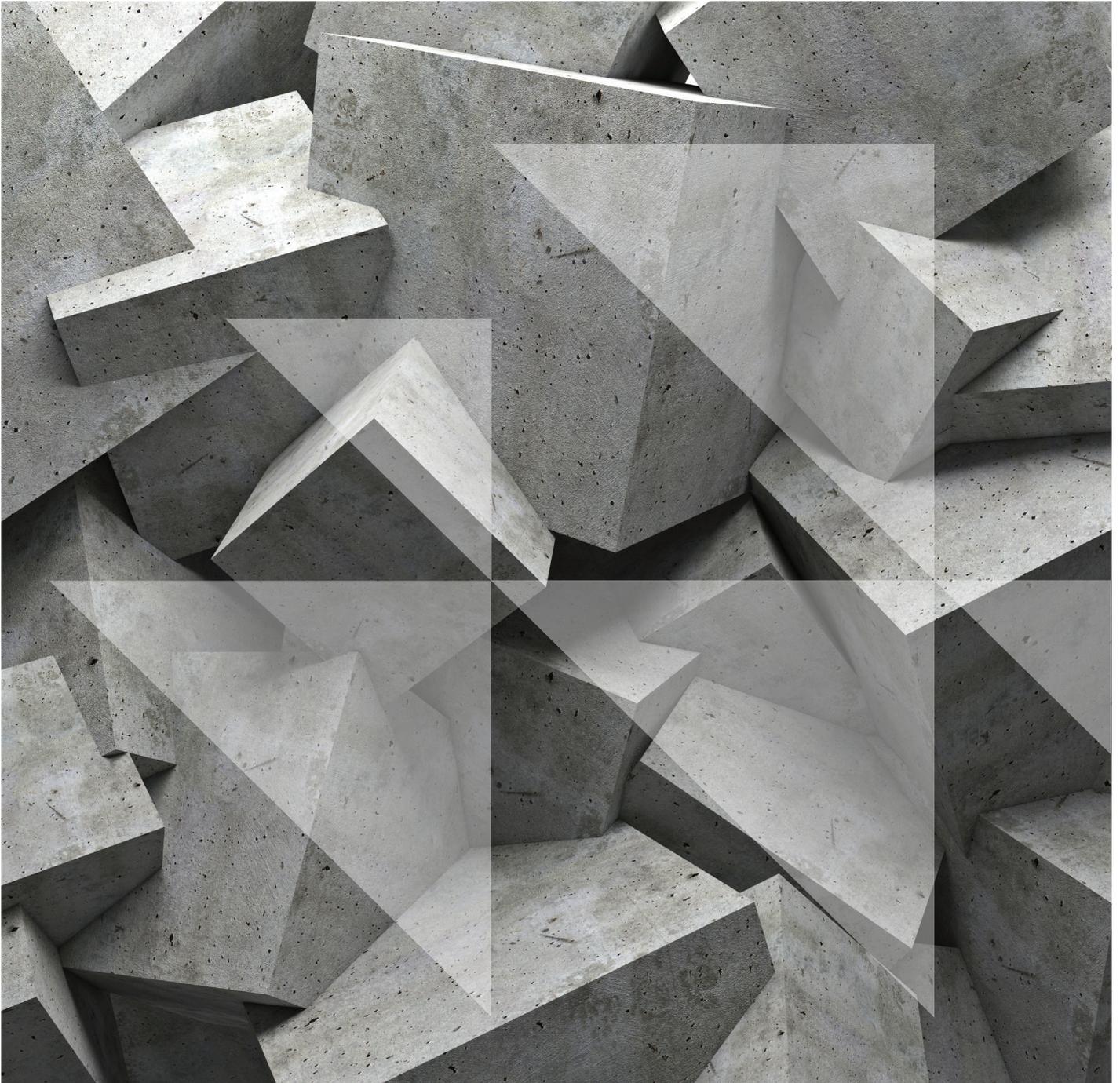

Building pressure

Which cement companies will be left behind in the low-carbon transition?

April 2018



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Contents

Linking climate-related metrics to earnings for cement companies	3
Key report findings	7
Transition risks	10
Physical risks	20
Transition opportunities	26
Climate governance & strategy	33
The built environment	42
Supplementary figures	48
Appendix I: Company performance traffic light chart	49
Appendix II: Company summaries	50
Appendix III: Methodology and limitations	57

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Linking climate-related metrics to earnings for cement companies

This report updates and expands CDP's research and League Table for cement companies, first published in June 2016. It ranks 13 of the largest publicly listed cement companies on business readiness for a low-carbon economy transition. The companies in aggregate represent 15% of global cement production but cover significant portions of key markets, such as India, Europe and the US. A notable limit is related to the coverage of the Chinese cement sector, which represents more than 50% of the global market with limited disclosure preventing inclusion in our analysis.

Compared to our 2016 report, the scope of our report has been extended to include four additional Asian companies (ACC and Ambuja – both listed subsidiaries of LafargeHolcim, Dalmia Bharat and Asia Cement Corporation), while Italcementi is now part of HeidelbergCement. In addition, we analyze drivers in the built environment which could impact cement demand in the future.

The cement industry is the third largest consumer of energy and the second largest industrial emitter after the steel industry with 6% of global emissions (IEA, 2017). In its current form, it is not compatible with the commitment taken at COP21 in Paris, and needs a significant change in business-as-usual practices to align to a 2-degrees trajectory.

A majority of the sector's emissions are inherent to its production process, making them more difficult to abate compared to other sectors. This poses numerous risks to the business-as-usual models of cement incumbents. Levers on the opportunities side remain limited with the use of alternative materials and alternative fuels the main routes for decarbonization – new product development activity is relatively low with CCS technology the main route for abatement.

There are four key areas assessed in the League Table, which are aligned with recommendations for company reporting from the G20 Financial Stability Board's Task Force on Climate-related Financial Disclosures (TCFD):

Transition risks: We assess companies' exposure based on emissions and thermal energy intensity, financial flexibility and exposure to downstream regulation.

Physical risks: We assess companies on exposure to acute physical risks, water stress risk and the usage and management of their water supply.

Transition opportunities: We assess companies' progress in shifting towards a low-carbon economy by looking at exposure to alternative materials and fuel, and low-carbon products and technologies.

Climate governance and strategy: We analyze companies' governance frameworks including emissions reduction targets and the alignment of governance and remuneration structures with low-carbon objectives.

Key findings

- ▼ **The universe of companies has on average reduced their emissions intensity by 1% p.a. over the last 4 years but this is not enough for a 2-degrees trajectory** and would need to more than double to meet a 2-degrees target.
- ▼ **Strong regional trends are found with Indian companies outperforming international peers with process emissions measured by the clinker ratio¹ of 69% vs 78%.** This is driven by better access to alternative materials such as fly ash and slag coming from other carbon intensive sectors, such as thermal power generation and steel production.
- ▼ **Use of alternative materials in developed markets is facing constrained supply.** European companies will need to find scalable and sustainable alternatives to fly ash and slag or develop low-carbon technologies to be able to improve current emission intensity levels.
- ▼ **Alternative fuels from waste offer another way to decarbonize at a low cost** with international companies in countries with robust waste legislation set to benefit compared to their Indian peers.
- ▼ **CCS is an important technology for this sector's decarbonization but remains at pilot stage.** HeidelbergCement leads the main projects in this space, with only limited R&D spend on CCS outside Europe.
- ▼ **R&D expenditure as a proportion of sales is low compared to other industries.** HeidelbergCement, Taiheiyo Cement and LafargeHolcim lead with 0.6% on average. Development of low-carbon products is still at a very early stage, with the Europeans leading the group.
- ▼ **Changes to water supply and weather patterns can pose risks to the cement value chain.** We performed a plant-level analysis to identify companies most exposed to the risk of droughts, floods, weather variability and water supply.
- ▼ **Carbon regulation for the sector remains benign, with the sector in Europe continuing to benefit from surplus free allowances** within the EU ETS – carbon prices need to rise by three to six times to provide incentives to deploy technologies such as CCS.
- ▼ **Regulatory risks from tightening building regulation and ambitions for low-carbon cities could drive change** which could expose companies with plants near these cities – we conduct asset level analysis to evaluate this risk.
- ▼ 11 of the 13 companies in our sample have emission reduction targets, **but only three of these meet a 2-degrees goal².**
- ▼ Highest ranked companies are **Dalmia Bharat, Ambuja Cement** and **Cementos Argos**. Lowest ranked are **Taiheiyo Cement, Cementir Holding** and **Asia Cement Corporation**.

1. The clinker ratio refers to the proportion of clinker in one tonne of cement. Clinker is the main component of cement and highly carbon intensive.

2. Estimates based on IEA, 2017, ETP data.

The summary League Table below presents headline company performance and ranking. It is based on detailed analysis across a range of carbon and water-related indicators which could have a material impact on company performance. The League Table is designed to serve as a proxy for business readiness in an industry which will undergo significant change as governments increase efforts to implement the Paris Agreement. Companies placed towards the bottom are deemed less prepared for a low-carbon transition.

Figure 1: League Table summary⁽ⁱ⁾

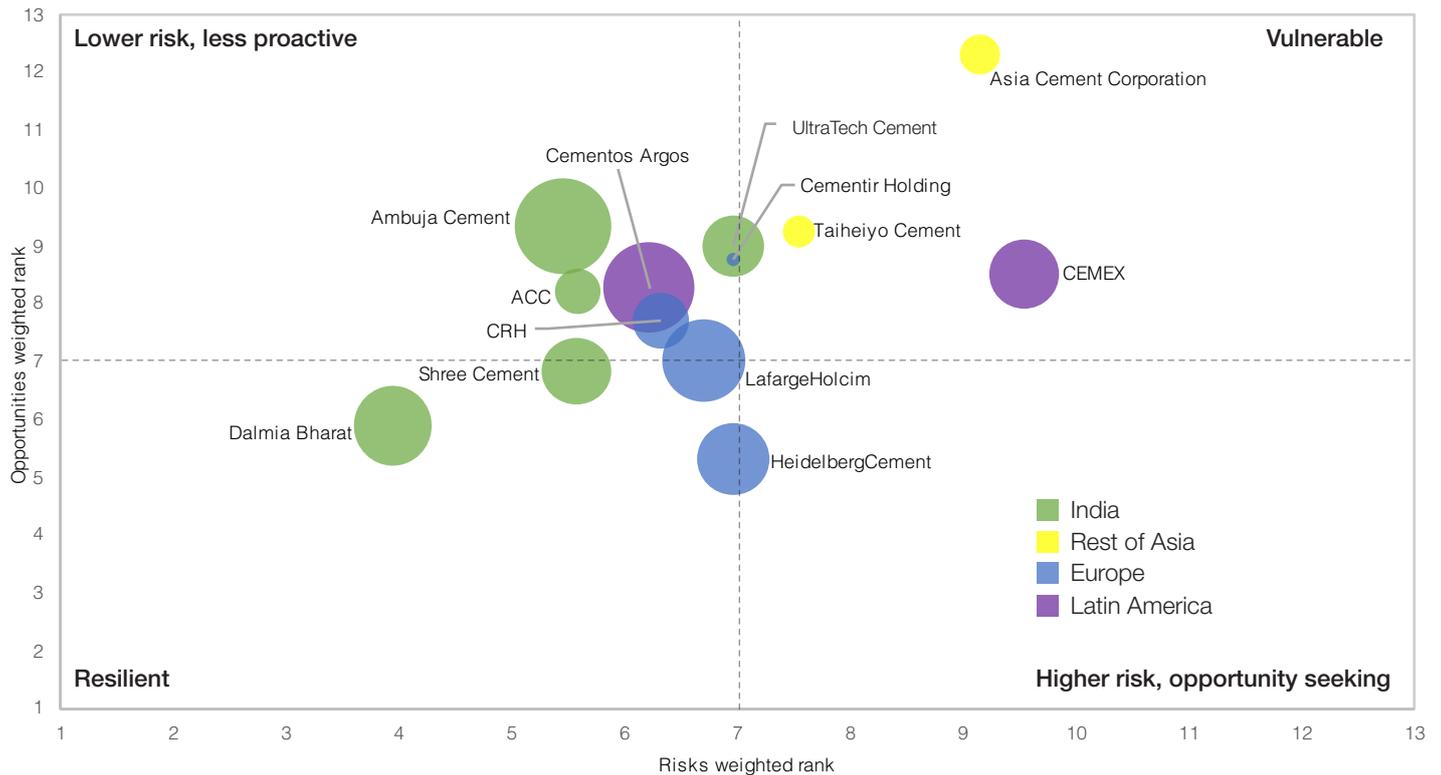
League Table rank	2016 League Table rank	Company	Ticker	Stock exchange listing	Average market cap 2017 (US\$bn) ^(iv)	2016 cement production (million tonnes) ^(v)	League Table weighted rank	Transition risks rank	Physical risks rank	Transition opportunities rank	Climate governance & strategy rank
1	n/a	Dalmia Bharat	DBEL IN	NSE India	3.4	15	4.64	1	9	2	4
2	n/a	Ambuja Cement ⁽ⁱⁱ⁾	ACEM IN	NSE India	7.7	21	5.62	3	11	12	1
3	5	Cementos Argos	CEMARGOS CB	Colombia SE	5.3	14	5.90	7	2	7	2
4	2	Shree Cement	SRCM IN	NSE India	9.4	20	5.91	2	13	3	7
5	1	LafargeHolcim ⁽ⁱⁱ⁾	LHN SW	SIX Swiss SE	34.8	233	6.03	8	6	4	3
6	6	HeidelbergCement	HEI GR	Deutsche Borse	19.3	125	6.08	9	7	1	5
7	4	CRH	CRH ID	Irish SE	29.7	34	6.85	6	4	5	9
8	n/a	ACC ⁽ⁱⁱ⁾	ACC IN	NSE India	4.7	23	7.02	4	10	6	10
9	8	UltraTech Cement	UTCEN IN	NSE India	17.0	48	7.32	5	12	10	8
10	7	CEMEX	CEMEXCPO MM	Mexico SE	12.6	67	8.04	12	8	8	6
11	10	Taiheiyo Cement	5233 JP	Tokyo SE	4.7	32	8.58	11	1	11	12
12	11	Cementir Holding	CEM IM	Borsa Italiana	1.1	10	9.00	10	5	9	13
13	n/a	Asia Cement Corporation ⁽ⁱⁱⁱ⁾	1102 TT	Taiwan SE	3.1	34	9.80	13	3	13	11

Weighting

- (i) Weighted ranks are calculated for each area. We display non-weighted ranks in this summary for simplicity only.
 - (ii) LafargeHolcim data is inclusive of its subsidiaries ACC and Ambuja Cement.
 - (iii) Data only available for Taiwan plants in transition risks and transition opportunities.
 - (iv) Daily average market cap for calendar year 2017.
 - (v) Figures are 2015 production for CRH and 2016 sales for Cementir Holding and LafargeHolcim.
- Source: CDP

35% 10% 25% 30%

Figure 2: Opportunity vs. risk for low-carbon transition



Bubble size: Larger bubble = stronger performance on climate governance & strategy
Source: CDP

Overview

The cement sector is a significant contributor to global carbon emissions, with an estimated 2.2GT CO₂ emitted in 2016 or 6% of global emissions. It is among the “hard-to-abate” sectors given the high proportion of inherent process emissions and the lack of obvious replacement materials. According to the IEA³, to stay within 2-degrees of global warming, a cumulative abatement of 14% of sector emissions is required by 2060 compared to a business-as-usual scenario. The localized nature of its production, the low margins of the industry and the traditionally low rate of innovation all make change at global scale harder to implement relative to other industries.

The cement industry has a number of large global companies, although the economics of the business are often driven by local and regional market dynamics. Global companies act as multi-regional players, acquiring assets in different markets as part of a market diversification strategy. The strategies being adopted by these large players will have a significant influence on low-carbon transitions given their market shares and presence in markets where cement demand is expected to grow based on development trends.

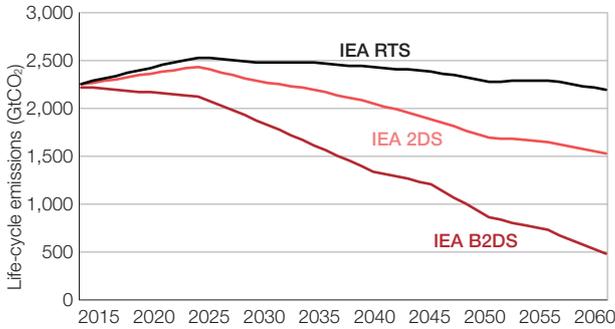
The sector has experienced a wave of consolidations over the past decade, with the aim of taking out excess capacity in search of better margins and cashflows. This has changed the shape of numerous top industry players, together with their emissions and sustainability profiles. M&A has not always generated value though,

sometimes leaving companies over-levered, with goodwill on balance sheet and operationally stretched⁴.

With the 13 companies in our report, we cover 15% of global cement production, however, we cover the majority of production in some key emerging and developed markets. China is the main omission, with only 3% of national market share covered by the companies in our sample due to limited disclosure. On average, the majority of cement production stays within the producing country, with traded flows representing only 4% of global production. In European countries, cement tends to be somewhat more traded than global averages, but with the exception of a few non-EU countries the flow tends to remain within the EU borders (90% of total EU imports are from other EU countries), with clear implications for carbon leakage arguments brought forward by sector lobbies.

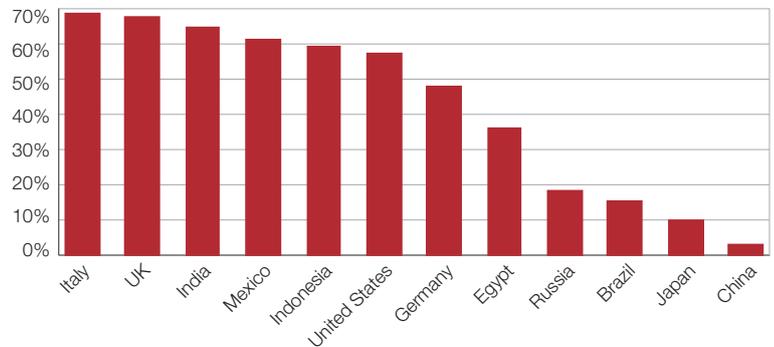
The main levers of emissions abatement in the sector have been the use of alternative materials and alternative fuels. Alternative materials have the largest decarbonization potential, although currently they are mostly by-products of other carbon intensive processes (fly ash from thermal power plants and slag from steel production) and thus not sustainable in the long-term, particularly in developed markets. This poses a challenge for players operating in Europe and the US, and requires them to find scalable and sustainable solutions to accelerate their process of decarbonization.

Figure 3: IEA 2017 cement sector emission scenarios



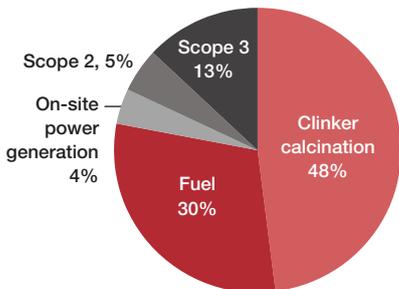
Source: IEA, 2017, ETP

Figure 4: Selected countries market share covered by companies in our sample



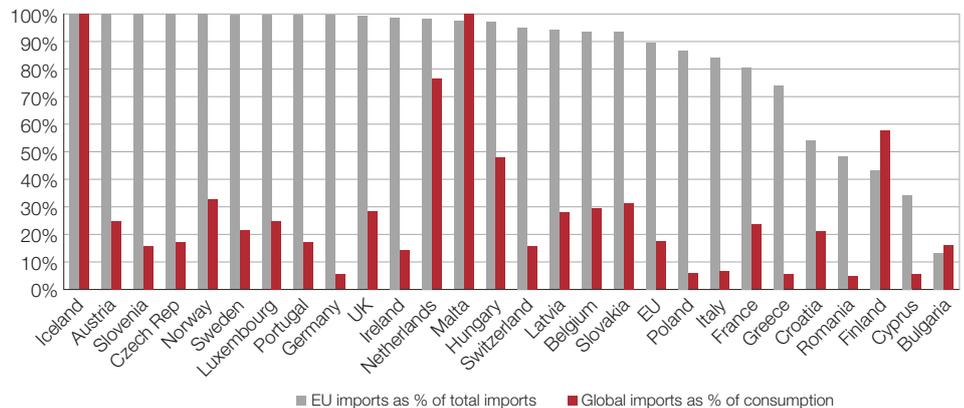
Source: Global Cement Directory, Cemnet, CDP

Figure 5: Cement emissions breakdown by source



Source: CDP, IEA, 2017, ETP

Figure 6: EU 28, Switzerland, Norway and Iceland cement imports



Source: Chatham House, Resource Trade Earth, CDP

3. Energy Technology Perspectives, 2017

4. McKinsey, 2015, The cement industry at a turning point: A path toward value creation

Indian companies currently make the largest use of alternative materials, which partly explains their best-in-class Scope 1 intensity. However, over the long-run, they will also need to transition towards more sustainable abatement practices.

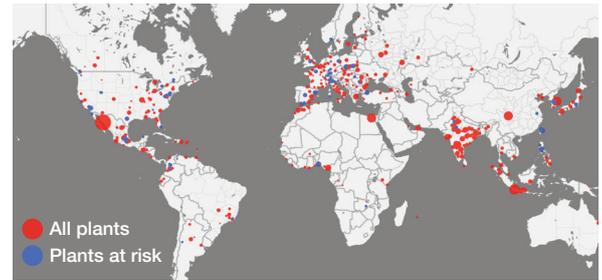
Alternative fuels (waste and biofuels) are still relatively under-utilized as a source of abatement, with globally 84% of fuel energy demand currently provided by conventional fossil fuels (mainly coal)⁵. Companies in emerging markets face the biggest challenges in sourcing supply of waste, but can play an important role towards promoting waste management regulation and infrastructure.

