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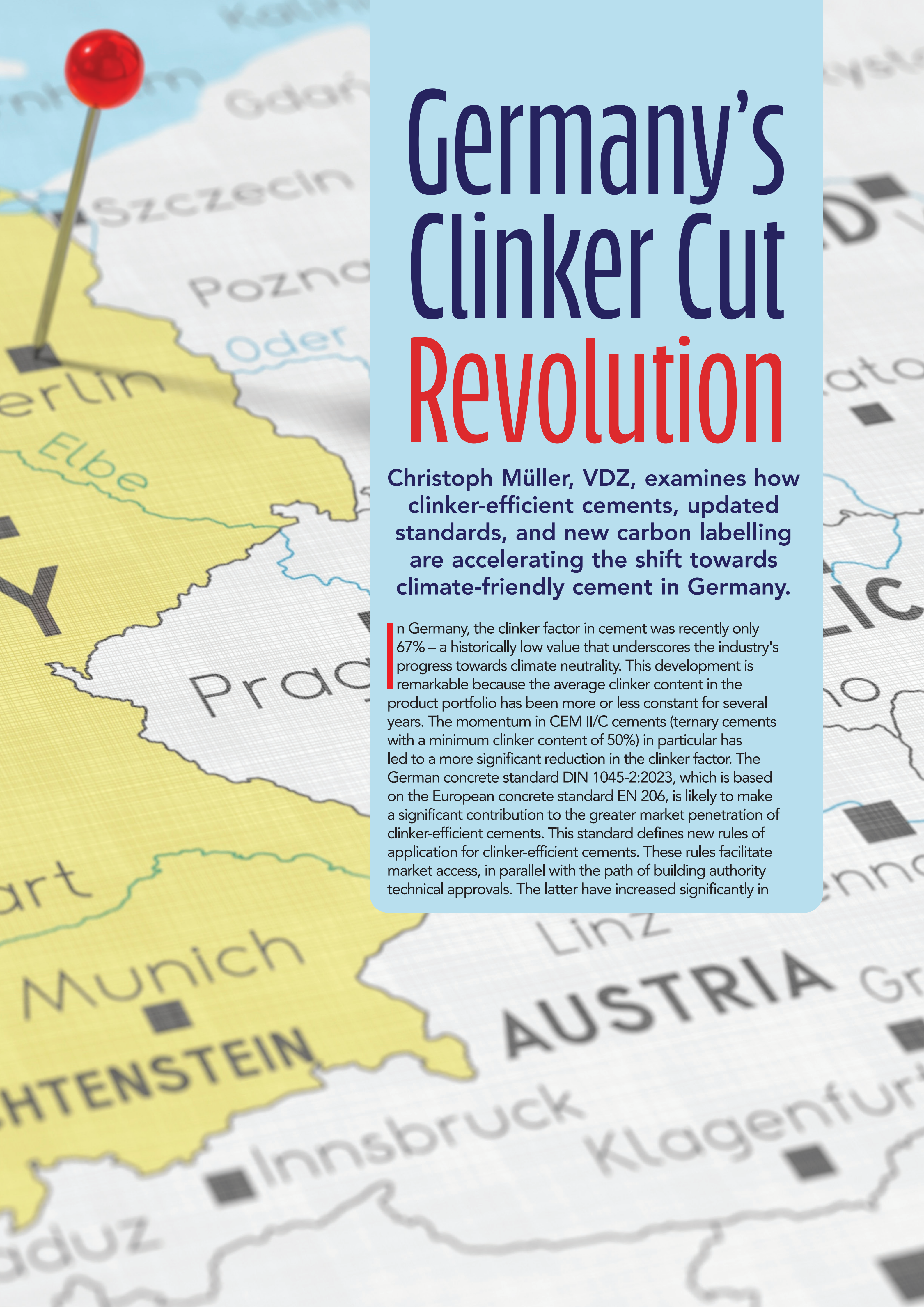

Germany's Clinker Cut Revolution

Christoph Müller, VDZ, examines how clinker-efficient cements, updated standards, and new carbon labelling are accelerating the shift towards climate-friendly cement in Germany.

