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Assessment of the CESAR1 solvent for full-scale deployment

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Abstract

Rapid upscaling and deployment of more cost-efficient and sustainable carbon capture solutions is needed to reduce the emissions of CO_2-intensive industries. Solvent-based carbon capture is an important technology that can be readily adopted to many emission sources. Such technology can achieve high capture rates and deliver CO_2 at high purity with a relatively low energy demand. In the AURORA project, the open and non-proprietary CESAR1 solvent technology is optimised and qualified for commercial deployment. To achieve these goals, a structured methodology for technology qualification and benchmarking was developed. This methodology (1) allows for a fair comparison between the CESAR1 solvent-based technology and the current benchmark, which relies on 30 wt% aqueous monoethanolamine (MEA) as its chemical scrubbing agent, and (2) supports risk mitigation for the deployment of large-scale carbon capture projects with the CESAR1 solvent applied to different scenarios and end-users[1]. An important part of the qualification is to validate the solvent performance for a broad range of flue gas conditions (CO_2 concentration, water content, flue-gas flowrate, temperature). In the AURORA consortium there are four end-users representing three different industrial sectors (oil refining by TotalEnergies and Motor Oil Hellas, cement by Heracles, and materials recycling by Umicore), while five different cases are defined for full-scale deployment at these end-user sites.

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The focus here is benchmarking of the CESAR1 solvent for the five cases regarding energy performance, taking into consideration heat integration options using absorber inter-cooling and various heat-pump solutions. In Table 1, the information about the flue gas conditions is given. Case 1 is a non-ferrous metals recycling plant in Belgium owned by Umicore, Case 2 is a refinery in Greece owned by Motor Oil Hellas, Case 3 is a cement plant in Greece owned by Heracles while the two last cases represent two different flue gases from a refinery in Belgium owned by TotalEnergies. Note that Case 1 is a batchwise process, with a flue gas flow rate fluctuating between zero and the value shown in Table 1. The flue gas is also dry, hence requiring the addition of water in the Direct Contact cooler for reaching saturation at 35°C prior to the absorber. It should also be noted that there are actually two modes of operation for the cement plant (Case 3).

Table 1: Flue gas conditions for different end-user cases

	Case 1	**Case 2**	**Case 3***	**Case 4**	**Case 5**
CO_2 flue gas concentration [vol.%]	23.7	16.22	10.7(17.1*)	9.4	16.9
H_2O flue gas concentration [vol.%]	0	18.91	10.8 (10.1*)	4.7	5.1
N_2 flue gas concentration [vol.%]	64.4	62.72	65.6(63.4*)	83.0	75.5
O_2 flue gas concentration [vol.%]	11.9	2.15	12.9 (9.4*)	2.8	2.3
Flue gas flow rate [kg/h]	114191	265000	1086 000 (837 000*)	410620.1	382729.5
Flue gas temperature [◦C]	65	197	100 (115*)	35	35
Flue gas pressure [bar]	1.01	1	1.01	1.1	1.1

*Values for “Direct mode” of the cement plant

Within the AURORA project, the process models for the CESAR1 solvent system have been improved and implemented in Aspen Plus [2] and CO2SIM (SINTEF’s inhouse simulator). While Case 1 and 3 are simulated using CO2SIM, the three other cases are simulated using Aspen Plus. A capture rate of 95% has been used for all cases. A base case without heat integration is established for all cases before further optimisation. In Figures 1-5, the U-curves for the 5 cases are shown for these base cases. As seen on the graphs, the minimum SRD for each case ranges from 2.7 MJ/kg CO_2 captured for the flue gas with the highest CO_2 concentration (Case 1) to 3.0 MJ/kg for the two cases with the lowest CO_2 concentration (Cases 3 and 4).

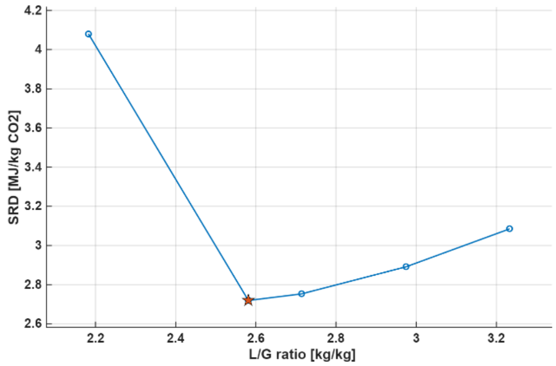

Figure 1: U-curve for case 1 (Materials recycling, Umicore)