These levers alone however are not sufficient over the long-term to keep the sector within a 2-degrees trajectory. Our analysis highlights how currently only three companies are on track to meet a 2-degrees budget by 2030 and the two East-Asian companies in our report show a significant gap needs to be closed to reach target levels.

Development of low-carbon products and technologies will need to accelerate to help close this gap. Some low-carbon products are already commercialized, such as LafargeHolcim's Solidia, but this is still at an early stage. Governments and regulators will need to increase efforts to develop such markets, by creating the appropriate regulatory framework and supporting demand through incentives and guidance.

Changes to regulation downstream in the value chain, such as buildings regulations, could also drive change, by shifting the focus from operational efficiency of buildings to embodied emissions as operational emissions diminish. Cities and regions with higher decarbonization ambitions could take the lead in this respect, and we have already seen examples of cities, green certifications and asset owners starting to focus on embodied emissions (e.g. the latest London planning consultation document or the latest BREEAM consultation). Cement companies which supply these cities would need to adapt to avoid losing market share in favour of more innovative competitors.

Figure 7: Company plants at risk from potential future tightening of building regulations



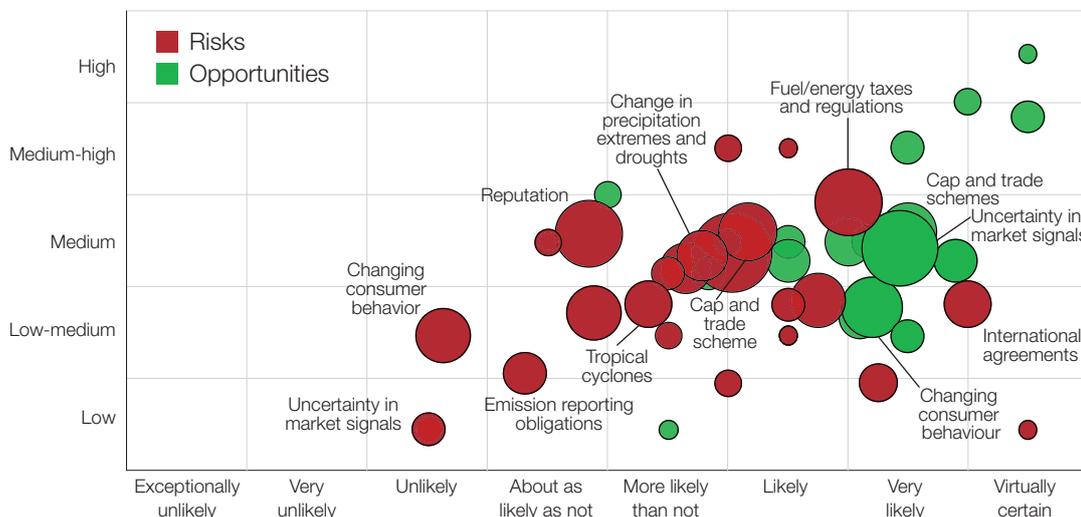
Source: Cement Global Directory, Cemnet, CDP

In our analysis, we have shown that 22% of capacity captured by our sample companies is potentially at risk from this transition.

On the technological front, CCS is on paper the technology with the largest potential impact. It is expected to play a crucial role for the cement sector in most climate models, responsible for 48%⁶ of sectoral emissions abatement in the IEA 2-degrees scenario against a reference business-as-usual scenario. Currently there are only pilot studies within the industry, with Heidelberg showing leadership in this space. The scalability of the technology is still in question, and carbon prices required to make CCS economically viable in the cement sector are three to six times higher than current levels.

Steering companies through these multiple constraints will present significant challenges and will require long-term planning and strategy. We mapped the climate-related drivers seen by companies to present risks and opportunities for the sector based on answers in the CDP questionnaire (Figure 8). This analysis shows that given the same drivers (e.g. changing consumer behavior), companies see a much higher likelihood of opportunities occurring than risks, and those opportunities occurring within a shorter-time frame than the risk. This skew could delay the sector from investing in solutions to reduce their carbon intensity and risk further lock in to business-as-usual strategies.

Figure 8: Risks and opportunities from climate change as perceived by companies' management: likelihood of occurrence and impact on companies



Note: Refer to "Assessment of Risks and Opportunities for the Cement Sector" for further details.
Source: CDP

5. CSI/ECRA, 2017, Development of State of the Art Techniques in Cement Manufacturing: Trying to Look Ahead
6. IEA, 2018, Cement Technology Roadmap

Key report findings

Operating Risks

- ▼ **Three Indian companies have the best emission intensity levels** (Dalmia, Shree and Ambuja) with Scope 1+2 intensities 18% lower than the rest of the group. Asia Cement, Taiheiyo and CEMEX rank bottom.
- ▼ **Most companies have decreased their Scope 1 emissions intensity over the period 2012-16**, with the exceptions of CEMEX, ACC, UltraTech and LafargeHolcim.
- ▼ **This is largely driven by a reduced clinker-to-cement ratio, which declined 1% p.a. over the period.** Only three companies increased their clinker ratio (LafargeHolcim, CEMEX and Cementir).
- ▼ **Thermal energy intensity was flat over the period** for the group, with the top companies (UltraTech, ACC and Ambuja) currently 11% more efficient than the rest.
- ▼ **Three Indian companies show the best financial flexibility rank** (Ambuja, ACC and Shree) thanks to lower levels of indebtedness. CEMEX and Asia Cement are at the bottom of the group.
- ▼ **From our analysis of the potential risks from downstream regulatory changes, CEMEX and Asia Cement are at greatest risk.** European companies rank middle of the pack due to their international presence, with the lowest risk for Indian companies.
- ▼ **Our acute physical risk analysis shows none of our companies are exposed to extremely high-risk areas.** Indian companies with domestic focused portfolios face higher risk from floods and seasonal variability than peers.
- ▼ **Although cement companies are not very water intensive, changes to water supply could significantly affect the cement value chain.** Two Indian companies currently have the majority of their capacity in high water stress risk areas (UltraTech and Shree).

Opportunities

- ▼ **Heidelberg performs best on transition opportunities**, using a high proportion of alternative fuels, having better financial scoping and showing leadership on CCS technology. Asia Cement ranks bottom.
- ▼ **The use of alternative materials was flat during the period. We see this as a missed opportunity as this is a key decarbonization tool for the sector.** The three Indian companies at the top (Dalmia, Shree and ACC) use on average 26% alternative materials in their cement compared to a 10% average for the rest of the group.

- ▼ **CCS projects are still largely at pilot stage in the cement sector.** Aside from Heidelberg, also LafargeHolcim, CRH and the two Latin American companies show some investment in CCS across various technologies, but progress is limited and scalability is still an issue.
- ▼ **CRH, Heidelberg and CEMEX top the alternative fuel rank, with average usage of 27% compared to 6% for the rest of the group.** All but two of our companies (CEMEX and Taiheiyo) have increased the portion of alternative fuels over the past four years. Companies in developed markets have better access to waste-fuel supplies, but biofuels still represent a minority portion of fuel across the board.
- ▼ EBIT margins vary widely between companies. **The top ranked companies (UltraTech, Shree and CEMEX) benefit from margins that are double the level of companies at the bottom.**
- ▼ **Low-carbon product development is still at a very preliminary stage.** LafargeHolcim is among the early movers with commercialized products such as Solidia⁷ potentially putting them in a position of strength should the low-carbon product market gain scale.

Governance & Strategy

- ▼ **11 of the 13 companies in our sample have emission reduction targets focused on Scope 1 emissions, with seven currently outperforming their targets.** Only Dalmia has a long-term emissions target in place (2050).
- ▼ **Only three companies' emission reduction targets (Dalmia, Ambuja and LafargeHolcim) are in line with the trajectory required for 2-degrees warming.** Asia Cement, Taiheiyo and Cementir rank bottom with trajectories significantly off the 2-degrees target.
- ▼ **Companies are generally not incentivizing long-term climate risk management through remuneration**, with only Cementos Argos including climate-related metrics in executive Long Term Incentive Plans (LTIPs).
- ▼ **All but three companies (Taiheiyo, Shree and Cementir) disclose a short-term climate-related remuneration element**, and nine out of 14 companies have some level of sub-executive climate-related remuneration.
- ▼ **Five companies do not have internal carbon prices** which is particularly concerning in a sector where carbon pricing legislation could have a huge material impact.

7. A cement product which can reduce emissions by up to 70% through actively absorbing CO₂ during the cement hardening process.

Company highlights

#1 Dalmia Bharat comes first by a distance, performing well on a number of metrics. The company scores best on Scope 1 emissions intensity, with both the lowest current level and the steepest decline since 2012. It makes most use of alternative materials and has the best emissions profile against IEA 2-degrees targets out to 2030. Dalmia has an internal carbon price and comes second for the quality of its emissions reduction target. Among its relative weaknesses are a higher than average gearing and a low level of R&D spend.

#2 Ambuja performs well on its clinker ratio, thermal energy efficiency and has the best financial flexibility. It ranks first in the governance section, thanks to the second-best emissions profile against IEA targets (2017-30) and executive remuneration. It uses the third highest internal carbon price and scores well for board level climate management and level of data verification. Its main weaknesses are a low level of R&D investment and its exposure to acute physical and water stress risk. Ambuja is a subsidiary of LafargeHolcim.

#3 Cementos Argos performs well in the governance & strategy section and exposure to physical risks. It has the best emissions reduction targets which requires the highest annual emissions intensity reduction and is currently performing best relative to this. It is the company with the best climate-related board level expertise and executive remuneration, being the only company to incentivize long-term climate-risk management through compensation. Cementos Argos also has the third-lowest exposure to acute physical risks. Its main weaknesses are a poor performance in alternative materials usage and a high level of capex intensity.

#4 Shree ranks second overall in the transition risk metrics, having the second-best emissions intensity and clinker ratio, and performs strongly in thermal energy intensity and financial flexibility. It also has the second-best EBIT margins and board level climate management. Its extrapolated emission profile is broadly in line with the IEA 2-degrees target levels. Among its weaknesses are a low level of R&D investment and elevated exposure to acute physical risks and water stress risk.

#5 LafargeHolcim performs well on governance & strategy, with the highest internal carbon price used (CHF 30) and ranks third for its emissions intensity profile against the IEA 2-degrees target. They are one of only three companies to have both short- and long-term emission reduction targets, although they are currently performing poorly against these. The company scores fourth on transition opportunities thanks to efforts on CCS and investments in low-carbon cement products, despite below average performances on financial scope and use of alternative materials. They show average performance on transition risk metrics.

#6 Heidelberg ranks best in terms of transition opportunities, as a result of their leadership in CCS and the highest level of R&D expenditure. They also perform well on alternative fuel use, at 22%. They rank fifth in governance and strategy, thanks to a reasonably high internal carbon price used. The company's clinker ratio and Scope 1 emissions intensity are average, and so is their exposure to physical risks.

#7 CRH has the highest use of alternative fuels, at 34%, which has improved significantly over the past years. The company also benefits from a low exposure to acute physical and water stress risk. The company ranks towards the mid-range of the pack on governance metrics despite strong data verification procedures, due to the lack of internal carbon pricing and below average climate-related remuneration and board level climate expertise. The company performs averagely on transition risk metrics.

#8 ACC scores well on transition risk metrics, with the fourth-best performance on emissions intensity and second best for financial flexibility. However, it scores poorly on governance, with weak climate-related remuneration and no disclosed internal carbon price level. It has also high exposure to acute physical and water stress risk. ACC is a subsidiary of LafargeHolcim.

#9 UltraTech is the worst performing of the Indian companies in the report. It ranks second last in exposure to physical risks, with 27% and 55% of their capacity at high acute physical and high water stress risk respectively. It performs worst on alternative fuel usage and their use of alternative materials is average. UltraTech ranks middle of the pack in governance metrics, with no internal carbon pricing, despite better than average board level climate management.

#10 CEMEX is the second worst prepared for transition risks with the highest level of energy intensity, the lowest level of financial flexibility and the highest exposure to downstream regulation. It also has the second lowest level of alternative materials usage. The company ranks in the middle on governance metrics but benefits from higher than average EBIT margins.

#11 Taiheiyo performs second worst overall for governance & strategy and third worst on readiness for transition risks. The company has the second largest gap for its future emissions intensity profile against the IEA 2-degrees targets. It does not disclose how it links remuneration to climate metrics nor how climate-risk management is integrated through all levels of operations. It has the second highest emissions intensity and limited financial flexibility due to a high level of gearing. It benefits from the lowest exposure to physical risks.

#12 Cementir is the worst performer on governance & strategy. The company currently does not have emission reduction targets, there is no link between remuneration and climate-metrics and they do not disclose any information suggesting a board/ executive climate committee. They rank fourth last on transition risks, with the second worst clinker ratios and an above average emissions intensity.

#13 Asia Cement is the least prepared for transition risks, scoring last on clinker ratio and emissions intensity as well as second last for financial flexibility. It ranks third last on governance metrics, with the largest gap to the IEA 2-degrees target and there is no link between remuneration and climate risk management. The company also scores poorly on transition opportunities, with the lowest use of alternative materials and fuel and the lowest level of proportional R&D expenditure.

Company selection and classification

Companies were selected from the largest publicly listed cement companies, based on 2017 market capitalization and those that responded to CDP's 2017 climate change information request. All of the companies that featured in CDP's 2016 cement report are included again, with the exception of Italcementi (now part of Heidelberg) and Buzzi Unicem (which did not answer the CDP climate change questionnaire in 2017). In addition, we have added 4 companies: ACC and Ambuja (both subsidiaries of LafargeHolcim), Asia Cement and Dalmia Bharat. Several companies that reported to CDP in 2017 were omitted due to incompatible business models or smaller relative size to the companies featured in the League Table.

Non-responding companies

We highlight the following companies as non-responders to CDP's 2017 climate change questionnaire who are therefore not included in this report. We encourage investors to raise this lack of transparency in discussions with company management.

Figure 9: Non-responders to CDP⁽ⁱ⁾

Company	Ticker	Stock exchange listing	Average market cap 2017 (US\$bn) ⁽ⁱ⁾	2016 cement production (million tonnes)	First approached by CDP	Public disclosure of emissions	Comments
Anhui Conch Cement	914 HK	HK/ Shanghai SE	18.5	277 ⁽ⁱⁱ⁾	2008	Partial	One of the largest cement manufacturers in China. Its business scope covers the manufacture and sales of cement and clinker.
Siam Cement	SCC TB	Thailand SE	17.9	190 ⁽ⁱⁱ⁾	2006 ⁽ⁱⁱⁱ⁾	Yes	Largest and oldest cement and building materials company in South East Asia.
Dangote Cement	DANGCEM NL	Nigerian SE	10.1	23	2015	No	Fully integrated cement company, headquartered in Lagos with operations in Nigeria and 14 other African countries.
China National Building Material	3323 HK	HK/ Shanghai SE	3.7	257	2008	No	Engages in cement, lightweight building materials, glass fiber and fibre-reinforced plastic products.

(i) Daily average market cap for calendar year 2017.

(ii) Sales production 2016 for Anhui Conch Cement & Siam Cement.

(iii) Siam Cement answered in 2007.

Source: CDP

Linking our findings to investment choices

We recognize that investment decisions are based on a multitude of different factors and that some of these can be misaligned with emission-reduction efforts. Our League Table identifies company readiness for the transition to a low-carbon economy and the physical impacts of climate change. We would flag that companies towards the bottom of our League Table are higher risk investments from a climate change perspective than those towards the top.

Methodology

We score each company based on a number of metrics which are ranked and then weighted within each key area (see table below for metric weightings within each key area). We then assign traffic light colors based on these weighted ranks. We calculate the overall League Table score by collating the weighted ranks for each key area. Each of the key areas has a separate chapter within this report. We disclose the precise methodology for how we rank each metric in an appendix.

Figure 10: A summary of key areas, associated metrics and weights within the League Table

Key area in League Table	Financial impact	Metrics	Metrics weighting	Key area weighting
Transition risks	<ul style="list-style-type: none"> Emissions and energy intensities directly impact operating costs. Tightening emission regulation could translate into increasing compliance costs for high emitters. 	• Emissions intensity	45%	35%
		• Thermal energy intensity	25%	
		• Clinker ratio	15%	
		• Financial flexibility	10%	
Physical risks	<ul style="list-style-type: none"> Risk to production and asset base from storms, floods and droughts. Increasing water scarcity can potentially disrupt operations and create risks to product markets. 	• Downstream regulation	5%	10%
		• Acute physical risks	50%	
		• Water stress risk	40%	
		• Water usage & management	10%	
Transition opportunities	<ul style="list-style-type: none"> Opportunities exist to abate costs from upgrading obsolete technologies and processes. Opportunity for new revenue streams from low-carbon products and supply of low-carbon technologies. 	• Alternative materials	40%	25%
		• Alternative fuel	20%	
		• Financial scope	20%	
		• Innovation scorecard	20%	
Climate governance & strategy	<ul style="list-style-type: none"> Ambition level of target setting provides insight on companies' strategies to avoid future climate-related financial costs. Operating with an internal carbon price indicates preparedness for tightening emission regulations. 	• Emissions reduction targets	25%	30%
		• IEA gap analysis	25%	
		• Emissions data verification	5%	
		• Climate-related remuneration	15%	
		• Board level climate management	10%	
		• Internal carbon price	15%	
		• CDP score	5%	

Source: CDP

For further study

Areas for further research include:

▼ The impact of Chinese cement companies in the global landscape for decarbonization of the cement sector.

▼ A more in-depth assessment of low-carbon products development, related R&D investments, and potential revenue generation from these products.

Transition risks

- ▶ The companies in our sample have on average reduced their emissions intensity by 1% per annum over the past 4 years. This is largely driven by improvements in clinker ratio with thermal energy intensity flat over the period.
- ▶ Three Indian companies, Dalmia Bharat, Shree and Ambuja, lead overall in terms of transition risk. This is due to their newer, more efficient plants and their larger access to alternative materials such as fly ash and slag.
- ▶ European companies CRH, LafargeHolcim and Heidelberg are middle range performers. They do not reach top ranks in any of the sub-metrics, with their internationally diversified operations drawing them towards the average of the group.
- ▶ Asia Cement and CEMEX perform least well. Both companies have high clinker ratios and high exposure to potential regulatory risk from down the value chain.

Overview

In this section we seek to identify companies that are comparatively more exposed to risks from the transition to a low-carbon economy through an analysis of their Scope 1 and Scope 2 emissions, thermal energy intensities, clinker ratios, financial flexibility and their exposure to potential future tightening of building regulations.

Clinker is the main component of cement, with traditional Ordinary Portland Cement (OPC) comprising of 95% clinker. Its production process is responsible for around 55% of cement emissions. Improvements in thermal efficiency and fuel switching play a comparatively smaller role towards emissions abatement. The remaining emissions from calcination will need to be abated through radical product innovation, substitution or carbon capture and storage.

There is awareness of these challenges among most of the companies in our sample, and some progress is visible in the reduction of emission intensities. Scope 1 intensities have fallen on average by 1% yearly between 2012 and 2016, largely as a result of declining clinker ratios and despite flat thermal efficiency levels. Improved regulation, management efforts and growing customer awareness of the performance characteristics of blended cements are all important drivers behind this trend, though the pace of improvement will need to more than double to put the industry on track for a 2-degrees warming target.

As cement is at the beginning of the value chain for the building and the infrastructure industries, future actions to curb emissions in these sectors could have repercussions on cement companies. For this reason, we include here an assessment of how a potential future tightening of cities regulation on buildings could affect the companies in our sample.

We assess transition risks using the following five metrics:

Metric 1) Emissions intensity: This metric identifies the companies with the lowest current Scope 1 & 2 emission intensity levels and evaluates the extent to which companies have reduced their operational emissions intensity over the period 2012-2016. Gross emission intensities are normalized by tonnes of cementitious product as per emissions disclosure guidance provided by the WBCSD's Cement Sustainability Initiative (CSI).

Metric 2) Thermal energy intensity: This metric evaluates the extent to which companies have reduced the thermal energy intensity of their operations over the period 2012-2016. Thermal intensity is normalized by tonnes of clinker as per CSI guidance.

Metric 3) Clinker ratio: This metric evaluates the current clinker ratio (the ratio of clinker to cementitious product) and how this has changed across the period 2012 to 2016. The process of clinker production is responsible for 55% of cement Scope 1 emissions. For further details refer to "Cement production and its emissions" on page 13.

Metric 4) Financial flexibility: This metric evaluates the financial flexibility of a company based on two measures of indebtedness: current level of gearing and net debt to EBITDA.

Metric 5) Downstream regulation: This metric evaluates the extent to which companies in our sample are exposed to potential future tightening of building regulation. It does this by capturing the percentage of capacity which is in a 150km proximity to cities which are part of the C40 network and/or have committed to future actions on building codes and regulation.

