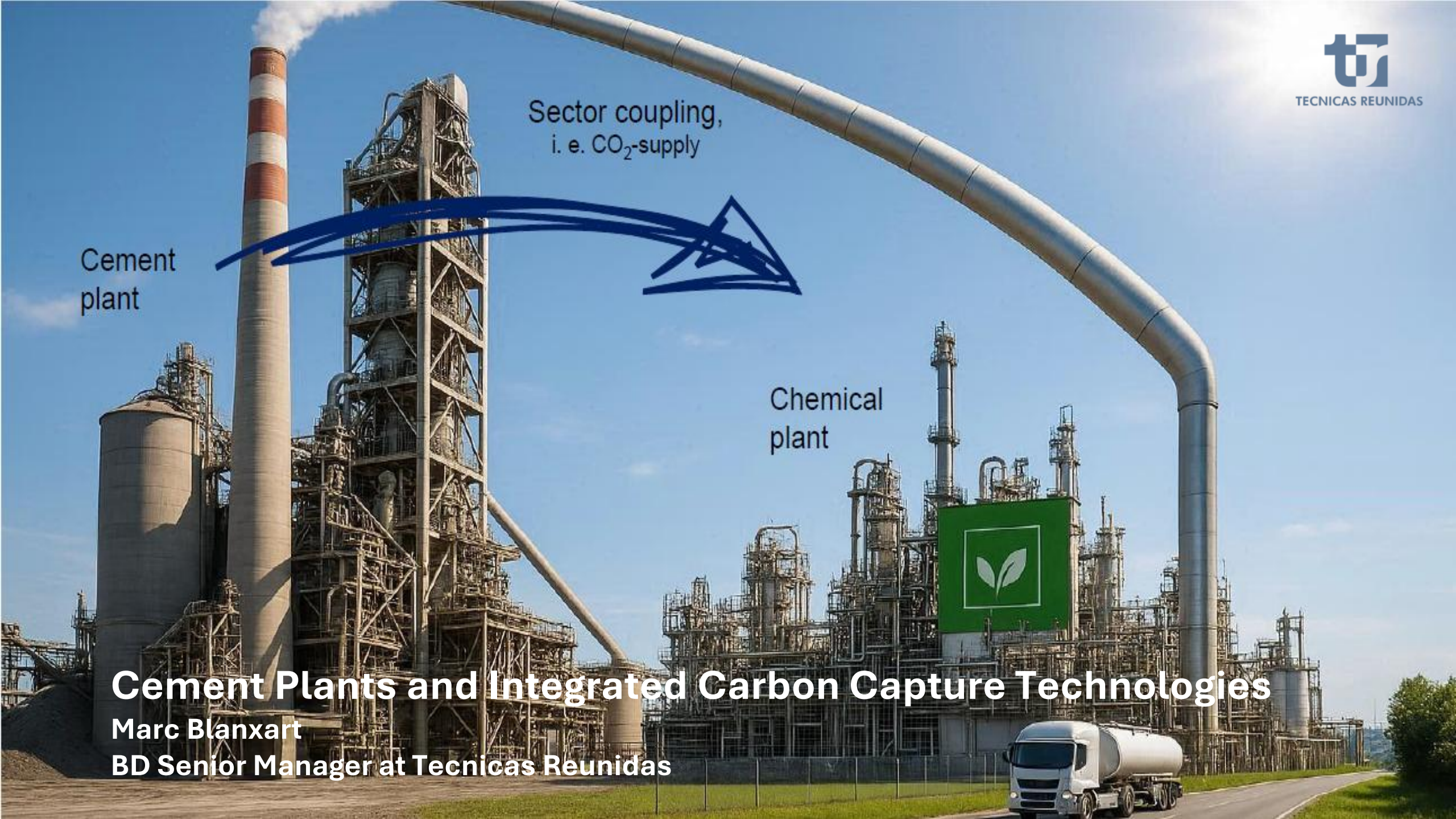


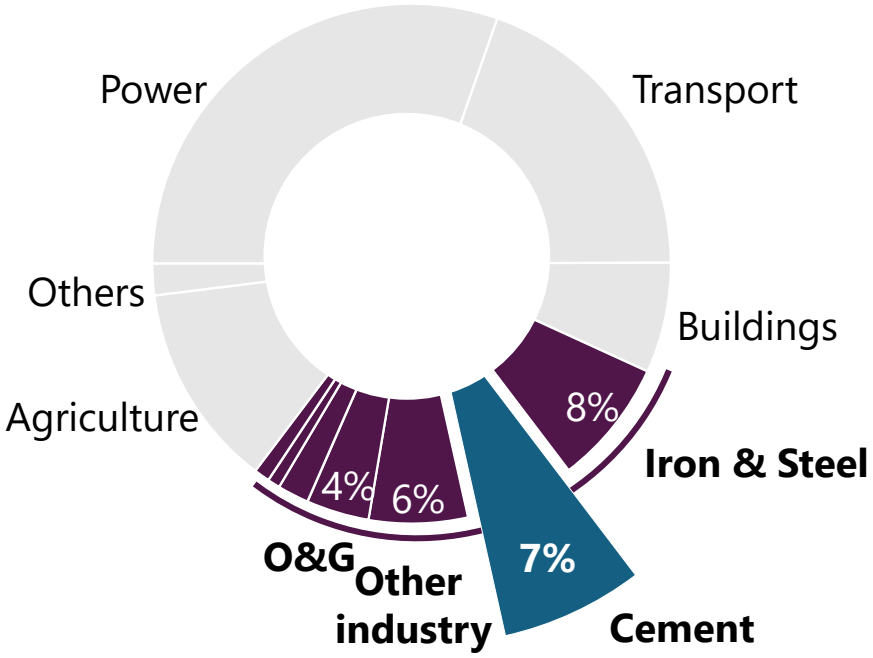
Cement Plants and Integrated Carbon Capture Technologies

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Cement production is a major source of global CO2 emissions

Cement production accounts for 7% of global CO2 production,

Share of global CO2 emissions, percent in 2017



