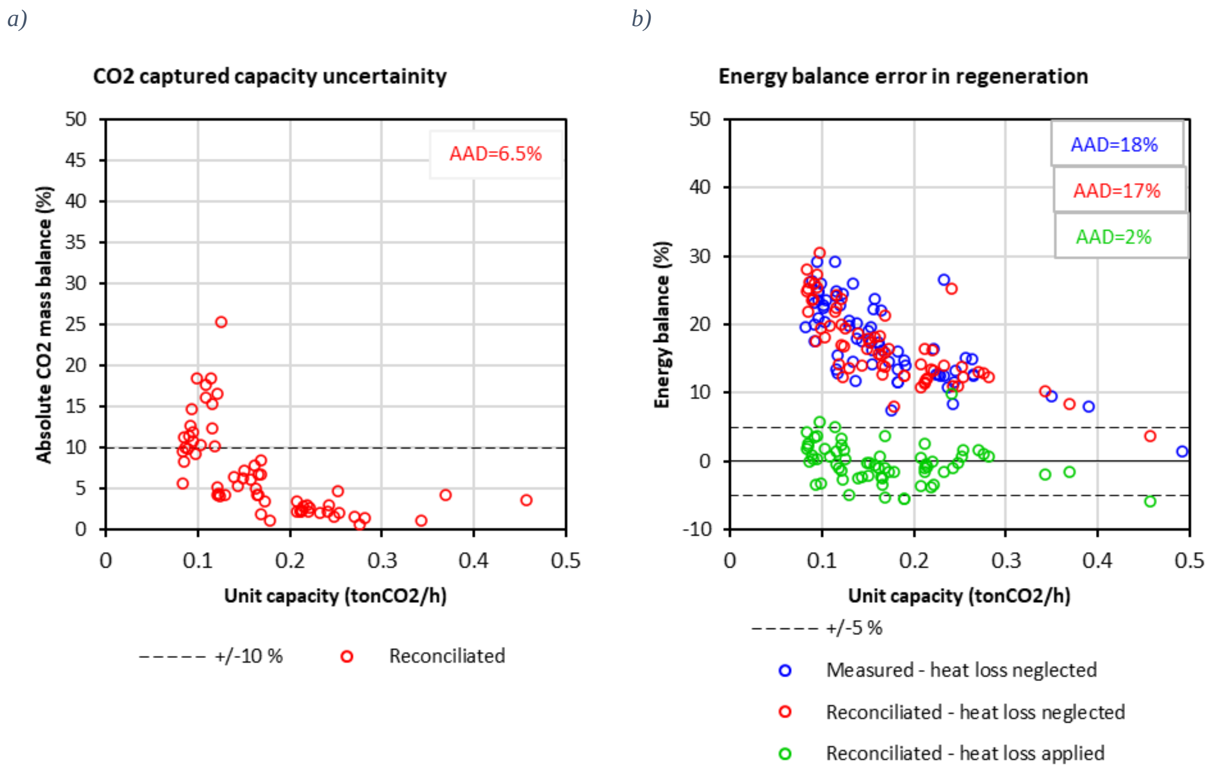

Figure 2 Mass and heat uncertainties as function of the operating capacity for the last 3000 hours of operation of the 3D demonstrator: a) CO_2 overall mass balance b) Energy balance around regenerator. AAD: Absolute Average Deviation

Keywords: Post-combustion Capture; Chemical Absorption; Demixing Solvent; Pilot Plant Demonstrator; Industrial Gases; DMX process

---

Bibliography

[1] P. Broutin , P. Briot, S. Ehlers and A. Kather, “Benchmarking of the DMXTM CO2 Capture Process,” *Energy Procedia,* vol. 114, pp. 2561-72, 2027.

[2] L. Raynal, P.-A. Bouillon, A. Gomez and P. Broutin, “From MEA to demixing solvents and future steps, a roadmap for lowering the cost of post-combustion carbon capture,” *Chemical Engineering Journal,* no. 171, p. 742–52, 2011.

[3] M. Dreillard, P. Broutin, P. Briot, T. Huard and A. Lettat, “Application of the DMXTM CO2 Capture Process in Steel Industry,” *Energy Procedia,* vol. 114, p. 2573–89, 2017.

[4] D. Albarracin-Zaidiza, V. Carlier, P. Bachaud, C. Salais, B. Petetin and M. Lacroix, “DMX demonstrator for CO2 capture: pilot unit presentation,” *SSRN Journal,* 2023.

[5] A. Suresh Babu and G. T. Rochelle, “Energy use of piperazine with the advanced stripper from pilot plant testing,” *International Journal of Greenhouse Gas Control,* p. 103531, 2022.