Figure 11: Transition risks summary

Company	Emissions intensity	Thermal energy intensity	Clinker ratio	Financial flexibility	Downstream regulation	Overall weighted rank	Transition risks rank
Dalmia Bharat	1	5	1	9	1	3.2	1
Shree	2	2	2	3	5	3.7	2
Ambuja	3	4	3	1	1	4.3	3
ACC	4	3	7	2	3	4.9	4
UltraTech	9	1	9	4	4	5.9	5
CRH	7	8	5	6	11	6.9	6
Cementos Argos	5	12	4	9	8	7.1	7
LafargeHolcim	6	9	8	8	6	7.2	8
Heidelberg	8	11	6	6	9	7.5	9
Cementir	10	7	12	5	7	7.6	10
Taiheiyō	12	6	10	9	10	8.9	11
CEMEX	11	13	11	13	13	10.7	12
Asia Cement	13	10	13	12	12	10.7	13

Weighting **45%** **25%** **15%** **10%** **5%**

Note: In calculating the weighted rank in this table, we use the weighted ranks for each area. We display non-weighted ranks in this summary for simplicity only. Source: CDP

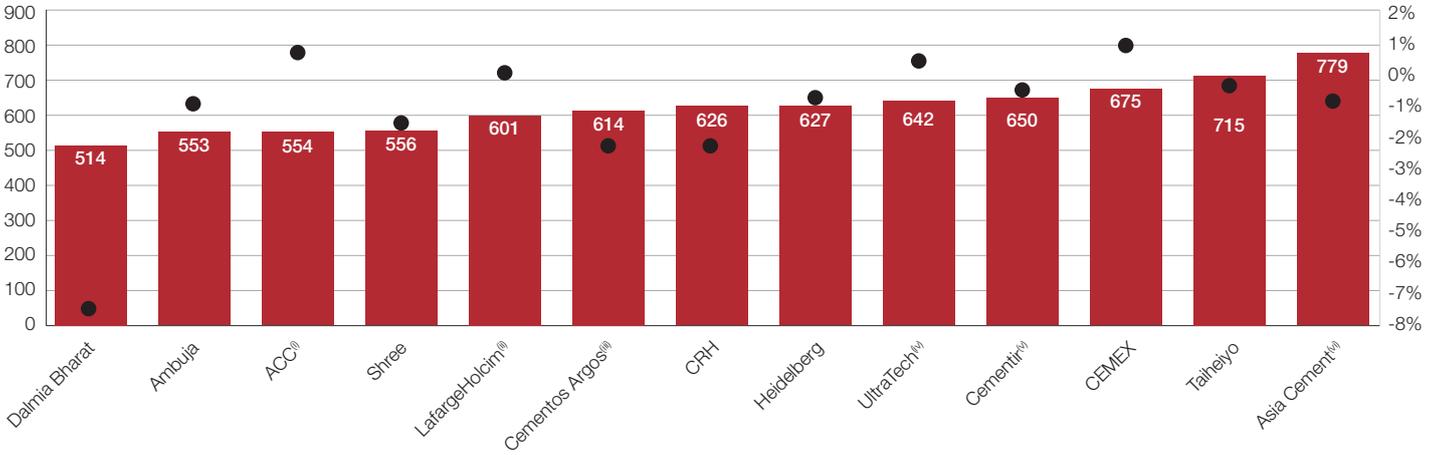
Highlights

- ▼ Dalmia Bharat leads overall in this section with best performance in emissions intensity, clinker ratio and exposure to downstream regulation.
 - Despite topping the ranks in thermal energy intensity, UltraTech is ranked fifth last in Scope 1 emissions intensity due to its high clinker ratio.
- ▼ Shree, Ambuja and ACC sit under Dalmia Bharat, all delivering strong emissions performance and financial resilience with Ambuja and ACC holding negative net debt.
- ▼ Asia Cement comes last for emissions intensity and clinker ratio, second last for built environment and financial flexibility and therefore ranks last overall.
- ▼ CEMEX is positioned second last, coming last across three metrics: thermal energy intensity, financial flexibility and downstream regulation exposure. It has also shown deteriorating performance across most metrics over the period.
- ▼ LafargeHolcim’s emissions intensity profile has been flat over the past three years, and Heidelberg’s intensity improvements have come to halt as a result of the Italcementi acquisition.
- ▼ Asia Cement and Taiheiyō are the worst performing companies in terms of Scope 1 emissions intensity. This is largely driven by their higher clinker ratios, while being middle range performers in terms of thermal energy performance.
- ▼ Heidelberg’s acquisition of Italcementi has increased the group’s absolute emissions by 23% and its net emissions intensity by 3%.
- ▼ Most companies have exhibited progressive reductions in Scope 1 emissions intensity over the four year period with the exceptions of ACC, UltraTech, LafargeHolcim and CEMEX. LafargeHolcim refers to the fact that intensity has flat-lined as they have approached the limits of many known levers.
- ▼ Indian companies Shree, UltraTech and ACC lead the pack with regards to Scope 2 emissions intensity. This is surprising considering the emissions intensive nature of the grid in India, however, this may be due to a significant amount of on-site power generated by these companies. According to the most recent CSI guidance these emissions should be captured in Scope 1 emission calculations.

Emissions intensity

- ▼ Three Indian companies (Dalmia, Ambuja & ACC) are new additions to the report and rank respectively first, third and fourth in current Scope 1 emissions intensity performance.
- ▼ Dalmia Bharat has the best Scope 1 intensity emissions performance in our group, with a level 19% below global average, and has delivered the most aggressive reduction in Scope 1 intensity over the period 2012-2016.
- ▼ Indian companies generally tend to outperform European and Latin American companies in terms of Scope 1 emissions with the exception of UltraTech.
- ▼ Conversely, CRH, CEMEX and Cementir are the worst performers which may be driven by the reverse context in which a majority of electricity consumed is purchased from the grid.
- ▼ All companies have delivered reductions in Scope 2 intensity over the four year period with the exception of Ambuja and CEMEX.

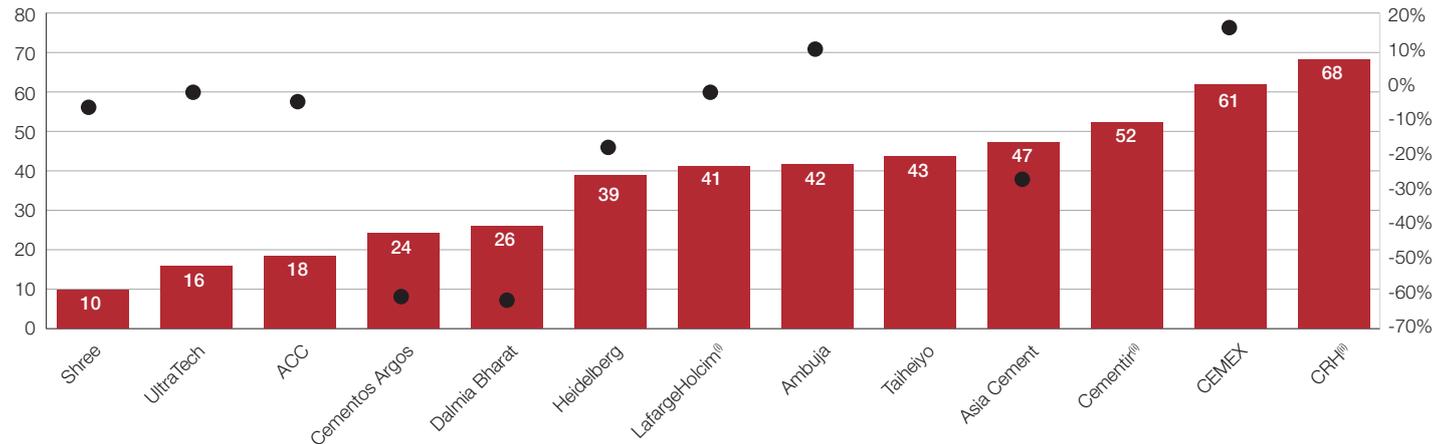
Figure 12: Scope 1 emissions intensity



■ Scope 1 intensity (kg CO₂ / tonne cementitious product) - Average 2015-2016 (LHS) ● CAGR 2012-2016 (RHS)

- (i) ACC – gross emissions intensities for 2012 and 2013 have been estimated from net emissions intensities by applying the proportion of absolute gross to absolute net emissions in 2012.
 - (ii) LafargeHolcim – figures before 2013 have been estimated as the average of individual Lafarge and Holcim reporting.
 - (iii) Cementos Argos - gross emission intensities for 2012 and 2013 have been estimated from net emissions intensities using 2014 proportion of gross absolute to net absolute emissions.
 - (iv) UltraTech – all gross emission intensity figures across the period have been estimated from net emission intensities using the proportion of gross absolute to net absolute emission in that year.
 - (v) Cementir – emission intensity originally normalized by tons of cement equivalent, this has been converted to tons of cementitious material using a 7% reduction factor.
 - (vi) Asia Cement – Taiwan plants only.
- Source: CDP, company reporting

Figure 13: Scope 2 emissions intensity



■ Scope 2 intensity (kg CO₂ / tonne cementitious product) - Average 2015-2016 (LHS) ● CAGR 2012-2016 (RHS)

- (i) LafargeHolcim – figures before 2013 have been estimated as the average of individual Lafarge and Holcim reporting.
 - (ii) CRH and Cementir current figures represent 2016 data only.
- Source: CDP, company reporting

Cement production and its emissions

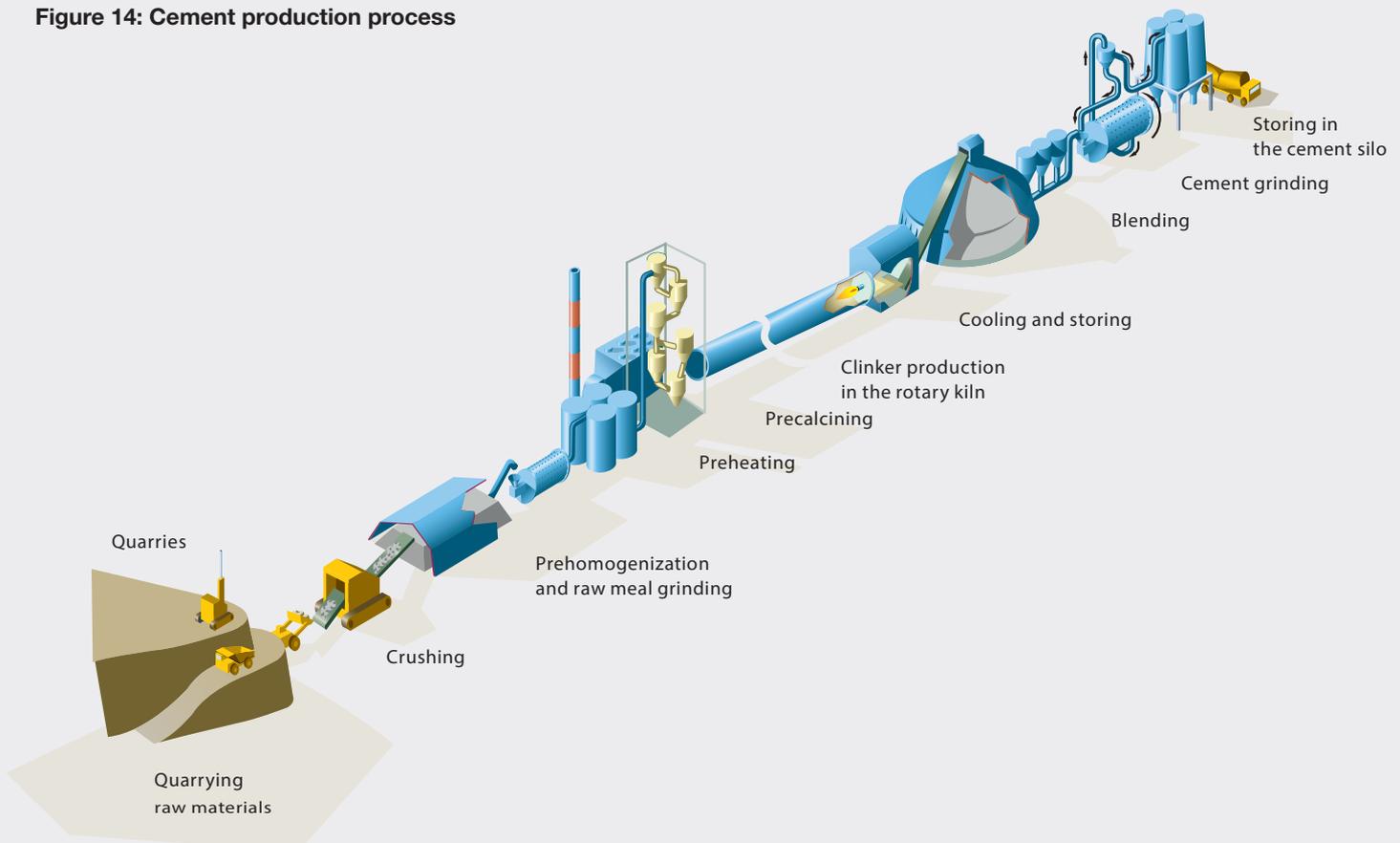
Cement is a hydraulic binder, largely used to fix fine sand and coarse aggregates together to make concrete. In the cement production process, direct emissions are generated from two main sources: the calcination of carbonates within the raw material mix which accounts for around 55% of the emissions generated and the combustion of kiln fuels accounting for around 35% of the emissions profile. Some additional emissions may also be produced where power is generated on-site. Together, these three emission sources form the basis of Scope 1 emission calculations⁸.

Indirect emissions are also produced from the generation of purchased electricity which forms the basis of Scope 2 emissions calculations. Finally, Scope 3 emissions are generated from a range of sources including purchased goods (e.g. purchased clinker) and services such as clinker, transport and any emissions relating to the use phase of the product downstream. This emissions category is much more complex to calculate and generally there is a broad range of calculation methodologies of varying levels of sophistication. Due to this complexity and the relatively low weight of emissions compared to the other sources and in order to avoid unfairly comparing inconsistent methodologies and penalizing companies with more complete Scope 3 calculations, we have not included Scope 3 as a metric in our analysis.

The cement production process is largely standardized but can vary marginally from plant to plant depending on the chemical composition of the raw materials, the kiln and the grinding technologies available. Fundamentally, cement production is made up of four key stages:

- 1) Quarrying raw materials:** Limestone is quarried usually from a nearby deposit along with other raw materials such as shale or clay to produce the raw mix. The chemistry of the raw mix varies geographically, however it is typically comprised of around 85% limestone. This raw mix is then crushed and dried before entering the pre-calciner.
- 2) Pre-calcination:** The pre-calciner is a suspended preheater which raises the temperature of the raw mix to around 750 degrees Celsius, beginning the thermal processing of limestone. Not all plants use a pre-calciner but this technology is considered to be more efficient and commonplace in newer plants.
- 3) Clinker production:** The materials then move into the rotary kiln where the remaining calcination process takes place. The kiln is heated to up to 1,450 degrees Celsius which drives endothermic reactions converting CaCO_3 into CaO and CO_2 . CO_2 is released into the atmosphere in an impure form and nodules of clinker remain in the kiln.
- 4) Mixing and grinding:** Gypsum is then added (equating to around 5% of the total blend) to control the setting time of the end product. The clinker-gypsum mix is then ground into a power called Ordinary Portland Cement (OPC) or ground with other mineral components such as slag and fly ash components to produce blended cements. Typically ball mills are used for grinding, however, more efficient technologies such as roller pressers are used in newer plants⁹.

Figure 14: Cement production process



Source: IEA, 2009, Cement Technology Roadmap

8. CSI, 2011, CO₂ and Energy Accounting and Reporting Standard for the Cement Industry

9. Cemnet, 2014, The Cement Operations Handbook

Chinese cement producers and climate-related disclosure

China currently produces approximately 2.5 billion tons of cement per annum, accounting for over half of global production (around 60% in 2014)¹⁰. The scale of Chinese cement consumption is also equally considerable. Between 2011 and 2013, China used more cement than the U.S. used in the entire 20th Century¹¹.

In recent years however, the Chinese cement market has experienced significant overcapacity. As a result, the Chinese government has been driving industry rationalization, last year merging two of the largest Chinese cement makers, CNBM and Sinoma, to form the world's largest cement maker. According to the Global Cement Directory (2015), the top 20 cement producers in China and Taiwan account for 57% of cement production capacity but only 33% of cement plants, implying an average capacity per plant of more than 2,000 mt capacity. This highlights China's trend for consolidation such that the top producers operate fewer plants with greater production capacities. The remaining 43% of cement capacity in China and Taiwan is owned by hundreds of small cement companies, often operating remote plants with capacities as comparative to 50,000 tons per annum¹². This trend is captured in the IEA's 2018 Cement Technology Roadmap which projects that the Chinese share of global cement production will fall by 27% by 2050¹³.

In 2014, official Chinese statistics reported a national average clinker ratio of 0.57, relatively low comparative to other regions (this has not been verified with individual companies). The IEA's beyond 2-degrees scenario (B2DS) requires this clinker ratio to come down to 0.55 by 2060, assuming that 80% of emissions are captured by CCS by that year. As a number of clinker substitutes are by-products from other high emitting industries such as steel and coal based power generation, their availability in China is currently high but could present a challenge in the long term. The B2DS also requires production to peak before 2020 while still remaining the largest global producer out to 2060¹⁰.

Given the large number of remote cement plants and the lack of independent verification regarding the information supplied by Chinese producers, data regarding plant operations is incomplete¹². In addition, due to the lack of disclosure through the CDP disclosure platform we have been unable to include the large Mainland Chinese companies in our analysis. However, given the size of the Chinese cement market we have provided below some available basic data-points on some of the largest listed companies. We used the Global Cement Directory data and the clinker ratio included in CSI (0.77) to estimate the emission profiles. We have also assessed the level of transparency provided in the public reporting of these companies.

Figure 15: Selection of large mainland Chinese cement producers

Company	Average market cap 2017 (US\$bn) ⁽ⁱ⁾	2016 cement production (million tonnes)	Estimated emissions intensity (kg/t cement) ⁽ⁱⁱⁱ⁾	Publicly reported CO ₂ emissions	Publicly reported energy data	Sustainability report in Chinese and/or English
Anhui Conch Cement	18.5	277 ⁽ⁱⁱ⁾	557	Partial	No	Chinese
BBMG	8.6	55	725	No	Yes	Chinese and English
China National Building Material	3.7	257	726	No	No	Chinese and English
China Resources	3.7	76	509	No	Yes	Chinese and English

(i) Daily average market cap for calendar year 2017.

(ii) 2016 sales production.

(iii) Estimated by CDP based on Global Cement Directory data assuming a 0.77 clinker ratio as per CSI GNR (2015).

Source: CDP, company reporting

This lack of transparency significantly limits the extent to which investors and other stakeholders, in China and internationally can assess company risk and preparedness for a low-carbon transition. This data, in addition to information on climate governance & strategy, would help investors and other stakeholder appropriately assess their risk exposures.

10. IEA, 2017, ETP

11. Vaclav Smil, 2013, Making the Modern World: materials and dematerialization

12. Global Cement, 2015, The cement industry of China - a new normal

13. IEA, 2018, Technology Roadmap: Low carbon transition in the cement industry

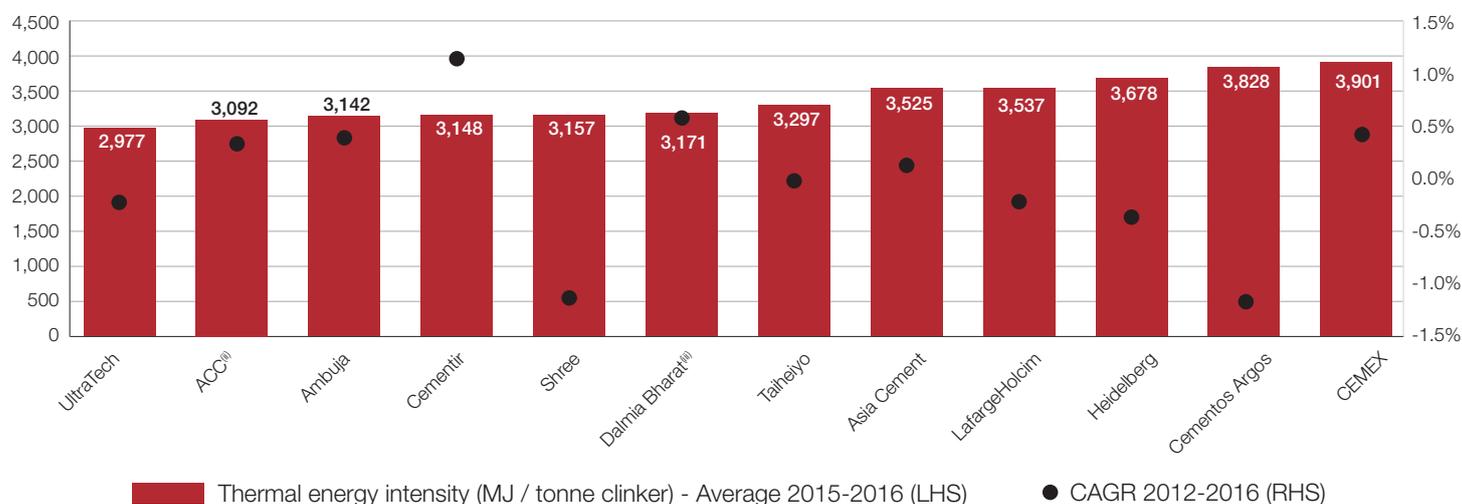
Thermal energy intensity

- Clear geographical clusters emerge across thermal intensity performance. Indian companies perform best, followed by East-Asian and European companies (with the exception of Cementir), with Latin American companies worst performers.
- As thermal energy intensity is largely dependent on the kiln technology, this regional spread partly reflects the fact that the newest and most efficient plants coming online in recent years have been in India and Asia, where market growth is high, with European plants tending to be older.
- UltraTech performs best in thermal energy intensity. Its portfolio of plants is completely dry and it has been upgrading its asset base to plants of progressively larger denomination.
- CEMEX ranks last and has continued to increase its thermal energy intensity over the period. Its current intensity sits significantly above the 2014 GNR global average. In 2016 this was particularly profound as some of their highest performing kilns were out of service during a significant part of the year.
- While Cementos Argos is ranked second last, it has delivered the most aggressive reduction in thermal energy intensity over the period. This is due to recent expansion into the United States which has shifted the balance of its plants from wet to dry. Conversely, Cementir ranks fourth for its current intensity, however, this has risen by over 150 MJ/t clinker since 2012.