1. Advanced Analytics

Source: ETC Mission Possible, McKinsey

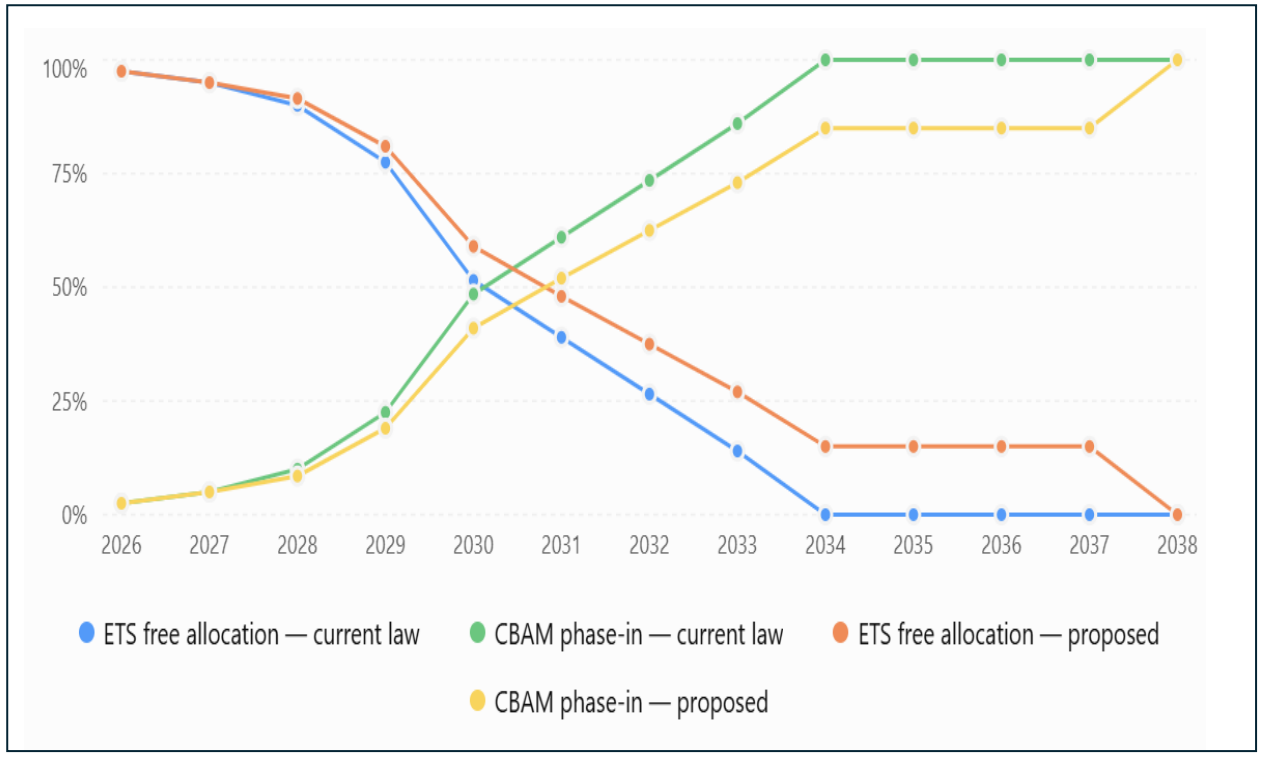
- As of 2026, **87 carbon pricing mechanisms** are in operation worldwide, comprising 40 emissions trading systems (ETS) and 47 carbon taxes. These mechanisms now cover approximately 29% of global greenhouse gas emissions, with further expansion expected.

