CEMCAP

CEMCAP is a Horizon 2020 project with the objective to prepare the grounds for cost- and resource-effective CCS in European cement industry.

Simon Roussanaly, Chao Fu, Mari Voldsund, Rahul Anantharaman

SINTEF Energy Research, Trondheim, Norway

Maurizio Spinelli, Matteo Romano

Politecnico di Milano, Milano, Italy

Contact:
Simon.Roussanaly@sintef.no

www.sintef.no/cemcap
Twitter: @CEMCAP_CO2

This project is funded by the European Union's Horizon 2020 Framework Programme for research and innovation

Techno-economic analysis of MEA CO_2 capture from a cement kiln – impact of steam supply scenario

Introduction

For CO_2 capture by amines, steam is required for solvent regeneration. When CO_2 capture by amines is applied to power plants, steam can be extracted at the plant, while this is not the case at cement plants. In this work we investigate the impact of steam supply scenario on cost of MEA CO_2 capture in a cement plant.

Reference cement plant

The cement plant studied is the reference cement plant in the CEMCAP project. This is a Best Available Technique plant producing 1 Mt clinker (1.36 Mt cement) per year. Direct CO_2 emissions are 622 kg/ton cement and indirect emissions are 30 kg/ton cement.

Figure 1. Flowsheet of reference cement burning line.

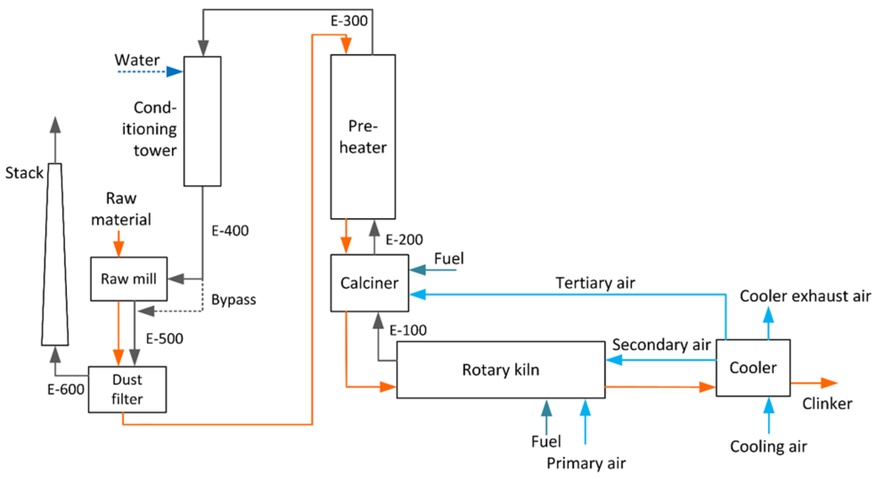


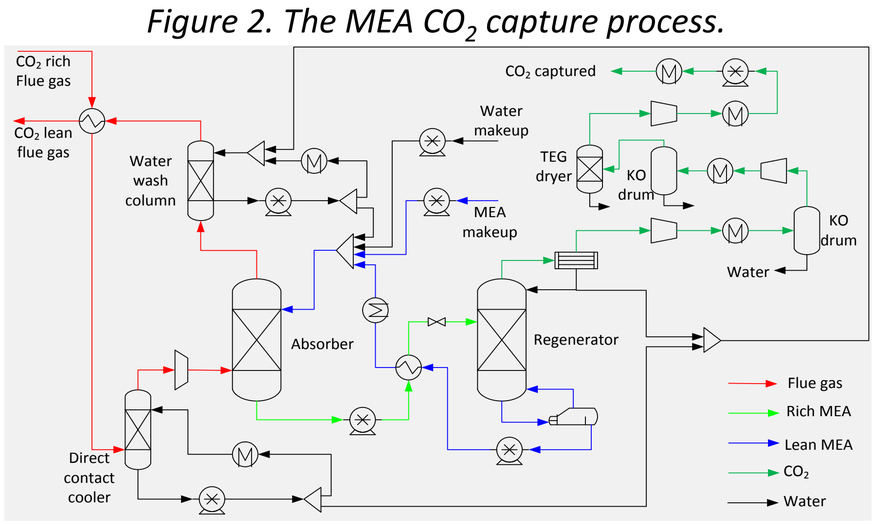
Table 1. Flue gas conditions at stack.

Parameter	First ½ year	Second ½ year
Total flow rate [kg/h]	318,192	388,098
Temperature [°C]	130	110
Gas phase composition, wet basis [vol%]		
CO_2	22	18
N_2	60	63
O_2	7	10
H_2O	11	9

Modelling of CO_2 capture system

The MEA system (Figure 2) was modelled with Aspen HYSYS V8.8, with the Acid Gas and SRK property packages. Column sizing was performed with SULCOL V3.2.20.