Clinker ratio

- Asia Cement and Taiheiyu rank last with respect to the clinker ratio, with current clinker ratios of respectively 17 and 9 percentage points above the 2014 global average.
- Indian companies Dalmia Bharat, Shree and Ambuja lead the pack with Dalmia Bharat exhibiting a clinker ratio well below the best in class. As these companies have a regional focus and primarily produce and sell into India, they are able to produce cement products which are specifically targeted to the local regulatory environment.
- UltraTech performs middle of the pack, with a clinker ratio higher than its Indian peers. This is due to a comparatively higher proportion of customer demand for OPC used in infrastructure work.
- Cementir, CEMEX and LafargeHolcim are the only companies in the universe which have increased their clinker ratios across the period. For CEMEX, this is due to increasing demand for structural cements with higher clinker ratios driven by largescale infrastructure projects in Latin America.

Figure 16: Thermal energy intensity⁽ⁱ⁾



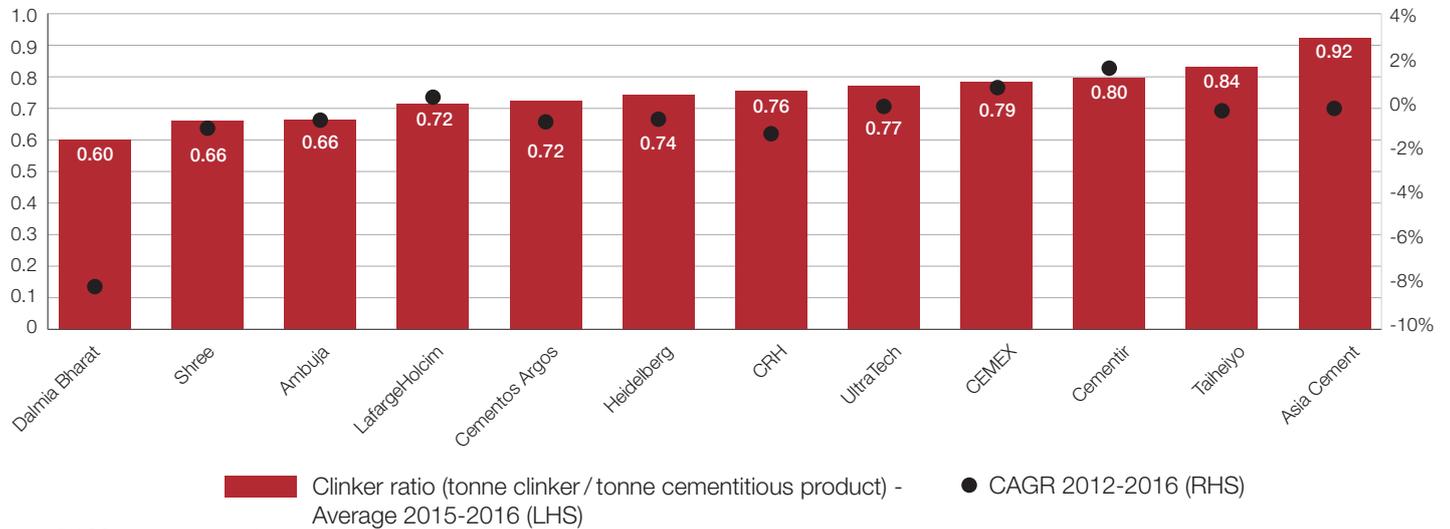
(i) CRH data not provided.

(ii) ACC data converted from kcal/ton of clinker to MJ/ton of clinker.

(iii) Dalmia Bharat 2013 data for three sites only.

Source: CDP, company reporting

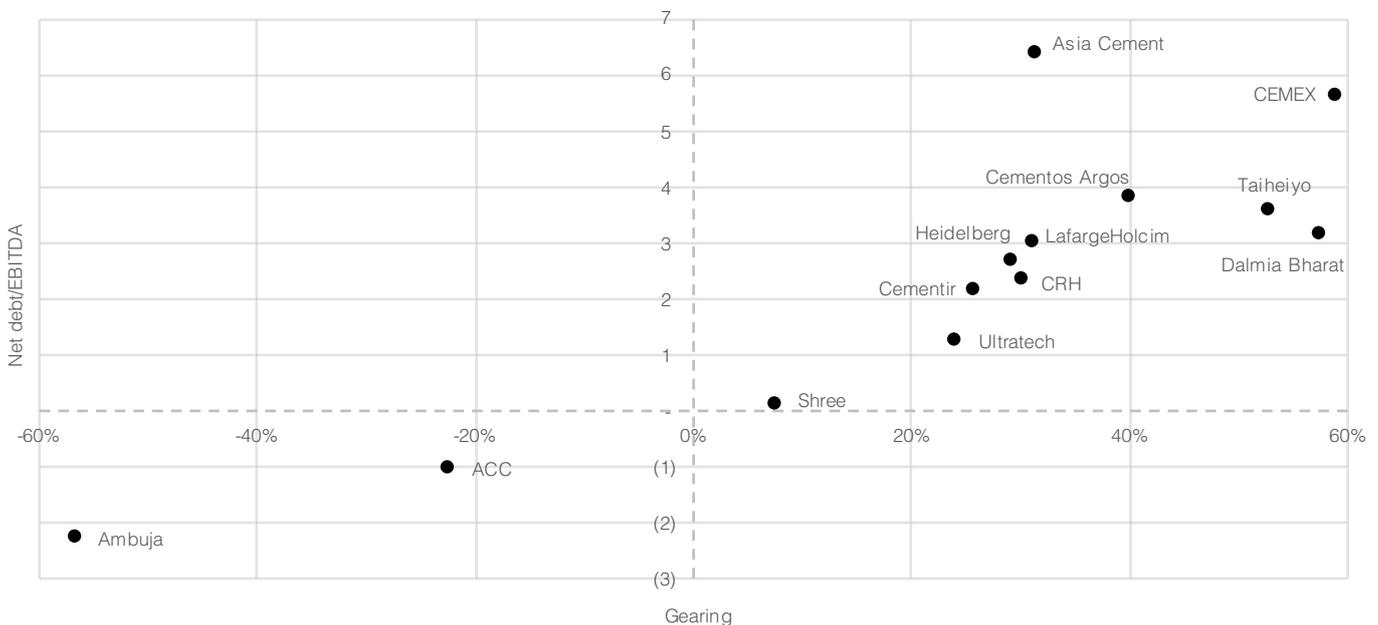
Figure 17: Clinker ratio⁽ⁱ⁾



Financial flexibility

- Both ACC and Ambuja are well positioned in terms of financial flexibility as their current cash reserves exceed their borrowings. They both therefore have negative gearing and a negative net debt to EBITDA ratio.
- Shree follows closely behind in third place for both gearing and net debt to EBITDA.
- CEMEX ranks last in terms of gearing, with gearing at nearly 60%. It also ranks second last in terms of net debt to EBITDA.
- Asia Cement ranks last in terms of net debt to EBITDA ratio. Currently it would take over five years' worth of operating income for Asia Cement to pay back its debt.

Figure 18: Financial flexibility



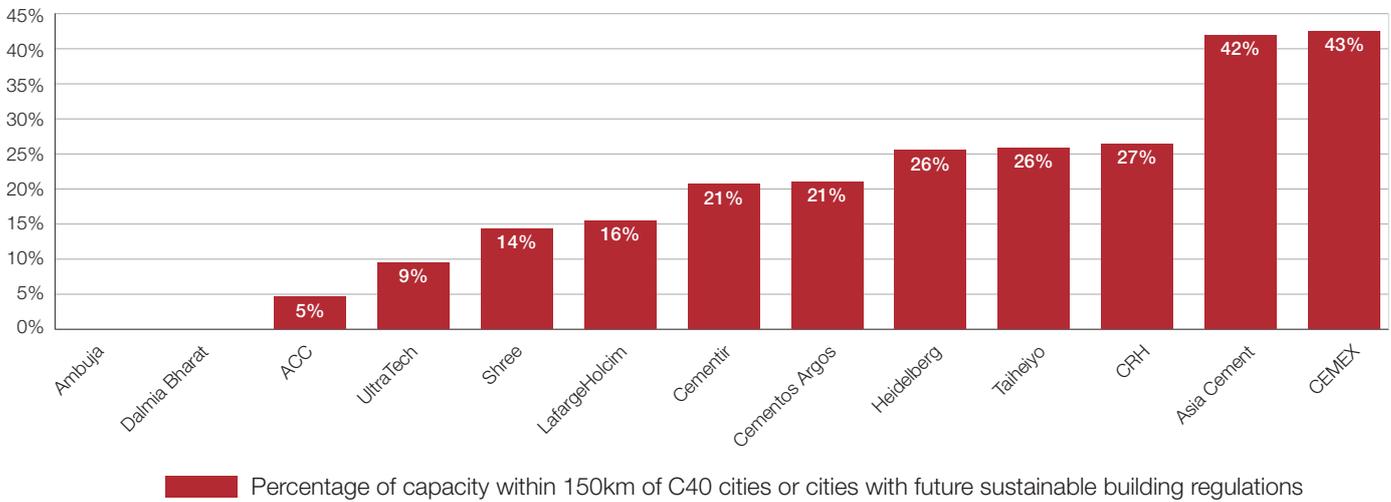
Downstream regulation

There is typically limited visibility over the specific end-markets where cement companies' products are sold into. Nonetheless, we believe this is an important indicator of a company's exposure to potential regulatory tightening in the future, with plants that supply cities which have set ambitious decarbonization targets being potentially more at risk than plants which are close to cities without decarbonization ambitions.

We have tried to estimate this by looking at the proximity of our sample companies' plants to cities with environmental ambitions. More specifically we have considered plants which are within a 150km radius from a) any city that is part of the C40¹⁴ network, and b) a city that has put in place future actions specifically related to buildings environmental regulation. In our view, this represents a fair proxy of cement production sold into cities which are more likely in the future to implement standards/regulation impacting building materials (be it around life-cycle assessment, embodied emissions or environmental product labelling).

- ▼ The top two companies exposed to this type of regulatory risk are CEMEX due to their production in the US and a number of C40 cities in Central/South America and Asia Cement due to the proximity of their plants to cities in Taiwan with building environmental regulation actions and some plants in Mainland China close to C40 cities.
- ▼ At the bottom are three Indian companies (ACC, Dalmia Bharat and Ambuja), with no or very limited exposure to cities with ambitious buildings regulation targets.
- ▼ LafargeHolcim and Heidelberg rank middle of the pack due to their diversified geographical exposure.

Figure 19: Downstream regulation



Source: CDP, Global Cement

14. C40 is a network of the world's megacities committed to addressing climate change. C40 supports cities to collaborate effectively, share knowledge and drive meaningful, measurable and sustainable action on climate change.

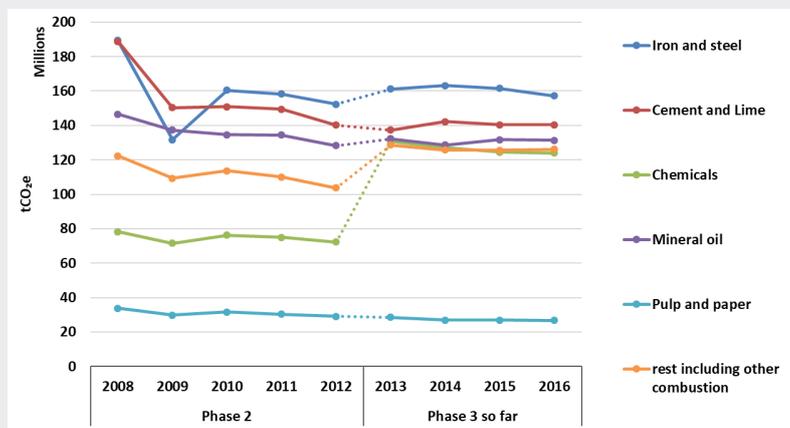
EU ETS and Windfall Gains for the Cement Sector

The EU Emissions Trading Scheme has been the main regulatory mechanism to regulate emissions from high carbon emitting sectors in Europe. The mechanism has suffered from structural issues related to its implementation with the process of allocation to regulated sectors through free allowances resulting in an oversupply of allowances.

The high carbon intensive sectors continue to undermine the system with their ongoing lobbying of policy makers to allocate allowances to them based on the argument of carbon leakage. The former is premised on the fact that sectors that operate globally may be unfairly penalized on their EU emissions where a carbon price is being applied to their activities in Europe while other global competitors may not be regulated by the same carbon pricing leading to potential displacement of business referred to as carbon leakage. We find this argument particularly weak for the cement companies given the regional and local nature of cement markets and our analysis of trade flows (Refer to “Cement flows across the world” on page 19 further details) shows that currently 90% of EU imported cement is coming from other EU countries. The UK and France are among the top 10 global importers of cement, however, around 80% of French imports and virtually the entirety of British imports are from EU countries (mainly Spain, Belgium, Germany for France and Ireland for the UK). On the export side, around 54% of EU cement exports are directed to other EU countries. Spain and Germany are in the top 10 global exporters for global flows with exports together accounting for around 10% of global export flows; respectively 29% and 97% of their exports are directed to other EU countries.

Recent analysis¹⁵ by Sandbag on the EU Emissions Trading Scheme shows that Cement and Lime remain top emitters in the EU along with Iron & Steel and Chemicals, with the percentage reduction of emissions in cement (which fell from 2009 to 2013) in Phase 2 of the scheme actually stabilizing and increasing in Phase 3 of the scheme.

Figure 20: Emissions per main industry sector since 2008 in Phase 2 & 3 of EU ETS



Source: Sandbag, 2017, State of the EU Emissions Trading System 2017

Furthermore, the study notes that for the cement sector, absolute emission reductions achieved between 2010 and 2013 were achieved in line with falling production while emission intensities have been rising for the sector as whole between 2013 and 2016.

Analysis of free allocations versus actual emissions shows that the cement sector continues to enjoy windfall gains from free allocations with iron & steel the only other sector to benefit from this in Phase 3.

While free allocations have tightened between Phase 2 and Phase 3, the cement sector continues to benefit more than other sectors with up to 340m more allowances than required for compliance by 2020.

The study shows that systematic over allocation to the cement sector would have led to potential financial gains of between €1.7-€5.1bn based on EUA prices of €5 to €15/t.

Figure 21: Cumulative balance between free allocations and verified emissions

Industry Sectors	Free allocation minus emissions/Mt CO ₂ e		Balance as % of emissions	
	2008 to 2012	2013 to 2016	2008 to 2012	2013 to 2016
Iron and Steel	405	114	51%	18%
Cement and Lime	282	61	36%	11%
Mineral Oil	57	-103	8%	-20%
Chemicals	89	-8	24%	-2%
Pulp and Paper	59	16	38%	15%
Glass	22	-10	23%	-13%

Source: Sandbag, 2017, State of the EU Emissions Trading System 2017

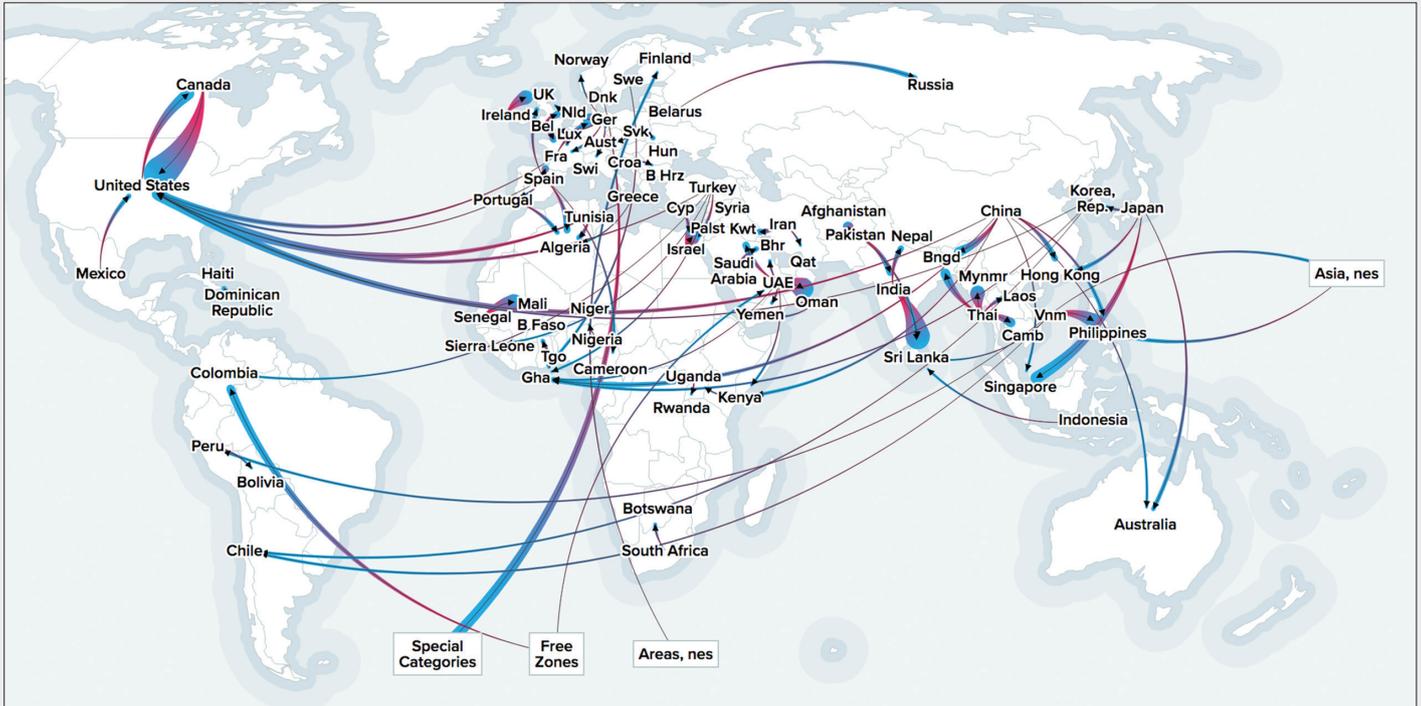
While Phase 4 of the EU ETS scheme should in theory have greater ambition to deal with supply/demand imbalances, the binary approach to carbon leakage being adopted by the scheme negates this impact on sectors such as cement. The binary approach essentially means that if industries argue that they are exposed to carbon leakage – potential for unfair competition from companies outside the EU – they will get 100% free allocation with no adjustment for the degree of carbon leakage risk. Lobbying by the cement sector risks this treatment continuing and the incentive from carbon regulation through the ETS continues to have limited impact on the sector.

15. Sandbag, 2017, State of the EU Emissions Trading System 2017

Cement flows across the world

Cement is a localized industry, given its low value and the widespread availability of limestone, with only 4% of global production traded in 2016. It represents 22% of globally traded industrial minerals and around 1% of traded metals and minerals. The top cement exporter countries are China, Turkey and Japan, with the USA, Bangladesh and Sri Lanka being the top importers. The EU (plus Switzerland, Norway and Iceland) is responsible for around 15% of global imports and 26% of exports, with 90% of imports and more than 50% of exports remaining within the EU borders.

Figure 22: Global cement trades flows



Source: Resource Trade Earth (https://resourcetrade.earth/?_ga=2.133205645.2045801688.1522951762-1149959904.1521027336)

Cement national production and consumption rates can vary widely between countries, with Iceland and Singapore importing virtually their entire consumption from abroad, and Ireland and UAE exporting almost half of their production (Figures 23 and 24 below). The USA, despite being the largest importer in the world, only imports 12% of its consumption, and China, despite being the largest exporter, only exports 3% of its production.

Figure 23: Top 10 global exporters of cement

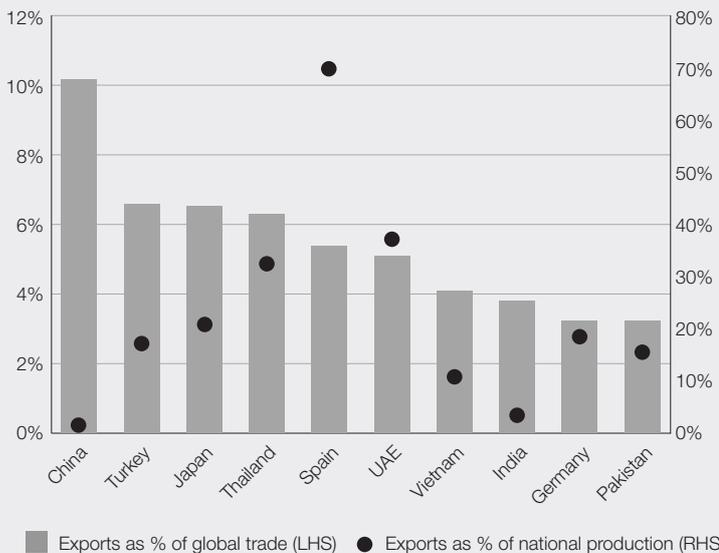
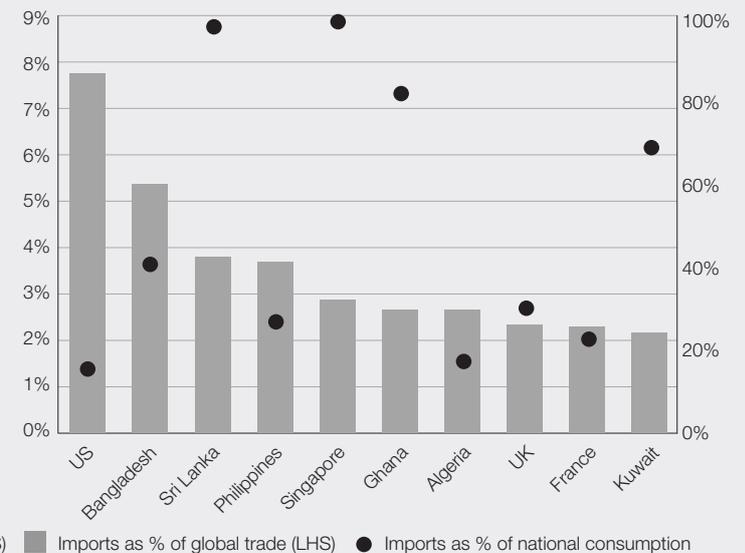


Figure 24: Top 10 global importers of cement



■ Exports as % of global trade (LHS) ● Exports as % of national production (RHS) ■ Imports as % of global trade (LHS) ● Imports as % of national consumption (RHS)

Source: CDP, Resource Trade Earth

Source: CDP, Resource Trade Earth

Global exports are quite concentrated, with the top 10 exporting countries responsible for 55% of global trade, against 35% for the top 10 importers. Among the most concentrated bilateral relationships, we find Sri Lanka with 64% of its imports from India (representing 63% of Indian exports), Singapore with 69% of imports from Japan (30% of exports), Bangladesh with 43% and 41% of imports from China and Thailand (respectively 22% and 34% of exports), and the Philippines with 43% of imports from Vietnam (38% of exports).