In Germany, the clinker factor in cement was recently only 67% – a historically low value that underscores the industry's progress towards climate neutrality. This development is remarkable because the average clinker content in the product portfolio has been more or less constant for several years. The momentum in CEM II/C cements (ternary cements with a minimum clinker content of 50%) in particular has led to a more significant reduction in the clinker factor. The German concrete standard DIN 1045-2:2023, which is based on the European concrete standard EN 206, is likely to make a significant contribution to the greater market penetration of clinker-efficient cements. This standard defines new rules of application for clinker-efficient cements. These rules facilitate market access, in parallel with the path of building authority technical approvals. The latter have increased significantly in

2024 and 2025 – in addition to the use of portland composite cements CEM II/C-M, portland limestone blast furnace cements with a very low clinker factor and high proportions of unburned limestone, as well as the use of a first CEM VI cement, have also been approved by the building authorities. Ultimately, the goal is to further reduce the clinker factor significantly to around 53% by 2045. The availability of suitable clinker substitutes is a limiting factor here. In future, calcined clays, limestone, and recycled fines from concrete and masonry rubble are likely to play a role. In addition, the public sector is needed as an important driving force and role model for initiating green lead markets. To this end, the 'Cement Carbon Class CCC' label was published at the beginning of 2025, which gives cement manufacturers the opportunity to transparently disclose not only the product properties but also the carbon footprint to customers and in tenders. A number of labels have been awarded.

Cement type development

Clinker-efficient cements have been used in Germany for many years. In addition to portland cement clinker, the main constituents used are granulated blast furnace slag (marked with the letter S), natural pozzolan (P), which is essentially trass, siliceous fly ash (V), burnt shale (T), and unburned limestone (LL). Figure 1 shows the development over recent years. According to this, portland composite cements (CEM II) and blast furnace cements (CEM III) are increasingly being produced and used. This contrasts with a reduction in portland cements (CEM I), whose domestic share has more than halved from over 60% at the end of the 1990s to around 24%. Until around 2003, CEM II cements and CEM III contained one further main constituent besides clinker. CEM II/A has a minimum clinker content of 80%, while CEM II/B has a minimum clinker content of 65%.

In CEM II cements, all of the above-mentioned main components can be used in addition to portland cement clinker, while in blast furnace cements CEM III with a minimum clinker content of as low as 20%, only granulated blast furnace slag can be used. From 2003 onwards, ternary CEM II-M cements were also produced with two additional main constituents besides portland cement clinker. Since the publication of the VDZ's CO_2 roadmap in 2020, portland composite CEM II/M cements have continued to gain in importance. Their market share rose from 6.5% in 2019 to 16% in 2024. Of this, an estimated 790 000 t were accounted for by the new CO_2-reduced CEM II/C-M cements with a minimum clinker content of 50%. In the future, a further shift in the market towards clinker-efficient cements, such as CEM II/C-M with a minimum clinker content of 50% or CEM VI with a minimum clinker content of 35%, is planned. As a result, the average proportion of cement clinker in cement is to be reduced from 67% today to around 53% by 2045.

Environmental Product Declaration (EPD) for cement

Information on the environmental impact of construction products used is becoming increasingly important as a basis for assessing the sustainability of buildings. Until now, manufacturers of construction products have preferred to provide this data in the standardised format of the EPD. In an EPD, product manufacturers disclose life cycle assessment-based indicators such as resource use and global warming potential and have them independently verified. VDZ has so far developed five EPDs for cement and had them externally verified.

The EPDs are based on the evaluation of production data from VDZ member companies for the relevant period and assumptions about the composition of the cements.