- **Global carbon pricing revenues exceeded USD 107 billion** in 2025, highlighting the growing financial impact of emissions trading systems (ETS) and carbon taxes, and their increasingly important role in financing industrial decarbonization and the transition to a low-carbon economy.

- **Europe** remains a major contributor, particularly through the EU ETS, while carbon pricing schemes in **UK, Canada, China, and several states from US** are strengthening the global carbon pricing landscape.

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EU ETS – CBAM: implementation calendar



In July 2026 the European Commission has proposed extending the phase-out of free EU ETS allowances for CBAM sectors from 2034 to 2038. This is a legislative proposal, **not yet adopted law**. The change is particularly relevant to the cement industry because it would slow the withdrawal of free CO_2 allowances.

- In 2025, EU ETS auction revenues exceeded **€43 billion**. In the European Union (Member states are required to **allocate 100%** of EU ETS revenues to climate and energy-related projects aimed at reducing greenhouse gas emissions).

- Between 2021 and 2026, 19 cement CCUS projects secured approximately **€3.3 billion** in EU Innovation Fund allocations, representing 18.8% of total funding.

Year	#projects	Funds	Weight	Funds Total
2020	1	196	16,7%	1.175
2021	4	651	37,0%	1.759
2022	4	771	22,3%	3.459
2023	4	670	14,1%	4.749
2024	5	772	26,6%	2.900
2025	**1**	**224**	**6,6%**	**3.400**
Total	**19**	**3.284**	**18,8%**	**17.442**

- Despite an increase in overall Innovation Fund commitments, the cement CCUS sector's share **declined sharply** this year.

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Overview of the integrated cement footprint in Europe



In Europe, **217 integrated cement** plants are currently in operation, with a total installed production capacity of approximately 257 Mio.t of cement per year.

Based on TR internal estimates, the cement plant footprint in Europe is expected to shrink from 217 to approximately **150 plants**, with imports supplied by around **15 facilities located outside** the continent.