Physical risks

- From an acute physical risk perspective, none of our companies are exposed to areas of extremely high risk. However, five of the 13 companies (all Indian) have their entire capacity at medium to high or higher levels of risk. This level of risk is only set to increase in the future.
- Cement companies are not highly water intensive but water stress could pose risks further down the value chain. Two companies (UltraTech and Shree) currently have the majority of their capacity in areas with high water stress risk and will respectively have 41% and 61% of their capacity located in areas of extremely high future baseline water stress risk in 2030.
- The worst performing companies in this section are Indian companies who, with their domestic focused plant portfolios, are seen to be at high levels of risk from water stress and the acute physical risks analyzed, including flood occurrence and seasonal variability.

Overview

There is an understanding within the cement sector that unreliable water supply due to unpredictable weather patterns, coupled with an increase in costs for water procurement, could pose material risks to companies' operations and results. On the other hand, the sector itself is not very water intensive, especially in comparison to other high emitting sectors. Subsequently, only eight of the 13 companies were requested to respond to CDP's water questionnaire, of which only four companies answered.

The role of water within cement production has been reduced over time with wet process kilns being replaced by more efficient dry kilns. In wet kilns, water is evaporated during the production process in the kiln whereas in dry kilns, the raw mix is heated in a pre-heater tower which is more energy efficient and less water intensive. As a result, in the more commonly used dry cement production processes, water is used principally for cooling.

However, despite the limited usage of water in the cement production process, further downstream the production of concrete requires large volumes of cement, aggregates and water. CEMEX state that water is critical to their operations as it comprises nearly 25% of their concrete mixtures and have thus implemented a state-of-the-art water recycling system at their Balcones quarry which will reduce reliance on local water sources by 90%¹⁶.

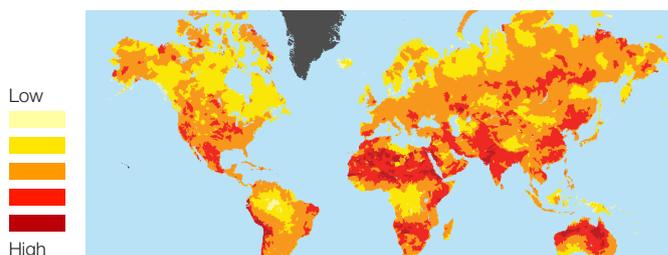
Companies like CEMEX and CRH, with more downstream divisions, face a greater risk from water scarcity than their cement focused peers but the greater physical risk stems from broader meteorological hazards, including droughts and flooding.

Flooding linked to storms and hurricanes can heavily impact all sectors and the cement sector is no different. For Cementos Argos, in September 2017 hurricanes caused a reduction of 8.9% in cement volumes and 11.3% in ready-mix in the south-central region of the USA¹⁷.

CEMEX also suffered, describing 2017 as a 'challenging year' as its operating earnings fell due to a lower contribution from the US, largely down to the hurricanes that hit Florida¹⁸.

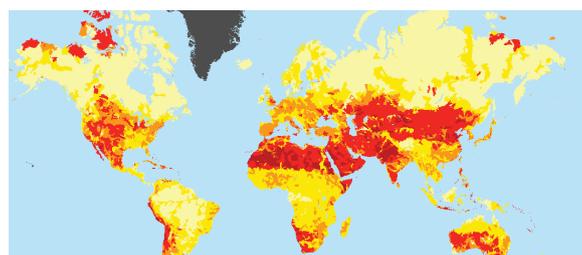
It is not just the physical risks relating to flooding, droughts and the variation in water supply that can adversely affect the companies. The extremely cold weather that hit North-Western Europe in February and March 2018 is estimated to have cost the construction industry 1% of its annual output in the UK. This will be of concern to certain more downstream focused companies in the report who have interests in the European construction sector¹⁹.

Figure 25: Current water stress risk for construction materials



Source: WRI

Figure 26: Current acute physical risk for construction materials



Source: WRI

16. CEMEX, 2016, sustainability report

17. <https://www.cemnet.com/News/story/162837/cementos-argos-raises-cement-volumes-by-16-7-in-3q17.html>

18. <http://www.globalcement.com/news/itemlist/tag/Cemex>

19. <https://www.ft.com/content/0002f9ce-214d-11e8-9efc-0cd3483b8b80>

Metric 1) Acute physical risks: We assess localized acute physical risk on a plant by plant basis using the World Resource Institute (WRI) Aqueduct mapping tool. We adapt the methodology to focus on inter-seasonal variability (the variation of water supply between seasons), annual variability (the variation of water supply between years), flood occurrence (a count of the number of floods recorded from 1985-2011) and drought severity (a factor of average length and dryness of droughts from 1901 to 2008). A company's acute physical risk exposure is scaled by asset level capacity relative to total capacity, to capture its relative size within a company's portfolio.

Metric 2) Water stress risk: We assess localized water stress on a plant by plant basis using the World Resource Institute (WRI) Aqueduct mapping tool. It assesses current water stress conditions based on physical water quantity and quality indicators as well as regulatory and reputational risks. Future water stress exposure is based on baseline water stress, calculated as the ratio of water use to supply. A company's water stress exposure is scaled by asset level capacity relative to total capacity, to capture its relative size within a company's portfolio.

Metric 3) Water usage & management: This metric assesses the water consumption levels of companies relative to their cement production, the percentage of plants with water recycling and also the levels of freshwater withdrawal relative to other water sources. Water consumption evaluates a company's net impact on a watershed or aquifer where current intensities and reductions since 2012 are assessed. The proportion of current sites with water recycling technologies enabled and current levels of fresh water withdrawal are further examined.

Figure 27: Physical risk summary

Company	Acute physical risks	Water stress risk	Water usage & management	Overall weighted rank	Physical risk rank
Taiheiyo	2	3	3	2.9	1
Cementos Argos	3	2	10	3.1	2
Asia Cement	7	1	13	3.7	3
CRH	4	4	5	4.4	4
Cementir	1	10	9	4.6	5
LafargeHolcim	6	5	7	5.1	6
Heidelberg	5	7	12	5.2	7
CEMEX	8	8	6	5.6	8
Dalmia Bharat	9	6	8	6.6	9
ACC	10	9	11	7.9	10
Ambuja	11	11	2	9.3	11
UltraTech	12	12	4	10.6	12
Shree	13	13	1	12.0	13

Weighting **50%** **40%** **10%**

Note: In calculating the weighted rank in this table, we use the weighted ranks for each area. We display non-weighted ranks in this summary for simplicity only. Source: CDP

Highlights

- ▼ Taiheiyo comes first overall in the physical risks section. The company comes second in the acute physical risks metric where 62% of its capacity is at low to medium risk, it comes third for water stress risk where only 13% of its capacity is currently at high water stress risk and third for water usage & management, sourcing the lowest proportion of its water from fresh water sources of all companies. Taiheiyo also has water recycling technologies at all of its plants.
- ▼ Shree is in last place and is judged to be at the highest risk from a mixture of floods, droughts, seasonal variability and inter-annual variability. 46% of its capacity is currently at high risk from acute physical risks and 67% is at high or extremely high risk from water stress – the worst figure on both metrics. However, this is countered by Shree coming first for water usage & management, reducing its water consumption intensity by 22% annually since 2012, only sourcing 10% of water from fresh water sources and employing water recycling at all plants.
- ▼ Cementos Argos comes second overall. Cementos Argos is third for acute physical risks with 34% of its capacity at low to medium acute physical risk and they are second for water stress risk with low current water stress risk and future baseline water stress risk. However, Cementos Argos do come tenth for water usage & management with the fourth highest current water consumption intensity and with only 72% of its plants fitted with water recycling technologies.
- ▼ UltraTech and Ambuja come second and third last respectively. UltraTech currently has 27% of its capacity at high acute physical risk and Ambuja 19%. For water stress risk, they are the only two companies aside from Shree to have current capacity at extremely high risk, due to their domestic focus. However, like Shree, both UltraTech and Ambuja are managing their physical risks well, reducing their water consumption intensities since 2012 annually by 2% and 35% respectively and both having 100% of their sites capable of water recycling.

Acute physical risk exposure

- From an acute physical risk perspective, not a single company has any of its capacity currently at extremely high risk.
- The five companies viewed as currently being at most risk are the five Indian companies, all who have a very domestic focused portfolio of plants. All five Indian companies have their entire capacity at medium to high or higher levels of acute physical risk.
- The company with the highest acute physical risk related to its plant locations is Shree. This is because Shree's plants are all in India, a country which is highly exposed to meteorological hazards.
- Cementir is at least risk with 86% of its capacity at low to medium risk, the highest proportion of all companies. Cementir's strong performance has been aided by the selling of Cementir Italia to Italcementi, a subsidiary of Heidelberg, as areas of Northern Italy, where certain Cementir Italia plants are based, are at medium to high risk which would increase Cementir's overall physical risk.
- Looking at how the different acute physical risks can impact the companies, the Indian companies seem to be at greater risk than the other companies from seasonal variability. In Figure 29, we can see that the bar representing seasonal variability is considerably bigger for the Indian companies relative to the other companies, indicating that the risk relating to variation in water supply between months of the year is far greater for the Indian companies than their peers.
- Figure 29 also shows that the main acute physical risk that the cement companies face comes from flooding. This includes flooding from storms and on average just under 50% of the acute physical risk that a company faces comes from flooding. The financial risks associated with storms and flooding are very evident with Hurricane Maria in Puerto Rico affecting Cementos Argos's plant there for 153 days in 2017, negatively affecting the Q4 EBITDA margin²⁰.

Figure 28: Current acute physical risk exposure

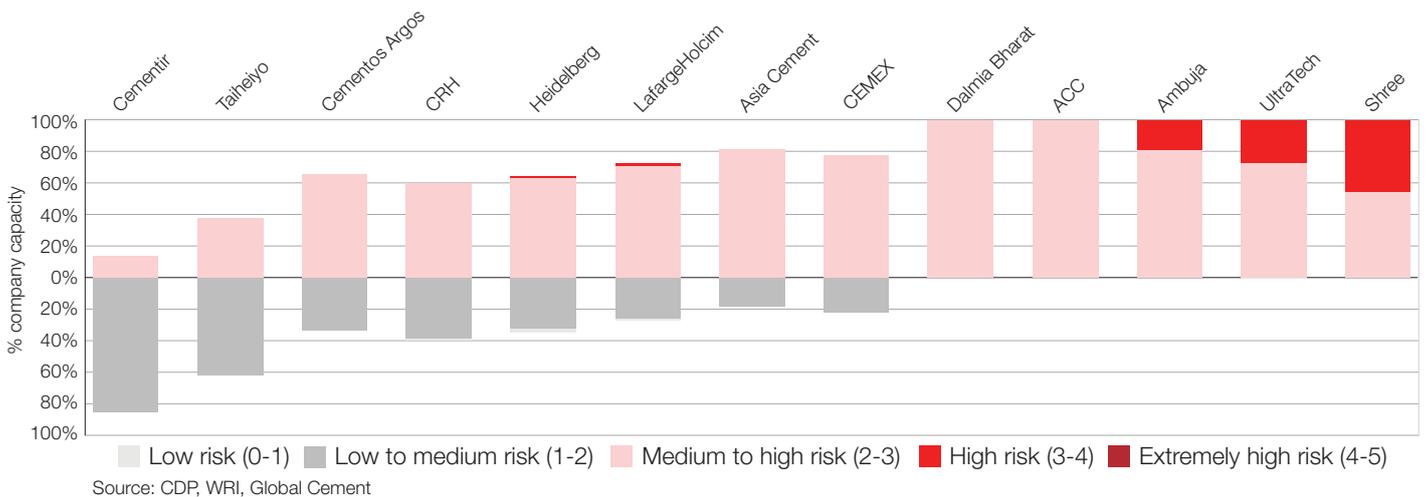
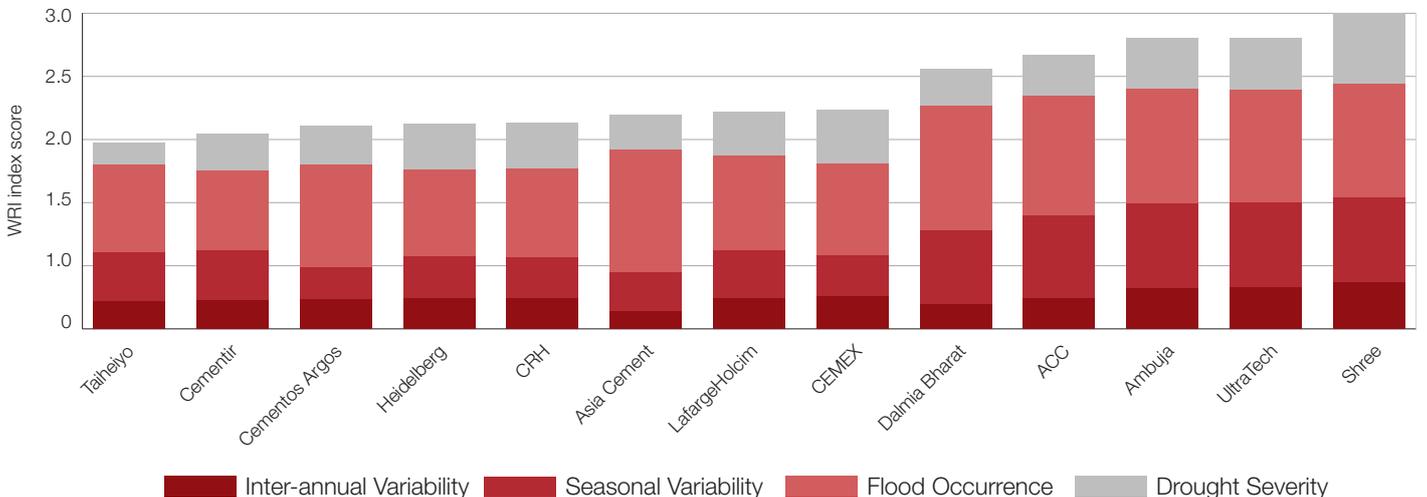


Figure 29: Current acute physical risks breakdown⁽ⁱ⁾



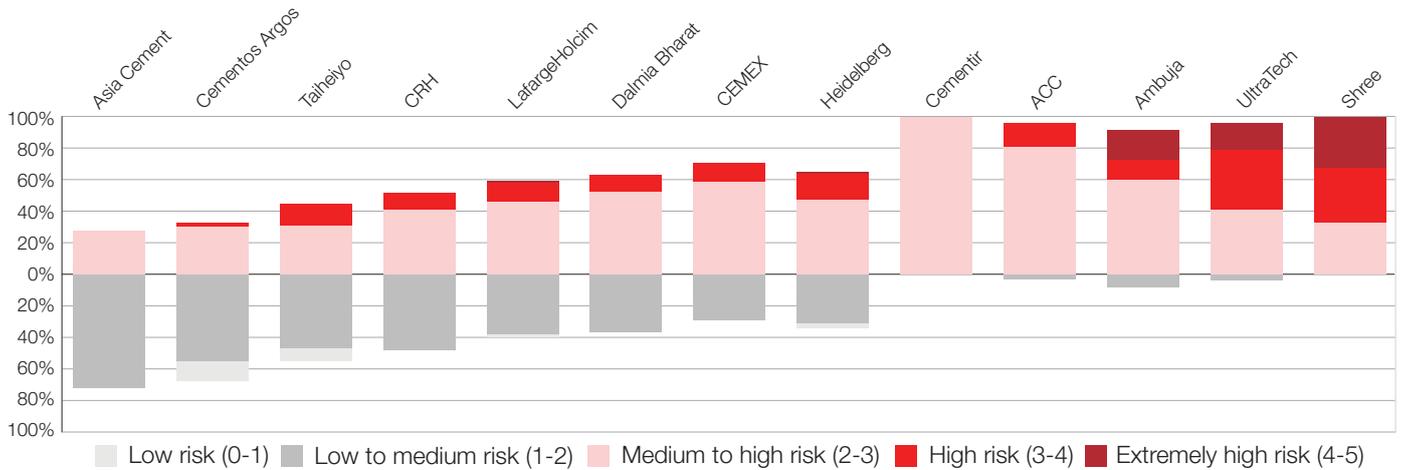
Water stress risk

- Currently, the top four companies at the highest risk from water stress are all from India. Shree, UltraTech, Ambuja and ACC all have domestic dominated portfolios and the current water stress risk in India is very high.
- Shree is the company currently most at risk from water stress with 32% of its capacity at extremely high risk and 35% at high risk. The remaining 33% is still at medium to high risk so it is critical for Shree to be prepared for these risks as their entire capacity is at least at medium water stress risk.
- Moreover, in 2030, Shree is predicted to have 76% of its capacity at high or extremely high baseline water stress risk. That ultimately means in the areas where 76% of their capacity operates, there will be substantial risks relating to the water usage relative to its supply and this could impact negatively on company operations and earnings.
- UltraTech and Ambuja come second last and third last, currently having 55% and 31% of their capacity at high risk or extremely high risk respectively. Furthermore, both Ambuja and UltraTech have the highest proportion of their plants at medium baseline

risk or higher in 2030 – 91% of Ambuja’s capacity and 89% of UltraTech’s capacity.

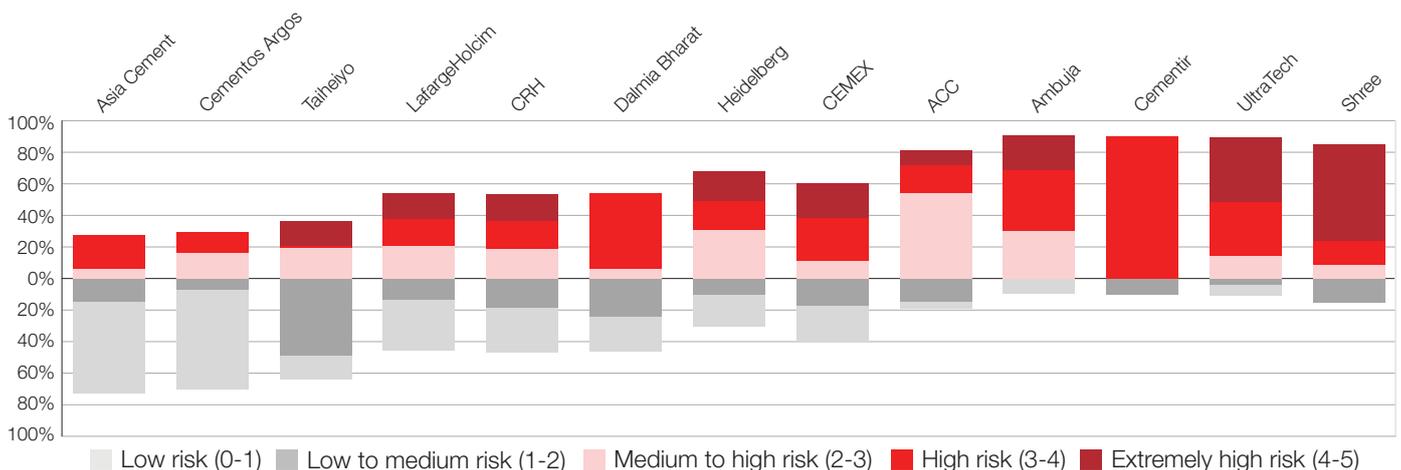
- Cementir are a good example of a company who currently have limited overall water stress risk but in 2030 are predicted to face very high baseline risk. Currently, they have no plants in high risk or extremely high water stress risk areas but in 2030, 90% of their portfolio will be at high water baseline risk.
- Asia Cement, Cementos Argos and Taiheiyo come first, second and third respectively for current water stress risk and that remains the case in a 2030 future baseline water stress scenario. For all three future companies, in 2030 it is expected that much less than half of their capacity will be at medium or higher risk from baseline water stress.
- Asia Cement is the least at risk from water stress at this moment in time with 73% of their capacity at low to medium risk, the highest proportion of all companies. Moreover, Asia Cement is one of only two companies, Cementir the other, to currently have none of its capacity in either high risk or extremely high risk, down to their East Asian focus.