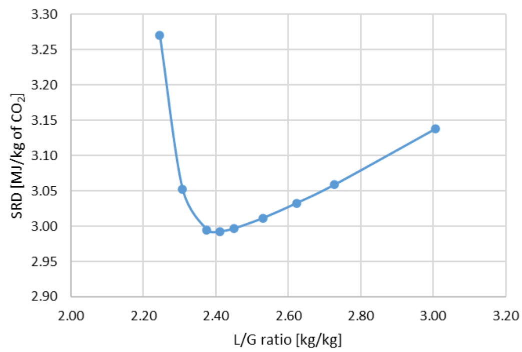

Figure 2: U-curve for case 2 (Refinery 1, Motor Oil Hellas)

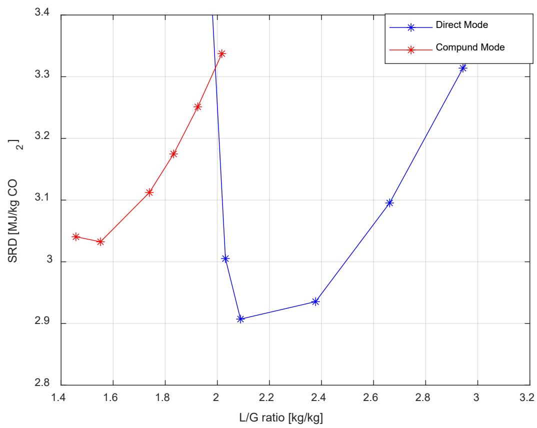

Figure 3: U-curve for case 3 (cement plant with two operation modes, Heracles)

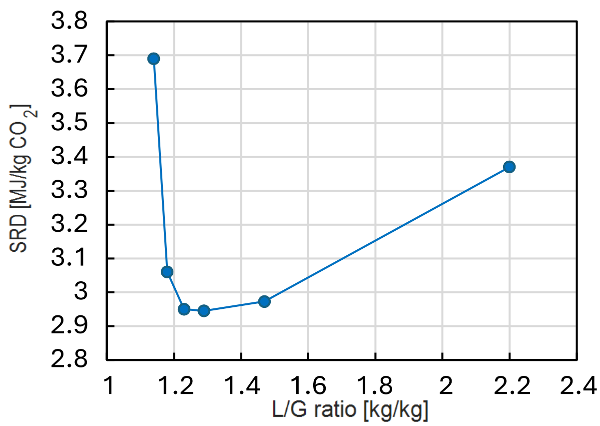

Figure 4: U-curve for case 4 (Refinery 2, process 1)

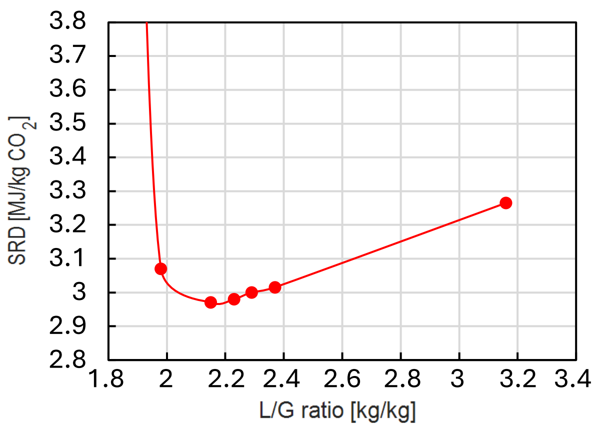

Figure 5: U-curve for case 5 (Refinery 2, process 2)

For each of the various heat integration options, a full techno-economic assessment is conducted for further optimisation. The final results of this optimisation for all cases will be presented in the full paper and at the conference.

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References

1. Wanderley, R., Berget, K., Kvamsdal, H., Buvik, V., Knuutila, H., Gjertsen, F., Putta, K.R., and Jouenne, S., Deliverable D4.1 Methodology for large-scale assessment and benchmarking, https://aurora-heu.eu/results/#deliverables, 2024
2. Morlando,D., ZhangY., Wang, S. and Knuutila, HK., Development of a Validated Rate-Based Model for CO_2 Absorption in Aqueous 2-Amino-2-methyl-1-propanol and Piperazine Blends Using Aspen PlusEnergy & Fuels 2025 39 (40), 19350-19367, DOI: 10.1021/acs.energyfuels.5c03281

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