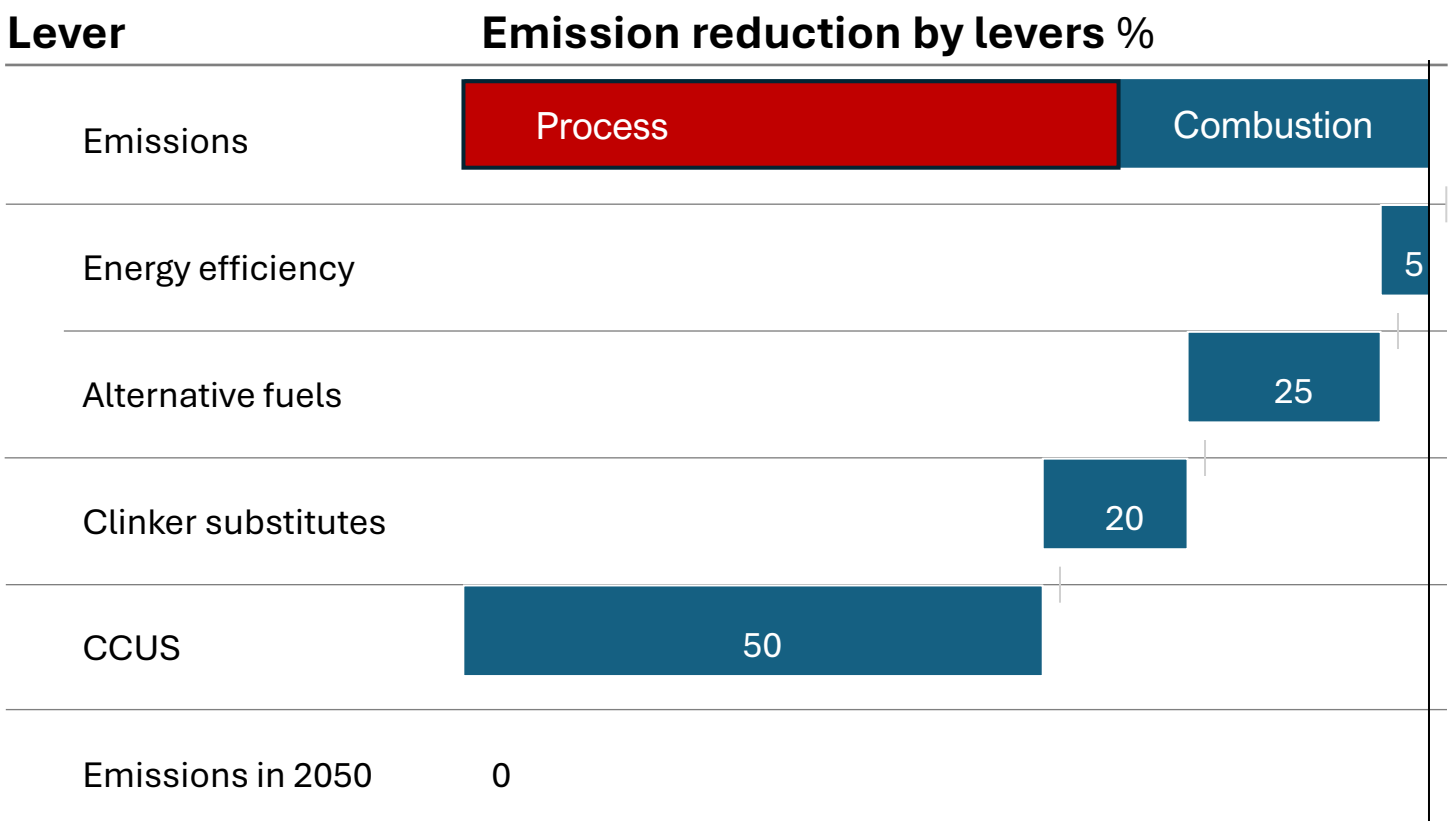
To meet its 2038 decarbonization calendar, the European cement industry would need to develop approximately **12 CCUS projects per year**. However, progress remains significantly behind the required pace, with **no final investment decisions (FIDs)** reportedly reached to date.

- Over the period 2020–2025, average annual cement consumption stood at around 160 Mio. t, of which roughly **11.5% were imported** (mainly from Turkey, Ukraine, Algeria, Egypt, and Tunisia). As a result, the sector is operating with an estimated **overcapacity of about 45%.**

Europe (Mio.t Cem)	Demand	Capacity	Overcapacity
Scandinavian	8	8	2%
English speaking	13	14	3%
German speaking	41	41	0%
French speaking	20	30	49%
Italy	19	36	**87%**
Iberia	20	49	**149%**
Balcans	29	47	**60%**
Baltic-Eastern	26	33	29%
TOTAL	**176**	**257**	46%

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Cement industry: how to achieve net-zero emissions target