Figure 30: Current water stress risk



Source: CDP, WRI, Global Cement

Figure 31: Future baseline water stress risk

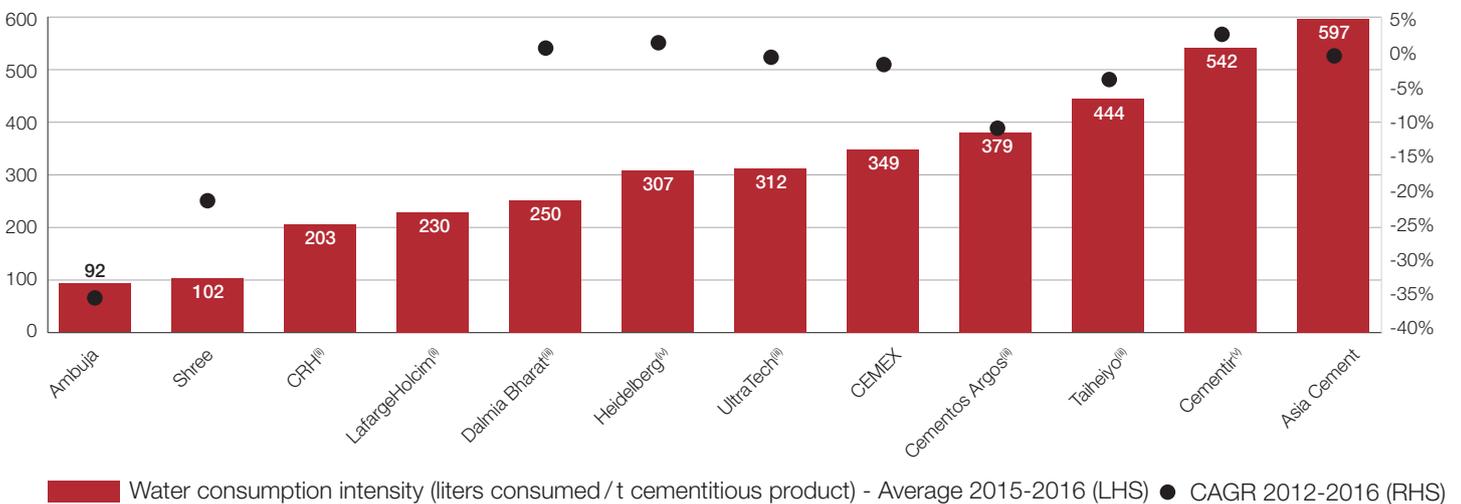


Source: CDP, WRI, Global Cement

Water usage & management

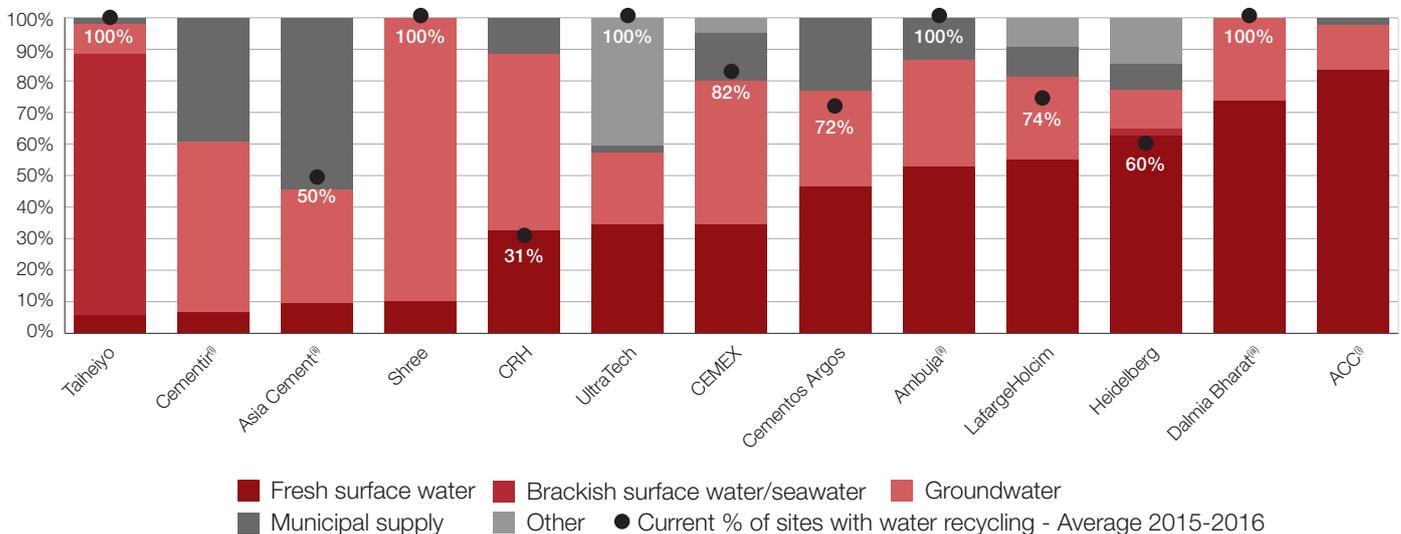
- Generally, there was a vast contrast in disclosure for the sub-metrics of water usage & management. Disclosure was poor for water consumption intensities as less than half the companies reported figures and less than half also disclosed the proportion of their sites with water recycling technologies enabled. This is despite awareness from the CSI that these metrics are key physical risk indicators for the sector.
- Shree comes first for this metric. Shree has the second lowest current water consumption intensity, has reduced this at the second quickest rate (22% fall p.a. since 2012), only withdraws 10% of its water from fresh surface water sources and has 100% of its plants fitted with water recycling technologies.
- Ambuja comes second, demonstrating the most rapid cut in water consumption intensity since 2012 of 35% p.a and now has the lowest water intensity level of 91.5 litres of water consumed per tonne of cementitious product.
- Asia Cement comes last with the highest water intensity which has only been reduced 1% annually since 2012. Moreover, only 50% of its plants are fitted with water recycling technologies, the second lowest reported proportion.
- Heidelberg also performs poorly on this metric, coming second last. Its water consumption intensity has increased since 2014 (when it first started measuring water data) by 1% annually, it withdraws 63% of its water from fresh surface water sources (third highest) and only 60% of its plants are enabled with water recycling capabilities.

Figure 32: Water consumption intensity⁽ⁱ⁾



- (i) No data for ACC.
(ii) Insufficient data to calculate CAGR for CRH and LafargeHolcim.
(iii) CAGR 2013-2016 for Cementos Argos, Dalmia Bharat, Taiheyo and UltraTech.
(iv) CAGR 2014-2016 for Heidelberg.
(v) CAGR 2012-2015 and current average 2014-2015 for Cementir.
Source: CDP, company reporting

Figure 33: Water withdrawal by source and proportion of sites with water recycling



- (i) No data for % of sites with water recycling for ACC and Cementir.
(ii) Current % of sites with water recycling is 2016 only for Ambuja and Asia Cement.
(iii) Dalmia Bharat - 2015 data used as 2016 data not segmented.
Source: CDP, company reporting

Water positivity and reporting in the cement sector

Compared to other industries and processes, the cement sector is not very water intensive and water reporting tends to have a greater focus on community water use and companies' desire to be water positive – especially for Indian companies who have a large proportion of their plants in water-stressed areas of India.

Water positivity is the idea that companies are creating more water than they are using²². This can be achieved in three main ways:

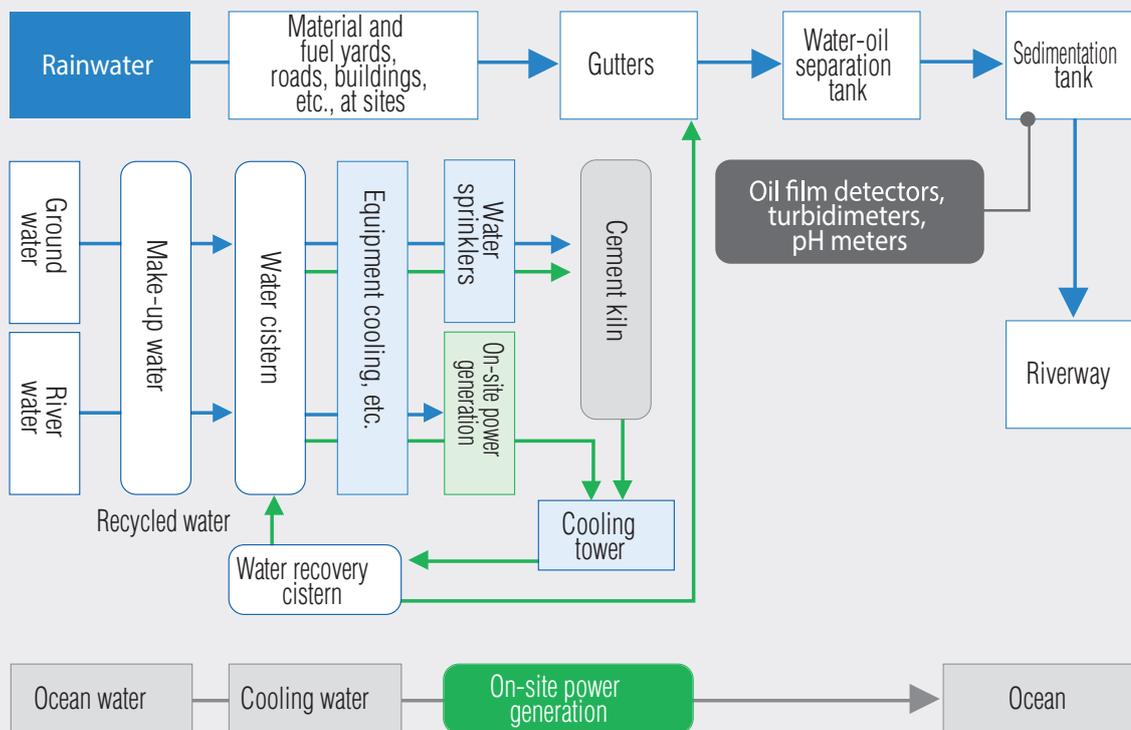
- 1) Reducing water consumption** – limiting water withdrawal and water discharge and upgrading to the most water efficient technologies.
- 2) Recycling water** – installing sewage treatment plants (STP), effluent treatment plants (ETP) and zero liquid discharge (ZLD) systems.
- 3) Capturing water** – rain water harvesting in plants and community areas.

At ACC, the objective is to achieve a water positive status and in 2016 the company ordered ZLDs for their Wadi and Chanda Cement works and STPs for their Lakheri and Damodhar Cement works to achieve this goal²².

Moreover, Ambuja has recently been certified as over five times water positive where in 2016 it had a water credit of 37,884,835 cubic meters. Its aim is to become six times water positive by 2030, focusing not only on its own operations but also water saving at the customers' end in construction²³.

At Dalmia Bharat, the aim is to attain water-neutrality across all integrated plants by the end of the 2017 calendar year. Dalmia, like their domestic counterparts, also has a huge focus on water conservation in the local communities which it serves, demonstrated by their developing of 258 farm ponds, 26 village ponds, constructing one check dam, seven ring wells and renovating 23 wells in Tamil Nadu and Andhra Pradesh²⁴.

Figure 34: The role of water in cement manufacturing



Source: Taiheiyō Cement, 2017, CSR report

21. <https://www.veolia.com/anz/net-positive-water-what-does-it-mean-and-is-it-possible>

22. ACC, 2016, sustainable development report

23. Ambuja, 2016, sustainable development report

24. Dalmia Bharat, 2016-2017, annual report

Highlights

- Heidelberg performs the best on transition opportunities, increasing its use of alternative fuels, having better financing scope and showing leadership on CCS technology.
- Dalmia also performs well on the use of alternative materials, the highest weighted metric in this area. The company has the best blended cement product in the market at 342 kg CO₂/t vs the Indian average of 579 kg CO₂/t.
- Shree follows the pattern of Indian companies performing well in the use of alternative materials (ranked second) but poorly in the use of alternative fuels (ranked second last).
- LafargeHolcim, which consolidates all its data, outperforms its listed subsidiaries ACC and Ambuja on its use of alternative fuels and low-carbon innovation in potential low-carbon cement products through involvement with CCS.
- In the bottom half of the table are companies such as UltraTech, the worst performer of the Indian companies in the use of alternative materials, which is not offset by better performance in alternative fuels or innovation.
- Similarly, Asia Cement is innovative in their development of masonry cement which has scope to reduce GHG emissions by 20.3% compared to

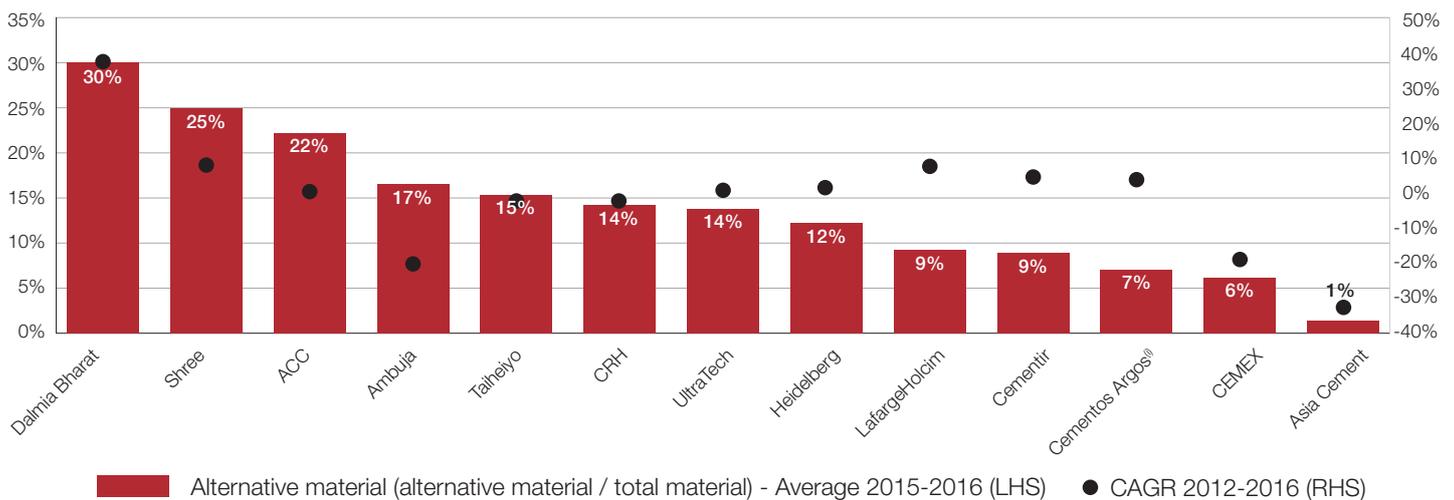
Ordinary Portland Cement. However, this is currently a small part of the revenues and the company does not perform well on other metrics in this area (ranking last for both alternative material and alternative fuel use).

- Cementir, which has a presence in the Northern European markets, underperforms its peers on the use of alternative fuels, an area they should be capitalizing on given their presence in markets with established waste legislation.

Alternative materials

The use of alternative materials is typically after the clinker formation in the kiln and is used to create a range of alternative blended cements which have the same acceptance amongst knowledgeable users of the product, mainly in the developed markets. The main alternative materials used to substitute for clinker are fly ash (a waste from thermal power generation plants) and slag (waste from steel plants). Natural substitutes are also used, such as limestone, pozzolanas and calcined clays, although to a lower extent than industrial substitutes. The availability of fly ash and slag depends on where cement plants are operating and with the retiring of coal fired thermal plants and the shifting of steel production from countries in Europe to Asia, the availability of fly ash and slag as clinker substitutes are expected to decline and to be replaced by lower grade lime. With thermal power plants and steel plants being more prevalent in markets such as China and India, cement producers in these regions are likely to continue to benefit from the supply of fly ash and slag.

Figure 36: Alternative material substitution



(i) CAGR 2014-2016 for Cementos Argos.
Source: GDP, company reporting

- The regional trends are apparent in the universe with the Indian companies Dalmia, Shree, and the listed subsidiaries of LafargeHolcim (ACC and Ambuja) all performing well.
- UltraTech has the lowest alternative material use ranking of the Indian cement companies with a product focus mainly on OPC.
- The internationally diversified companies such as Heidelberg and LafargeHolcim perform less well on this metric (ranked 8th and 9th respectively) with Asia Cement performing the worst.

Regional trends

Cement is a very local product in terms of proximity of production to consumption, therefore, local factors have a significant influence over production and consumption. Companies who operate in different regions face different opportunities to allow them to decarbonize.²⁵ The key regional factors which influence cement operations and associated emissions are: regulations and technical standards, market demand, availability of alternative materials and fuels and the age and growth rate of the market.

Regulations and technical standards: National technical standards influence many aspects of cement operations such as grinding. In India, for example, the technical standards are specified so cement producers can meet technical requirements at a cement fineness which is coarser than cement ground in other regions of the world, improving the energy use.²⁶

Built environment technical standards also govern the extent to which different cement types can be applied to meet construction requirements. Blended cements have different structural properties to OPC in terms of compressive strength, durability and chemical resistance and are therefore suitable for different applications.²⁷

Market demand: While it is possible to produce blended cements that meet the technical specifications for a wide range of applications, the market uptake of blended cements is determined by regional market preferences.²⁸ The stage at which OPC is mixed with alternative materials changes regionally, influencing demand. In the US it is more likely that concrete producers will buy OPC and mix it with alternative materials themselves, driving cement companies that sell into the US such as CEMEX to produce a larger share of OPC cements.

Availability of alternative materials and fuels: Cement producers may be constrained in their use of alternative raw materials and fuels due to supply of such materials. Regions with well-developed waste management infrastructure are typically better positioned to use waste into fuel. Alternative materials to clinker such as slag and fly ash are by-products of other high emitting sectors, such as steel and coal-based power generation, which need to be operating at scale and accessible to cement plants to be economic. Cement producers in India are well placed with established long term contracts to access fly ash.

Age and growth rate of market: Faster growing emerging markets have invested in more efficient state of the art technology giving them a relative advantage to OECD countries.²⁵

The role of alternatives materials in the IEA 2DS decarbonization scenario

In the IEA's 2018 Global Cement Technology Roadmap, the reduction of the clinker ratio through the increased uptake of alternative materials is the second most significant abatement technology accounting for 37% of abatement from 2020 to 2050 in the 2DS. The current global average clinker ratio of 0.65 needs to be reduced to 0.60 to meet the decarbonisation path required for the 2DS. While the availability of blast furnace slag and fly ash decreases in the 2DS due to their reliance on high emitting industrial processes, more naturally occurring raw materials such as limestone and calcined clay play a more significant role in clinker substitution out to 2050.³⁰

The IEA estimates that cements using limestone as a filler represent 25-30% of current global cement production, and project that this share will increase by up to 48% by 2050. While calcined clay currently accounts for 0% of global cement compositions, this is projected to increase to 8% in 2050. Recent developments in the optimisation of limestone and calcined clay blends are driving this, potentially enabling up to 50% clinker displacement without affecting the structural properties of the associated cements.³¹

Figure 37: Global average estimates of cement composition



Source: IEA, 2018, Technology Roadmap: Low carbon transition in the cement industry

25. European Cement Research Academy, 2017, CSI/ECRA-Technology Papers

26. IEA, 2012, Low Carbon Technology for the Indian Cement Industry

27. British Standards Institute, 2011, BS EN 197: Composition specifications and conformity criteria for common cements

28. The European Cement Association, 2017, The Role of Cement in the 2050 Low Carbon Economy

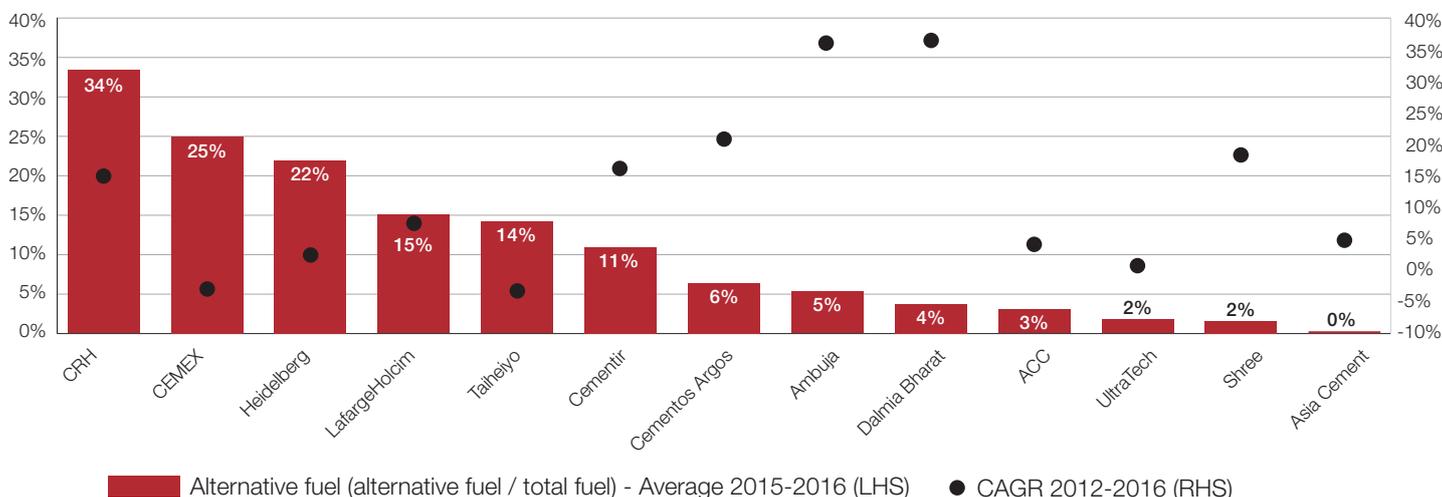
29. IEA, 2018, Technology Roadmap: Low carbon transition in the cement industry

30. UNEP, 2016, Eco-efficient Cements: Potential, Economically Viable Solutions for a Low CO₂, Cement-based Materials Industry

Alternative fuels

The fuel sources being used to fire kilns to the high temperatures required have been mainly through highly carbon intensive fossil fuel sources such as bituminous coal and pet coke which have been largely cheaper sources of fuel compared to natural gas. A cost-effective way to reduce carbon emissions and the cost of fuel has been to use a variety of sources of waste from old tyres and a range of industrial, agricultural and municipal waste. Producers operating in countries with organized waste collection and sorting services with the European players benefit from being able to source waste more efficiently.