Figure 2. The MEA CO_2 capture process.



Cost of cement, CO_2 captured and CO_2 avoided

Cost of cement without and with CO_2 capture is given in Table 2. For the case with CO_2 capture cost of steam make up 1/3 of variable opex. Cost and climate impact of steam vary significantly between different steam sources and electricity prices (Table 3). The impact of steam supply scenario (Table 4) can be seen in Figure 3.

Table 2. Cost of cement.

Cost of cement [€/t_{cement}]	Without CO_2 capture	With CO_2 capture (base case)
CO_2 capture rate	0	0.90
Raw meal	3.68	3.68
Fuel	6.92	9.92
Electricity	5.64	9.69
Steam	0	14.19
Cooing water	0	0.65
Other variable costs	0.80	2.32
Variable OPEX	**17.03**	**37.44**
Operative, administrative and support labor	6.40	9.03
Insurance and local taxes	3.08	4.72
Maintenance cost (incl maintenance labor)	3.85	5.90
Fixed OPEX	**13.33**	**19.64**
CAPEX	**14.99**	**23.60**
Cost of cement	45.3	80.7
CO_2 captured cost [€/$t_{CO2,captured}$]	-	63.2
CO_2 avoided cost [€/$t_{CO2,avoided}$]	-	83.2

Table 3. Cost of steam.

Steam source	Cost [€/MWh_{th}]	Climate impact [kg_{CO2}/MWh_{th}]
Waste heat available on the plant	7	0
Natural gas boiler	25	205
External coal power plant, el. cost 58 €/MWh	13.5	178
External coal power plant, el. cost 80 €/MWh	18.5	178
Natural gas CHP, el. cost 58 €/MWh	27.5	205
Natural gas CHP, el. cost 80 €/MWh	3.5	205

Figure 3. Cost depending on steam supply.

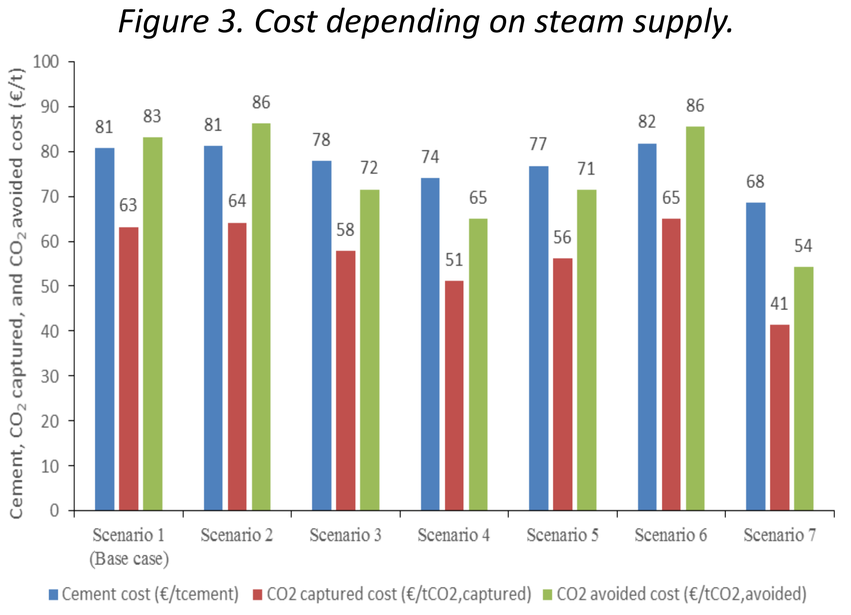


Table 4. Steam supply scenarios.

Scenario	Steam supply
Scenario 1 (base case)	Natural Gas boiler and 7% from waste heat recovery
Scenario 2	Natural Gas boiler and 0% from waste heat recovery
Scenario 3	Natural Gas boiler and 30% from waste heat recovery
Scenario 4	Extracted prior of LP Steam turbine [11] (electricity price 58 €/MWh) and 7% from waste heat recovery
Scenario 5	Extracted prior of LP Steam turbine (electricity price 80 €/MWh) and 7% from waste heat recovery
Scenario 6	Natural gas CHP plant (electricity price 58 €/MWh) and 7% from waste heat recovery
Scenario 7	Natural gas CHP plant (electricity price 80 €/MWh) and 7% from waste heat recovery

Conclusion

Cost of CO_2 capture at a cement plant is highly dependent on the steam supply and electricity cost. CO_2 avoided cost can decrease by up to 35% compared to the base case depending on steam supply and electricity price