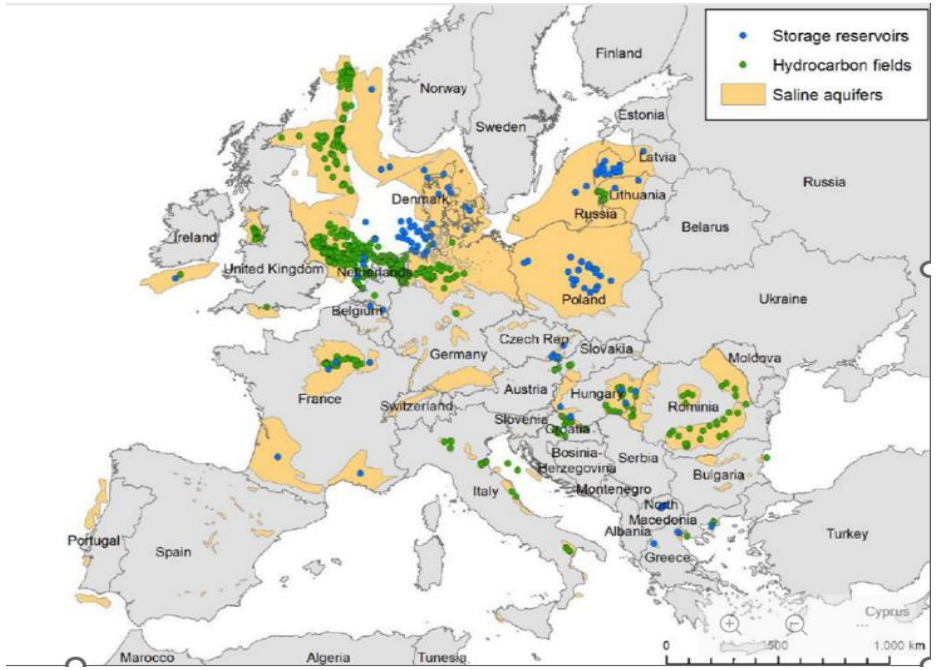


- Enhance thermal and electrical **energy efficiency** throughout the clinker production process.
- Replace fossil fuels with sustainable **alternative fuels**, biomass, and other low-carbon energy sources.
- Reduce process-related CO_2 emissions through the use of **alternative raw materials** and innovative, lower-carbon clinker chemistries.
- Deploy carbon capture, utilization, and storage **(CCUS)** technologies to abate residual CO_2 emissions.

Source: GCCA, ECRA, Expert interview, Cembureau, McKinsey

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1. Challenges: hubs & storage projects



Storage availability remains geographically concentrated and infrastructure-dependent, making **access to transport and storage a key constraint** for inland, southern Europe and smaller industrial emitters

Despite this, a growing number of **e-SAF and methanol projects** are emerging across Europe, although they are only able to address a limited portion of total cement plant emissions

Announced carbon storage projects

	2025	2026	2027	2028	2029	2030-34
Norway	Longship				Havstjerne	7 projects
Netherlands		Porthos			Aramis-L10	
Denmark		Greensands				8 projects
UK				Hynet		1 project
Greece			Piros			
Italy			Ravenna			
Croacia				Kodeco	Geotermal	
Bulgaria				Anrav		