Figure 38: Alternative fuel use



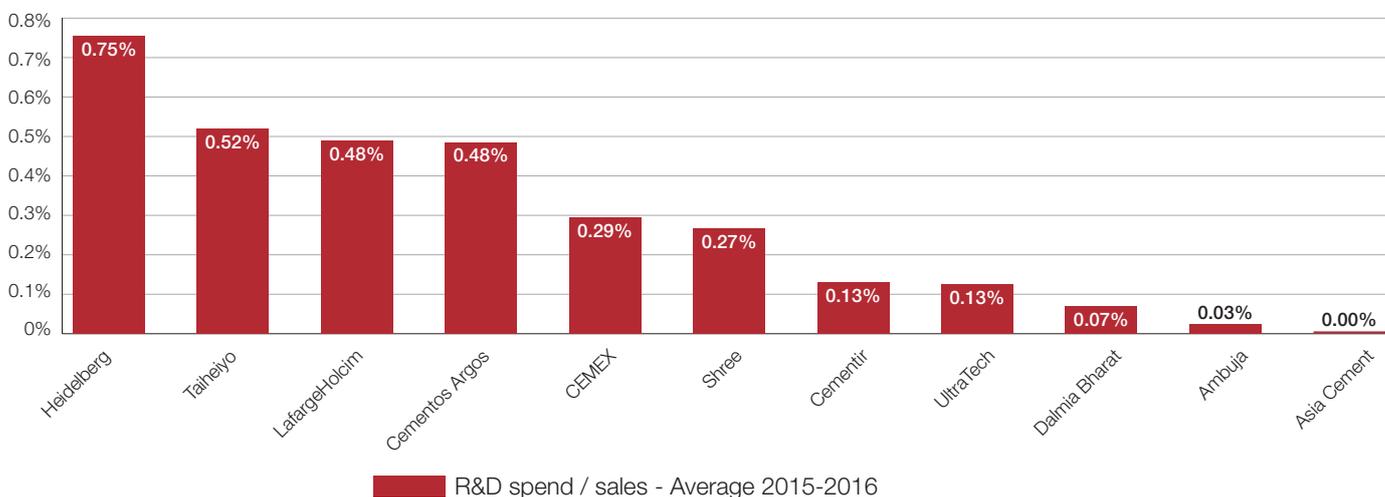
Source: CDP, company reporting

- ▶ This metric sees the complete reversal in terms of performance with the international diversified companies benefiting from better waste regulation in the European bloc with the Indian companies performing the worst.
- ▶ CRH performs the best on this metric with over 30% alternative fuel use comparative to Asia Cement which ranks last with 0%.
- ▶ Continuing improvement in waste legislation offers scope for companies to benefit from the use of waste to displace highly carbon intensive fuels currently being used.

Financial Scope

A range of blended cements have been the main route for cement producers to decarbonize their product portfolios and to provide the market with lower carbon alternatives to OPC which has the highest clinker ratio. R&D spend for the sector is low with no company investing more than 1% of their sales into R&D. This is on par with upstream sectors such as mining but lagging the chemicals sector where R&D spend was on average 2.5% with leaders investing up to 7% of sales in R&D. Only a few companies appear to be investing in new cement products such as LafargeHolcim with its Solidia³¹ product, with most of the innovation for the more vertically integrated groups being further down the value chain.

Figure 39: R&D spend relative to sales⁽ⁱ⁾

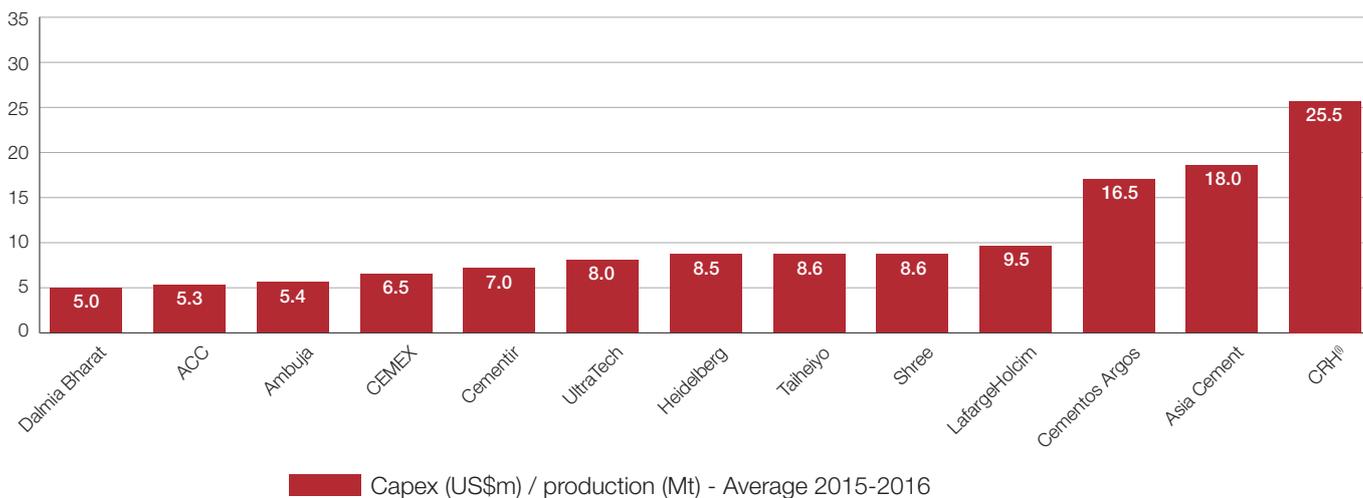


(i) Data for ACC and CRH not provided.
Source: CDP, company reporting

31. A cement product which can reduce emissions by up to 70% through actively absorbing CO₂ during the cement hardening process.

- Heidelberg does the best on this score with the highest R&D spend as a % of sales and stable and relatively high margins.
- The overall spend in terms of R&D spend is disappointing reflecting the sector's reliance on alternative materials as the main way of diluting the carbon intensity of cement.

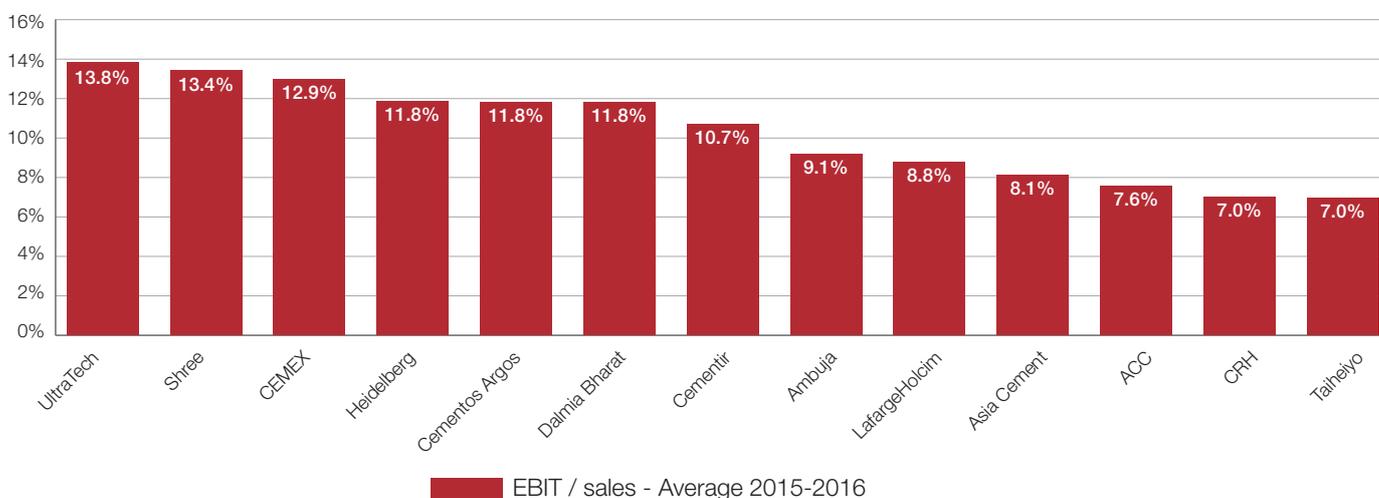
Figure 40: Capex intensity



(i) This figure is 2016 only and is calculated using group capex, not adjusting for the non-cement divisions of the group. Source: CDP, company reporting

There is little granularity of data on capital spend in the sector, which is highly capital intensive for business-as-usual processes. While we recognize that some of this capital may be allocated for more efficient plant upgrades, we would like to see capital allocated to new process/product development and therefore rank less capital-intensive companies more highly but give this metric a 20% weight within the financial scope metric.

Figure 41: EBIT margin



Source: CDP, company reporting

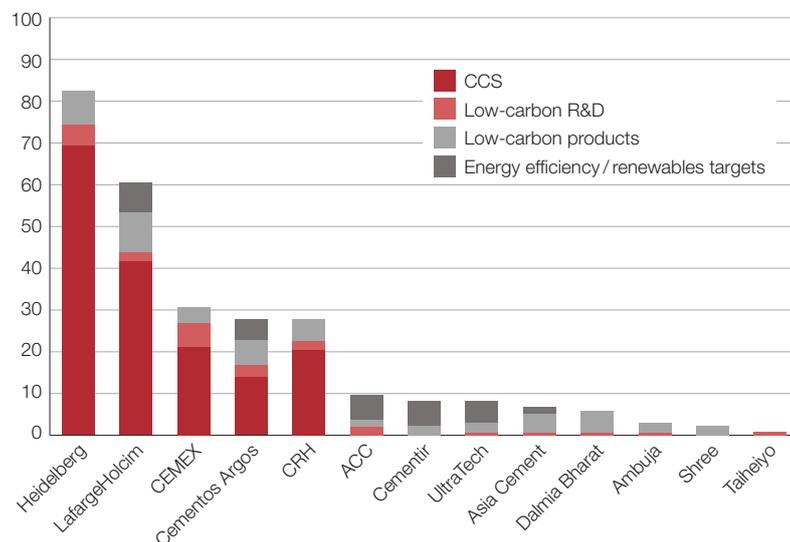
Innovation scorecard

A combination of energy efficiency, alternative fuels and alternative materials is expected to deliver 52% of cumulative emissions reductions out to 2050 required for a 2-degrees scenario³¹. This leaves CCS technology as the main lever for delivery of emission reductions unless new innovative products such as Solidia, which enables CO₂ absorption in the curing process of concrete, are commercialized at scale or green cement solutions come from the use of natural pozzolana as an alternative material to reduce clinker ratios.

Industrial CCS technologies are being pursued by some companies in the industry such as Heidelberg and LafargeHolcim, with the former leading on three pilot plants. Cumulatively, the CCS capture in the cement industry in IEA 2DS³³ is expected to be 16Gt CO₂ between now and 2060. This means by 2060, 47% of cement production is expected to be equipped with CCS based on this scenario with 0.7 Gt captured per year. The cement segment accounts for 44% of cumulative industrial emissions capture in 2DS.

In this scorecard we rank companies mainly based on their performance on CCS (70%) as we believe this technology will be crucial to capturing base level emissions and here Heidelberg is leading the way and does best on this metric. % R&D towards low-carbon products is also evaluated although we see little evidence of activity in terms of launching any meaningful low-carbon products.

Figure 42: Innovation scorecard



Source: CDP, company reporting

- ▼ Heidelberg performs the best overall on this metric with its commitment to testing CCS technology. Refer to “Carbon capture and storage in the cement industry” below for more details on operating CCS projects.
- ▼ LafargeHolcim is the second-best performer having some involvement with CCS as well as potential low-carbon products such as Solidia and the Aether cement range.
- ▼ Overall new product development and a strong capital commitment to large scale CCS is still some way off.

Carbon capture and storage in the cement industry

The cement industry is estimated in many climate models to be one of the largest users of carbon capture technologies in the future, given the significance of emissions inherent to the production process. In the latest IEA Cement Technology Roadmap (2018), CCS is responsible for 48% of cumulative emissions abatement between now and 2050 for a 2-degrees scenario. For more details on CCS in climate models and its applications to industrial and power sectors refer to CDP report “Mind the CCS gap”.

None of the 17 large scale CCS plants currently operating are cement ones. However, there are a number of cement CCS pilots, working on different technologies and applied at different points of the production process. A rapid scale-up of suitable technologies and captured capacity is required. Separately, investment in CCS infrastructure (transport and storage) is also fundamental to boost the technological development, while cross-sectoral collaborations are important to create synergies and economies of scale.

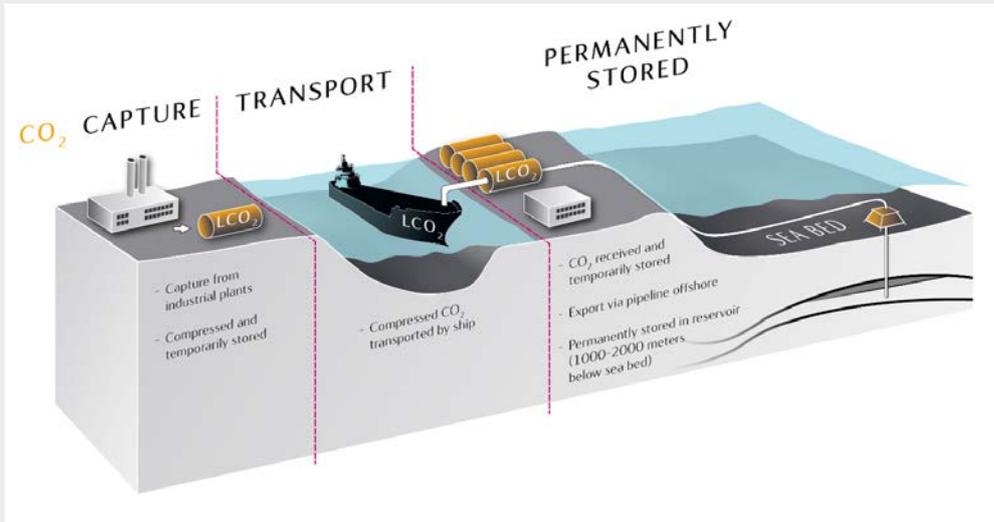
Looking at the capture technology, the main ones employed are post-combustion (where CO₂ capture occurs at the end of the industrial process), oxy-fuel (where a pure stream of CO₂ is generated during the process by oxygen fueled combustion) and direct separation (CO₂ is separated via a re-engineering of the calcination process). Different technologies present advantages/disadvantages, including varying CO₂ unit costs (from above EUR 100 to as low as EUR 20), capture rates and degree of process re-engineering required.

32. IEA, 2018, Cement Technology Roadmap

33. IEA, 2017, ETP

Heidelberg is currently engaged across three different areas of carbon capture development, in Brevik Norway (post-combustion), in the LEILAC project (direct separation) and with ECRA on oxy-fuel technology. The project in Brevik started in 2013 as a collaboration between Norcem, Heidelberg Northern Europe and ECRA to test four different capture technologies (amine liquid solution, amine solid solution, membrane technology and calcium looping). Norcem aims to produce carbon neutral cement by 2030, a solution that has already attracted interest from the Oslo and Gothenburg municipalities. The project is funded by the Norwegian government and is supported by Gassnova, and is part of a larger cross-sectoral project to create a carbon value chain to store CO₂ in the seabed of the Norwegian North Sea, with Statoil as storage operator and the goal to complete the full-scale CCS value chain by 2022.

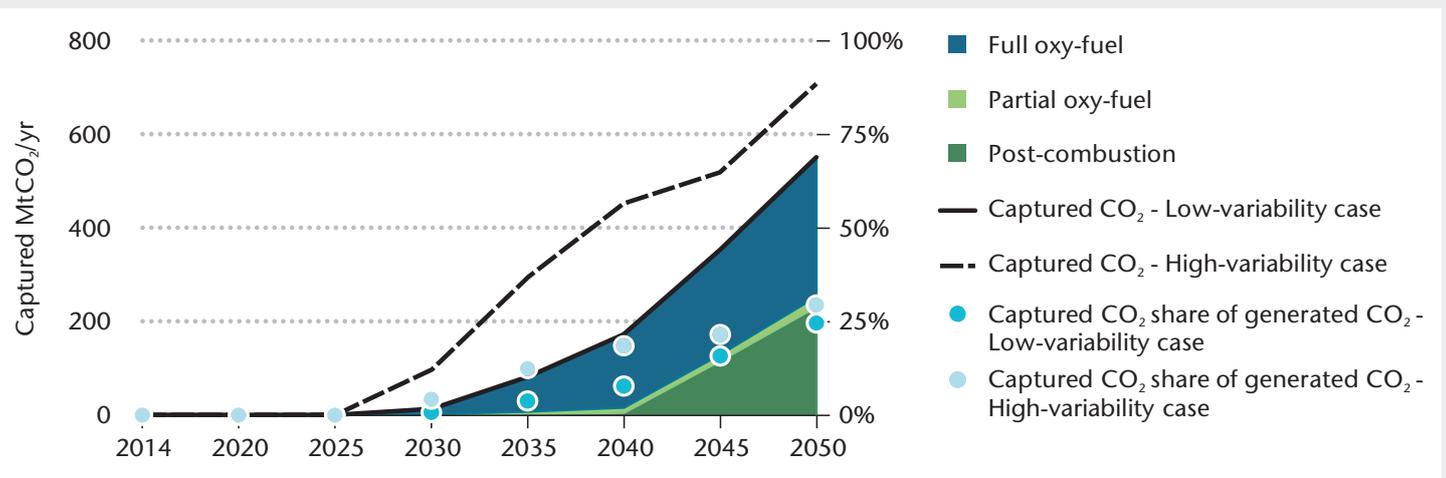
Figure 43: CO₂ value chain



Source: <https://www.statoil.com/en/news/co2-ncs.html>

In Belgium, Heidelberg is working with the EU at the LEILAC, a project started in 2016 and focused on direct separation. As part of this technology, the traditional process flow is re-engineered to produce a pure stream of CO₂ from the calcination process, thus better enabling the capture process. This technology only focuses on separation of process emissions (2/3 of cement emissions) but associated to oxy-fuel could address virtually 100% of cement emissions. Among the benefits of the technology is the fact that it requires limited changes to the conventional process for cement and has minimal energy losses.

Figure 44: Global deployment of cement CO₂ capture in 2DS



Source: IEA, 2018, Cement Technology Roadmap

Lastly, Heidelberg is engaged in developing an oxyfuel kiln which recirculates exhaust gases to the burner, while pure oxygen is added to keep the combustion effective. This results in exhaust gases with 70% or higher concentration of CO₂.

LafargeHolcim is also involved with ECRA in the development of oxyfuel technologies, at their plant in Retznei (Austria). Following successful pilot testing, this represents a step towards testing the technology in real-scale application via retro-fitting existing plants.

Climate governance & strategy

- 11 of the 13 companies have emission reduction targets focused on Scope 1 emissions and seven of these companies are currently outperforming their targets. Despite this, no company has a ratified Science Based Target.
- Benchmarked against the cement sector projections of the IEA, only three companies have emission reduction targets in line with limiting warming to 2-degrees.
- Companies are not incentivizing long-term climate risk management through remuneration, with only Cementos Argos including climate-related metrics in executive LTIPs.
- Ambuja come first overall and Cemntir come a distant last.

Overview

Following the recommendations made by the G20 Financial Stability Board's Task Force on Climate-related Financial Disclosures (TCFD), the mandated disclosure on climate risk and opportunities is likely to become the business norm. Moreover, there is a growing awareness of the need for all sectors to put in place climate-risk management strategies and enhanced disclosure for the benefit of investors and stakeholders.

Aligning long-term business strategies and governance measures with the requirements of a low-carbon future can aid companies in dealing with the risks and capitalizing on the opportunities provided by the general decarbonizing of the global economy.

Incorporating climate-related factors into business decision-making provides insight into how companies aim to make a success of the low-carbon transition, from appointing board members with vast experience in climate policy to incorporating emission reduction targets in corporate remuneration packages.

The setting of long-term emission reduction targets aligned with the Science-based Targets Initiative (SBTi) gives an indication of the levels of ambition companies have in reducing their carbon footprint, while promoting climate-related remuneration allows investors to ascertain the level to which companies are incentivizing the management of climate issues across operational levels.

In this section, we assess how companies are planning for a low-carbon future through aligning their governance structure with the associated risks and opportunities presented by the low-carbon transition. We rank companies on their climate governance and strategy using the following key metrics:

Metric 1) Emission reduction targets: We assess the coverage, timeframe and ambition of companies' emission reduction targets. The coverage focuses on which Scopes are targeted and what proportion of the overall Scope is included in the target while the timeframe assesses the base year and target year, with recent base years and distant target years favored. The ambition assesses the change in absolute emissions over the target time period, the company's calculated

annual reduction CAGR and their current performance against the calculated CAGR.

Metric 2) IEA gap analysis: To assess the relative ambition level of each company's targets, we assess the extent to which the company targets deviate from the emissions intensity level required to limit the global temperature rise to 2-degrees (2DS) according to the IEA³⁴. We use 2030 as the maturity year and calculate the cumulative emissions intensity gap between companies' targets and a 2DS trajectory. Where companies' targets do not extend to 2030, we linearly extrapolate the existing target out to 2030. For companies without a target, we have assumed emissions stay flat between 2017 and 2030.

Metric 3) Emissions data verification: We form a scorecard that assesses companies' emissions accounting procedures. This includes: level of third party verification and assurance, scope of verification and levels of verification uncertainty.

Metric 4) Climate-related remuneration: We assess the alignment between climate-risk management and remuneration across long-term incentives and short-term annual bonus programs at the senior executive level as well as other climate-risk remuneration practices for employees throughout the organization.

Metric 5) Board level climate management: Companies are assessed on a number of factors relating to board and executive climate responsibility performance including the proportion of climate-experienced directors on the board, the presence of climate-related committees (at board and/or executive levels) and the overall robustness of climate-risk management systems.

Metric 6) Internal carbon price: This metric is used to identify the extent to which internal carbon prices are incorporated into future capital expenditure plans and other key business decisions.

Metric 7) CDP score: The 2017 CDP Score provides an aggregate measure of the quality of climate-related disclosure and management systems addressing climate risks.