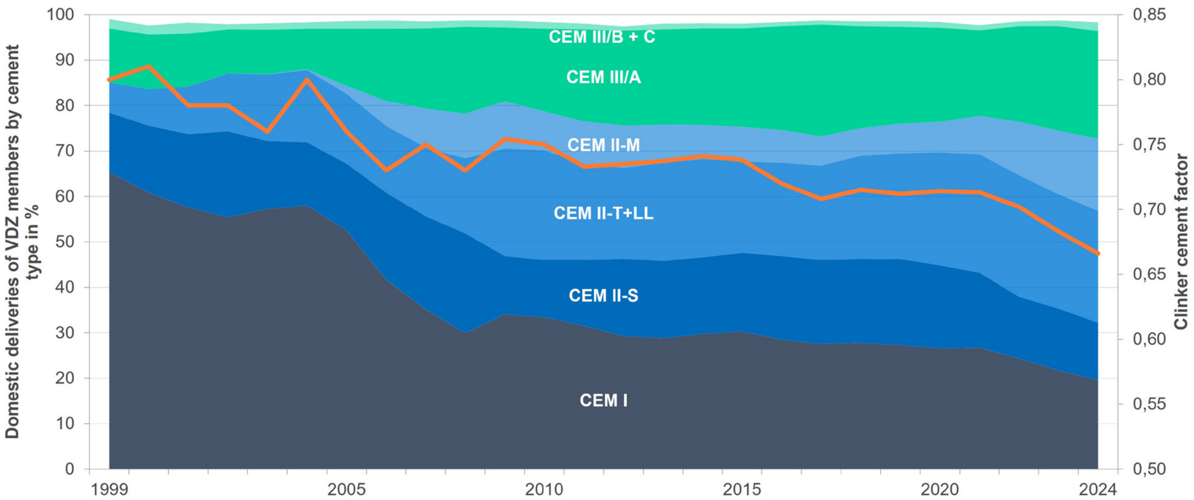

Figure 1. Development of the cement portfolio and the clinker factor in Germany from 1999 to 2024. Source: VDZ. Notes: the difference from 100% is distributed among CEM IV, CEM V, and other binders.

Figure 2 shows a comparison of the global warming potential (GWP) and non-renewable energy consumption of an average German portland cement (CEM I), an average German cement (CEM II), a blast-furnace cement CEM III/A with 50% granulated blast-furnace slag, a CEM II/C containing 50% clinker, 30% granulated blast-furnace slag, and 20% unburned limestone, as well as a blast-furnace cement CEM III/B. The composition of CEM II corresponded to the average composition of cements produced in Germany in 2020.

Properties and application

For concrete producers and contractors, the workability and strength development of the concrete used play a central role in the construction process. The type of cement used and its interaction with the admixtures used influence the fresh concrete consistency, the mixture stability, and the stiffening behaviour. According to German concrete standard DIN 1045-2, the concrete composition and the constituents for concrete must be selected in such a way that the specified requirements for fresh concrete and hardened concrete, including consistency, density, strength, and durability, are met taking into account the manufacturing process and the selected execution method for the concrete work. To comply with these robust fresh concrete properties, either the minimum values for paste content must be met for concretes with plastic consistency (class F3) and strength class C25/30, or alternatively an extended initial type test must be carried out. If these key criteria are met, the setting behaviour of concretes with identical compositions but different cements is qualitatively comparable.

Strength development then plays a central role in the further course of construction and determines the minimum curing time. In summary, early strength decreases and post-hardening increases with decreasing clinker content in many cases. In one of the VDZ's recent research projects, the minimum duration of curing required to achieve 50% of the characteristic strength was determined on the basis of strength development between 18 hours and 91 days. The results confirmed that the minimum curing times specified in DIN 1045-3 must be strictly adhered to on site.

The durability of the structure is then the focus as an important element of sustainability. In Europe, durability is predominantly ensured by deemed-to-satisfy rules. In addition to requirements for the concrete (constituents, concrete composition), this also applies to the concrete cover in reinforced concrete. The rules

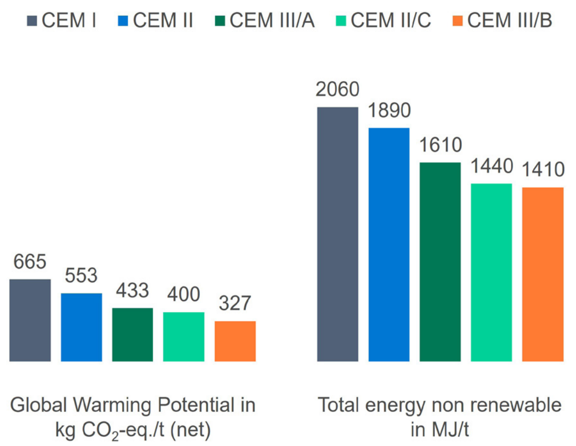

Figure 2. Global warming potential and non-renewable energy in the production of 1 t of cement (German 'average' values).

Exposure classes X = Valid area of application O = Not applicable for manufacturing according to DIN 1045-2:2023-08	No risk of corrosion/ risk of attack	Reinforcement corrosion										Concrete attack										Compatibility with prestressing steel
		Corrosion caused by carbonation				Corrosion caused by chlorides						Frost attack				Aggressive chemical environment			Wear			
						Other chlorides other than sea-water			Chlorides from seawater													
	X0	XC1	XC2	XC3	XC4	XD1	XD2	XD3	XS1	XS2	XS3	XF1	XF2	XF3	XF4	XA1	XA2	XA3	XM1	XM2	XM3	
CEM I CEM II/A (S, T, V, LL); CEM II/A-M (S, LL, T, V) CEM II/B (S, T, V); CEM II/B-M (S, T, V) CEM III/A[1)], CEM III/B[1)] CEM V/A (S-V)[1)], CEM VI (S-V)[1)]	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
CEM II/A (P, Q); CEM II/B (P, Q) CEM II/A-M (S-Q, D-Q, P-Q, Q-V, Q-T, Q-LL) CEM II/B-M (S-Q, D-Q, P-Q, Q-V, Q-T) CEM VI (S-P)	X	X	X	X	X	X	X	X	X	X	X	X	O	X	O	X	X	X	X	X	X	X[2]
CEM II/B-M (S-LL, V-LL, T-LL)[3] CEM II/C-M (S-LL)[4]	X	X	X	X	X	X	X	X	X	X	X	X	O	O	O	X	X	X	X	X	X	X
CEM II/B-M (S-LL; D-LL; P-LL; Q-LL; V-LL; T-LL) CEM VI (S-LL)[4)]	X	X	X	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O