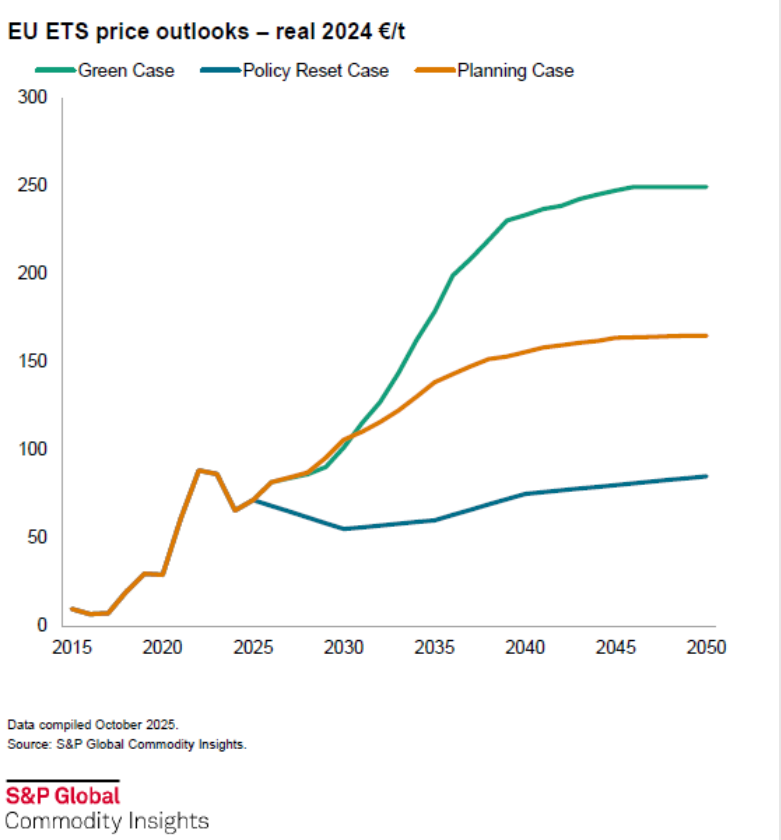
- CO_2 storage landscape in Europe is evolving with most large-scale capacity concentrated in the **North Sea countries and emerging UK hubs**. These projects are moving from demonstration to early commercial scale between 2026 and 2033, forming the backbone of cross-border CCS value chains.

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2. Challenges: economic feasibility

				CCUS				CCUS
Cement	**Units**	**2026**	**Allowance**	**Near**	**Average**	**Far**		**break-even**
Production cost	€/t	90	90	90	90	90		90
Factor Clk	%	75%	50%	50%	50%	50%		50%
Allowance	€/t		**150**					
Capture	€/t			80	80	80		**45**
Storage	€/t			45	45	45		45
Transport	€/t			**25**	**60**	**95**		60
Total cost	€/t	90	165	165	183	200		165
Margin	**€/t**	**30**	**30**	**30**	**12.5**	**-5**		**30**
Cement price	**€/t**	**120**	**195**	195	195	195		195

- By 2038, CO_2 allowance costs could add from **+66% to 100%** to cement prices
- Since costs of transporting cement will be more expensive than transporting CO2, plants near storage locations will have a **competitive advantage**
- In addition, the installation of capture units entails **substantial capital investment,** often comparable to that of building a new greenfield cement plant, making projects highly dependent on the availability of public subsidies

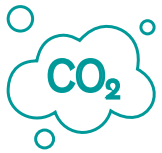


- Based on analyst estimates (S&P) the ETS carbon allowance price is expected to reach **150€/t** by 2034

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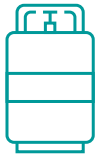
Second carbon capture generation technologies

State-of-the art



Amine based

Chemical absorption of CO_2 through aqueous amine solutions



Cryogenic

Gas cooling to selectively condense and separate CO_2 from other gases

Second generation technologies



Potassium carbonate

Potassium carbonate captures CO_2 by absorbing and forming $KHCO_3$



Membranes

Separate CO_2 based on permeability and diffusivity.



MOFs

CO_2 is captured by surface adsorption on porous solids



Algae

Algae absorbs CO_2 and Nox producing biomass

- 85% of projects awarded by EU Innovation funds will use a capture technology based on **Oxyfuel + Cryogenic systems**, and the rest are **amine-based**
- Solvent regeneration and process-gas cooling and heating require significant amounts of **energy**, the installation of capture units entails **substantial CAPEX**, even higher than that of building a new greenfield cement plant. Furthermore, **integrating** chemical-based capture systems with industrial cement processes will add considerable complexity to cement plant operations.
- Second generation CC technologies can be adapted to enable **phased investment** approach that will reduce financial risk.
- As public funding mechanisms are expected to offset a significant share of CAPEX, **OPEX** will become an increasingly decisive factor in technology selection. Technologies offering the lowest lifetime operating costs while maintaining high capture efficiency will gain the race.

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