1) Special application rule in XF4
2) Cements containing P or Q are excluded as they have not yet been tested for this application.
3) The permissible limestone content of cements (S-LL), (V-LL) and (T-LL) is limited to 20 M.-%. Compliance with the maximum permissible limestone content must be declared by the cement manufacturer.
4) CEM II/C, CEM VI: Limestone content already limited to 20% in cement standard EN 197-5
5) Cements containing V only with fly ash with up to 5% loss on ignition

Figure 3. Rules for the use of selected cements in DIN 1045-2:2023-08.

of application apply depending on so-called exposure classes.

The concrete standard DIN 1045-2 contains the rules of application for cements depending on these exposure classes. Figure 3 shows the rules of application for selected cements and illustrates four groups:

- Cements for all exposure classes.
- Cements for all exposure classes except XF2 and XF4 (frost attack with de-icing salts).
- Cements for all exposure classes except XF2, XF3, and XF4 (frost attack with de-icing salts or frost attack without de-icing salts with high water saturation).
- Cements for interior components or components without reinforcement (X0, XC1 dry, XC2).

In cases where the use of a cement is not permitted under the relevant standard, proof of suitability for use in the applicable exposure classes may be provided by a general building authority approval (abZ) issued by the German Institute for Building Technology (DIBt). The website of the German Institute for Building Technology lists the cements for which such general building authority approvals are available for specific exposure classes. Table 1 presents an overview of these approvals.

Table 1. Building authority technical approvals for portland composite cements as of August 2025.

Cement type	Number	Exposure classes	min K / max LL in %
CEM II/B-M	29	All	65/20
CEM II/C (without F as HB)	18	All	50/20
CEM II/C + FA	2	All	
CEM IV and CEM V	4	[1]	40/0
Cements with F (NB)[2])	6	All	95-35/0-20
Cements with F (HB)[2])	8[3]	All	80-50/20
Cements with F (HB) + FA	6/8[3])		
CEM II/C	8	All except XF2, XF3, XF4	50/20
CEM II/C + FA	11/21		
CEM VI	1	All except XF2, XF3, XF4	35/20
CEM X	2	All except XF2, XF3, XF4, XA2/3, XM2/3	35/37

Table 2. VDZ's Cement Carbon Classes (CCC) for cement.

CCC classes for cement		Requirement (GHG) CO_2e/t of cement
Climate-friendly	D	400 ≤ GHG < 500
	C	300 ≤ GHG < 400
	B	200 ≤ GHG < 300
	A	100 ≤ GHG < 200
	Near zero	< 100

'Cement Carbon Classes CCC'

At the beginning of 2025, the 'Cement Carbon Class CCC' label was published by VDZ to supplement the EPDs, giving cement manufacturers the opportunity to communicate their CO_2 footprint to customers and in tenders even more easily and transparently. The CO_2 footprint is audited and verified by the independent VDZ certification body. The classification of cements into CO_2 classes is based on a proposal by the International Energy Agency (IEA), which provides for six classes: the near zero (NZ) level and then, in ascending order, classes A to E depending on the clinker/cement factor. To implement the approach in Germany, a clinker/cement factor of 0.7 was taken as the regional input variable. The limit values for classes A to D and NZ derived for the clinker/cement factor of 0.7 are shown in Table 2. The net values are relevant, i.e., without CO_2 linked with waste incineration in clinker production, but with allocation of CO_2, for example, for granulated blast furnace slag. Some labels have been awarded.

Conclusion

Overall, clinker-efficient cements are already firmly established in the German market and are increasingly supported by standards, approvals, and transparent environmental information tools.

Their properties and application requirements are largely comparable to those of conventional cements when the relevant rules are observed. Further reductions in the clinker factor will depend on the availability of suitable substitute materials as well as on regulatory and market-related framework conditions. ■