34. IEA, 2017, ETP

Figure 45: Climate governance & strategy summary

Company	Emission reduction targets	IEA gap analysis	Emissions data verification	Climate-related remuneration	Board level climate management	Internal carbon price	CDP Score	Overall weighted rank	Climate governance & strategy rank
Ambuja	4	2	3	2	4	3	B	2.8	1
Cementos Argos	1	8	9	1	1	6	B	3.4	2
LafargeHolcim	3	3	10	10	7	1	A-	4.2	3
Dalmia Bharat	2	1	5	9	9	5	B	4.6	4
Heidelberg	7	9	11	6	8	4	A-	5.4	5
CEMEX	11	10	12	5	6	2	A-	5.4	6
Shree	6	4	7	11	2	7	B	5.7	7
UltraTech	8	5	8	3	5	10	C	6.5	8
CRH	10	6	1	4	10	9	C	6.9	9
ACC	12	7	2	7	3	8	B	8.2	10
Asia Cement	5	13	6	8	10	10	B	8.7	11
Taiheiyo	9	12	4	11	10	10	C	9.6	12
Cementir	12	11	13	11	13	10	D	12.3	13

Weighting **25%** **25%** **5%** **15%** **10%** **15%** **5%**

Note: In calculating the weighted rank in this table, we use the weighted ranks for each area. We display non-weighted ranks in this summary for simplicity only.
Source: CDP

Highlights

- Overall Ambuja comes first for climate governance and strategy, consistently coming in the top four for every metric assessed. Ambuja has a strong emissions reduction target which is in line with keeping global warming to 2-degrees, it financially incentivizes executive management on climate-risk management metrics and the company displays preparedness for future carbon pricing legislation through having a relatively high internal price on carbon.
- Cementos Argos comes second overall. It is seen to have the best emission reductions target which requires the highest annual emissions intensity reduction and is currently performing best relative to its target. Moreover, it comes first for climate-related remuneration as the only company with climate-related metrics in executive LTIPs and tops the board level climate expertise metric, with two climate experts on the board of directors, a board level climate-risk related committee and very strong climate-risk management procedures in place.
- LafargeHolcim and Dalmia Bharat come third and fourth respectively. LafargeHolcim has the highest internal carbon price at just over US\$30 and has short-term and medium-term emission reduction targets which align with keeping warming to 2-degrees. Dalmia Bharat has the best emissions reduction target relative to the alignment with a 2DS and is also the only the company to have a target year beyond 2030, as its long-term target looks out to 2050.
- The worst performer by a considerable distance is Cementir, who comes last in six of the seven metrics assessed for governance and strategy. Cementir does not have a current emissions reduction target, only 30% of its Scope 1 emissions are verified (considerably the lowest), there is no link between remuneration and climate-metrics throughout the company, it does not disclose any information suggesting that it has either a board level climate-risk committee or executive level climate-focused committee and it does not have an internal carbon price or suggest its plan to in the near future.
- Taiheiyo and Asia Cement come second and third last respectively. Taiheiyo has the second worst emissions reduction target relative to keeping warming to 2-degrees, does not disclose any links between remuneration and climate metrics and does not disclose in significant depth how climate-risk management is integrated through all levels of operations. Asia Cement’s emissions reduction target is considerably the worst in aligning with a 2DS, it does not disclose any link between remuneration and climate-risk management and it does not have an internal price on carbon.

Figure 46: Emissions reduction targets scorecard⁽ⁱ⁾

Company	Number of targets	Scopes covered by target	% of emissions in scope	Base year	Target year	% reduction from base year	Estimated change in absolute emissions	Target CAGR	Current % gap to target	Score	Rank
Cementos Argos	1	Scope 1	100%	2006	2025	35%	54%	-2.3%	10%	79.5	1
Dalmia Bharat	1	Scope 1	100%	2010	2050	45%	150%	-1.5%	8%	75.2	2
LafargeHolcim	3	Scope 1	95%	1990	2030	40%	3%	-1.3%	-6%	73.7	3
Ambuja	2	Scope 1+2	100%	1990	2030	40%	89%	-1.3%	2%	70.4	4
Asia Cement Corp	2	Scope 1+2	81%	2013	2019	3%	-2%	-0.5%	0.2%	65.3	5
Shree	1	Scope 1+2	100%	2012	2020	10%	45%	-1.3%	3%	64.6	6
Heidelberg	1	Scope 1+2	99%	1990	2030	30%	-30%	-0.9%	2%	61.1	7
UltraTech	1	Scope 1	98%	2006	2021	25%	n/a ⁽ⁱⁱ⁾	-1.9%	-1%	58.0	8
Taiheiyu	1	Scope 1	100%	2000	2025	10%	0%	-0.4%	4%	54.4	9
CRH Plc	1	Scope 1	86%	1990	2020	25%	-25%	-1.0%	-1%	53.0	10
CEMEX	1	Scope 1	99%	1990	2020	25%	7%	-1.0%	-2%	47.6	11
ACC ⁽ⁱⁱⁱ⁾	0	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.0	12.5
Cementir ⁽ⁱⁱⁱ⁾	0	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.0	12.5

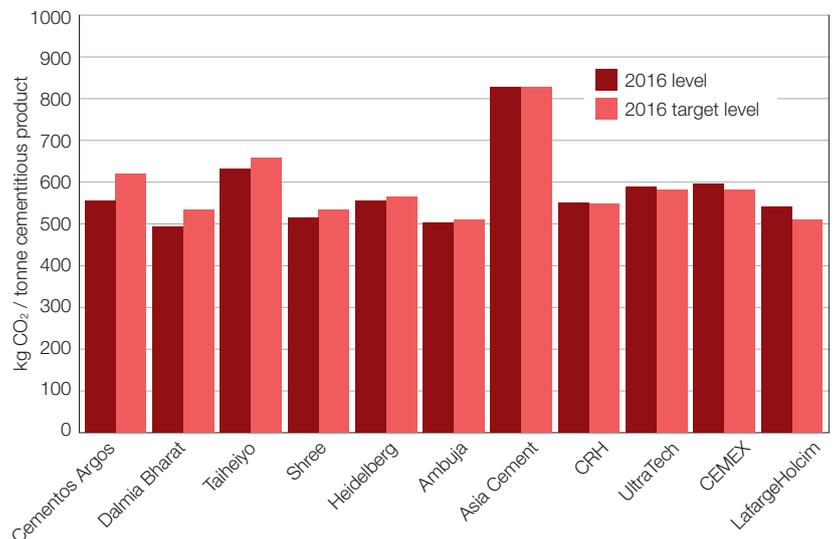
(i) The data displayed relates to the main target only which is the target with the most distant target year.
(ii) UltraTech have not disclosed an estimated change in absolute emissions during the course of their target.
(iii) ACC and Cementir do not have emissions intensity reduction targets beyond 2016.
Source: CDP, company reporting

Emission reduction targets

- According to the Science Based Targets initiative (SBTi), none of the companies in the report have a validated science based emissions reduction target. Despite this, Ambuja, CRH, Dalmia Bharat, Heidelberg and LafargeHolcim claim that their targets are scientifically aligned with the reduction in emissions required to keep warming to below 2-degrees.
- Using the SBTi methodology as a basis, Cementos Argos is deemed to have the best emissions reduction target where it aims to reduce its emissions intensity 35% by 2025 from its base year of 2006. Moreover, not only does Cementos Argos's reduction target demand proportionally the highest annual reduction, it is also the best performing company relative to its target; it is over 80% of the way to achieving its targeted reductions in just over 50% of the targeted time.
- Dalmia Bharat comes second and is notably the only company to have an emissions reduction target beyond 2030 as its target looks out to 2050. Dalmia also has the third best annual reduction target and is second only behind Cementos Argos on the way to achieving its target, 8% ahead of where it needs to currently be.
- LafargeHolcim comes third and, along with Asia Cement and Ambuja, is the only company to have more than one emissions reduction target. Its targets are all from a 1990 base year and look out to 2020, 2025 and 2030, with targeted reductions of 33%, 37% and 40% respectively.

- ACC and Cementir come last for this metric with no current emissions reduction targets. Both companies had targets which expired in 2017 but a failure to demonstrate longer term emissions reduction planning sees them occupy last place.
- Generally, it is positive to see that all but two companies currently have emission reduction targets. It is also very positive that of the 11 companies with targets, seven of those companies are currently outperforming their targets and reducing the emissions intensity of their operations more rapidly than planned.

Figure 47: Current emissions intensity vs. intensity target level⁽ⁱ⁾

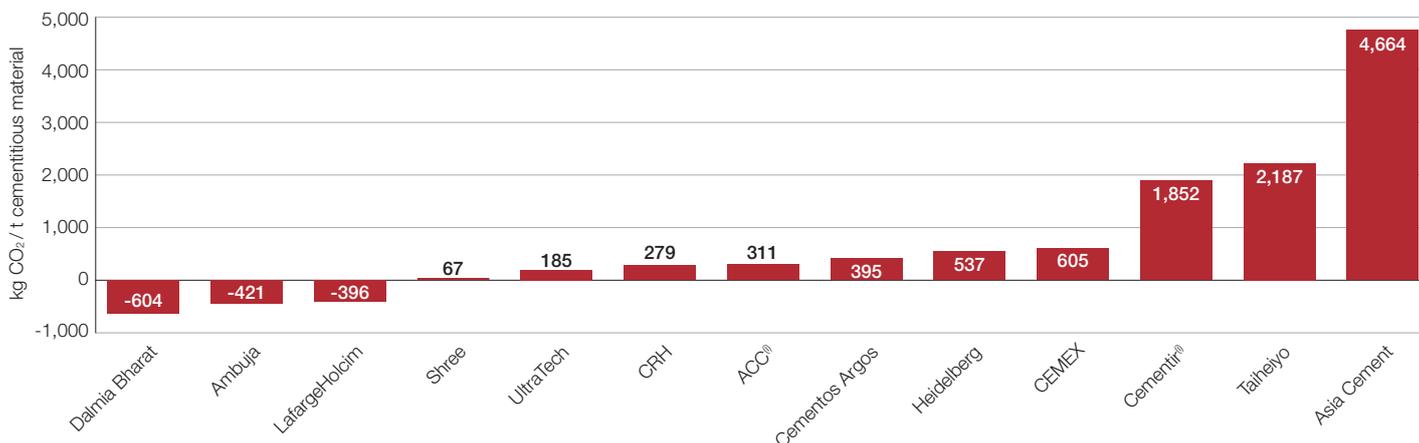


(i) Emissions intensity figures presented are net or gross depending on the relevant metrics used in company emissions reduction targets.
Note: ACC and Cementir do not have current emission reduction targets.
Source: CDP, company reporting

IEA gap analysis

- Three companies (Dalmia, Ambuja and LafargeHolcim) have target trajectories below the IEA target level. Dalmia performs best: it is the only company in our sample with intensity level currently below the IEA target level and has set an ambitious long-term target. Both Ambuja and LafargeHolcim spend most of the 2017-30 period within the IEA level target.
- Shree is almost in line with the 2-degrees trajectory, with a cumulative gap not far from zero.
- Asia Cement has the largest cumulative gap. This is due to a large gap between current intensity and IEA level (the largest in our sample) and an unambitious target (3% reduction from 2013 levels by 2019). Taiheiyo is second last ranked, having the second largest gap to IEA level currently and a similarly unambitious target.
- CRH, Cementos Argos, Heidelberg and CEMEX come middle of the pack, with an average annual gap of 2-7% against the IEA 2-degrees trajectory.
- ACC and Cementir do not have a future emissions intensity reduction target. Cementir ranks towards the bottom due to the large current gap to the IEA target and the limited decline experienced over the past four years. ACC come middle of the pack despite a low current intensity due to the limited progress experienced since 2012.
- The estimates in this analysis are based on IEA 2017 ETP data. In the IEA 2018 Roadmap, global production data has been revised downward, which allows for a higher intensity per tonne of cement in a 2-degrees scenario. Using this data would have resulted in more than three companies meeting the 2-degrees goal.

Figure 48: IEA emissions reduction targets gap



(i) ACC and Cementir do not have emissions intensity targets beyond 2016 - it is assumed their 2016 emissions intensities remain constant to 2030.
Source: CDP, IEA, 2017, ETP

Emissions data verification

- CRH ranks first on this metric, with reasonable assurance of its Scope 1, Scope 2 and Scope 3 emissions. The reasonable assurance type is higher than all peers for both Scope 2 and Scope 3 emissions bar Asia Cement and is only behind Cementir in the Scope 1 assurance type category. Moreover, the proportion of its emissions verified in each Scope is 100% and its uncertainty range is the smallest it can be at less than or equal to 2%.
- Cementir comes last with only have 30% of their Scope 1 emissions verified, no verification of Scope 2 emissions and no emissions data provided for Scope 3 emissions.
- Generally, there is limited assurance for most companies across the emissions Scopes with nine out of 13 companies displaying this assurance type for both Scope 1 and Scope 2. For Scope 3 emissions assurance, only three companies have greater than limited assurance of their emissions.

Figure 49: Emissions data verification scorecard

Company	Scope 1 assurance type	Proportion of Scope 1 verified	Uncertainty Scope 1 verified	Scope 2 assurance type	Proportion of Scope 2 verified	Uncertainty Scope 2 verified	Scope 3 assurance type	Proportion of Scope 3 verified	Total score	Rank
CRH	Reasonable	100%	≤2%	Reasonable	100%	≤2%	Reasonable	100%	97.9	1
ACC	Moderate	99%	≤2%	Moderate	99%	≤2%	Moderate	99%	95.3	2
Ambuja	Limited	100%	≤2%	Limited	100%	≤2%	Limited	98%	93.4	3
Taiheiyo	Limited	100%	2-5%	Limited	100%	≤2%	Limited	100%	91.6	4
Dalmia Bharat	Limited	100%	2-5%	Limited	100%	2-5%	Limited	100%	91.5	5
Asia Cement	Reasonable	78%	5-10%	Reasonable	94%	5-10%	Reasonable	100%	87.2	6
Shree	Limited	100%	≤2%	Limited	100%	≤2%	Limited	0%	87.1	7
UltraTech	Limited	100%	2-5%	Limited	100%	2-5%	Limited	0%	85.0	8
Cementos Argos	Limited	99%	2-5%	Limited	99%	2-5%	Limited	3%	84.9	9
LafargeHolcim	Limited	100%	≤2%	Limited	100%	≤2%	None	0%	84.6	10
Heidelberg	Limited	99%	≤2%	Limited	92%	≤2%	None	0%	84.2	11
CEMEX	Limited	99%	≤2%	Limited	90%	≤2%	None	0%	84.1	12
Cementir	High	30%	2-5%	None	0%	2-5%	n/a	0%	64.4	13

Source: CDP, company reporting

Ownership structure of Indian cement companies

ACC and Ambuja are both subsidiaries of LafargeHolcim. Currently, LafargeHolcim, through their subsidiary Holderind Investments Ltd, owns 63.11% of Ambuja. Ambuja in turn owns 50.05% of ACC. Holderind Investments Ltd, a subsidiary of LafargeHolcim, also owns 4.48% of ACC.

Timeline:

- January 2005:** Holcim acquires a majority stake in ACC and Ambuja.
- July 2015:** Lafarge and Holcim complete their merger of equals to form LafargeHolcim.
- July 2016:** Holcim India merges with Ambuja. LafargeHolcim receives 584 million new equity shares of Ambuja, increasing their ownership from 50.28% to 61.14%³⁵. Further to this, LafargeHolcim divests its interest in Lafarge India to Nirma limited³⁶. LafargeHolcim now only operates in India through its subsidiaries ACC and Ambuja.
- November 2016:** LafargeHolcim increases its stake in both ACC and Ambuja, purchasing another 39.1 million shares in Ambuja to take its stake up to 63.11% and 7.87 million shares in ACC to take its stake to 4.48%.

Moreover, UltraTech is a subsidiary of Grasim Industries who are in turn a subsidiary of the Aditya Birla Group, an Indian multinational conglomerate headquartered in Mumbai. In 2004, Grasim acquired a controlling stake in UltraTech and that remains the case today where Grasim owns over 165m shares in UltraTech, representing a 60.21% holding.

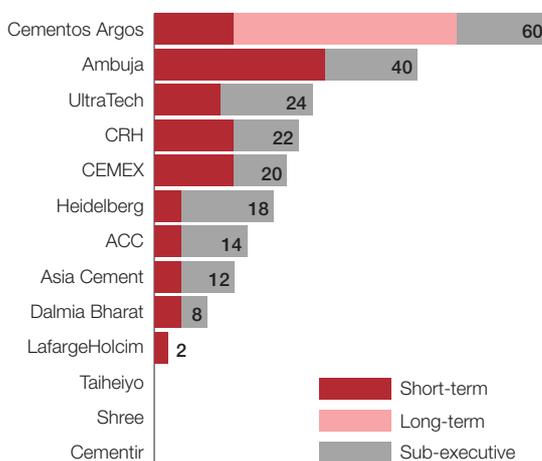
35. <https://www.lafargeholcim.com/lafargeholcim-simplified-group-structure-india>

36. <https://www.lafargeholcim.com/lafargeholcim-enters-agreement-nirma-limited-divestment-lafarge-india>

Climate-related remuneration

- Overall, Cementos Argos performed the best relative to its peers. In 2016, Cementos Argos paid out over US\$ 200,000 to the CEO and top management as a monetary reward for achieving goals related to the company's climate change strategy. Moreover, Cementos Argos is the only company to clearly disclose a link between climate risk management strategies and executives' long-term remuneration, with 15% of the executive LTIP focusing on Cementos Argos's performance in the Dow Jones Sustainability Index (DJSI).
- In second place was Ambuja. It came first for the short-term remuneration element with its Chief Manufacturing Officer having annual targets for 'CO₂ reduction, the usage of water, renewable energy and plastics' as well as a target for 'green' cement. Moreover, all plant level manufacturing heads of department have direct CO₂ emission KPIs which links to lowering the clinker ratio and using biomass as an alternative fuel in kilns.
- Cementir, Shree and Taiheiyo all came joint bottom, receiving scores of zero. These companies did not disclose any climate-related metrics in their executives short-term or long-term bonus schemes nor do they include climate-linked metrics in the remuneration schemes of other employees at the organisation.
- At a sub-executive level, UltraTech and Heidelberg came first and second respectively. The incentive packages of business unit managers at Heidelberg include several targets relating to emission reduction and the use of alternative fuels and at UltraTech emission reduction, energy reduction and efficiency improvement projects are linked to the KPIs of business unit managers.
- Generally, the total scores of all companies were low where the overall average score was just 17 out of 100, compared to 27 in the Chemicals sector analysis undertaken in October 2017 and 23 for the Autos sector analysis undertaken in January 2018, both using the same methodology.

Figure 50: Climate-related remuneration⁽ⁱ⁾

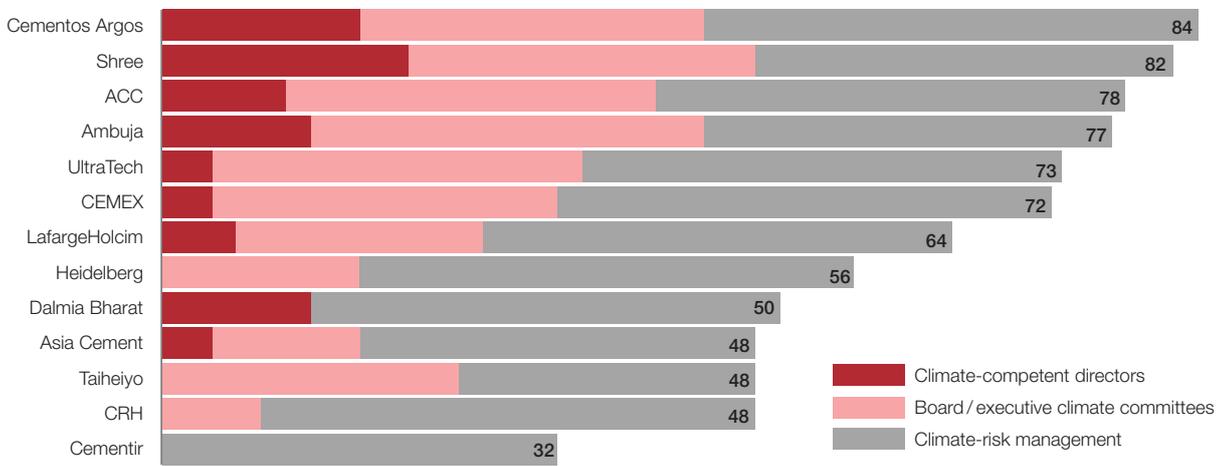


(i) Scored out of 100. The higher scores receive higher rankings.
Source: CDP, company reporting

Board level climate management

- Cementos Argos was found to be the overall strongest performing company, with two climate experts on the board of directors, a board level climate-risk related committee as well as very strong climate-risk management procedures in place where every six months or more frequently climate risks and opportunities are assessed globally.
- Cementir was found to be the weakest performing company. They do not have any climate experts on their board and do not disclose any information suggesting that they have either a board or executive level climate-risk committee.
- 11 out of the 15 companies were found to have a director on their board exhibiting varying degrees of climate-relevant professional experience. Shree has considerably the most climate competent board of directors, with two very highly in-depth climate experts. Shri Nitin Desai is a member of India's Prime Ministers' Council on Climate Change who has spent over a decade working on the UN Environment Programme. Moreover, Dr. Leena Srivastava was a Lead Author for Working Group III of the Third Assessment Report of Intergovernmental Panel on Climate Change and has received numerous international awards for her contribution to the fields of sustainable development and climate change.
- Regarding board and executive climate committees, Ambuja was found to be the strongest performer with both board level (CSR and Sustainability Committee) and executive level (Corporate Sustainability Steering Committee) climate-relevant committees. The CSR and Sustainability Committee looks into all sustainability aspects including climate change and water-related issues. The Corporate Sustainability Steering Committee is constituted of three permanent Members which are the Head of Corporate Environment and Sustainability, the Head of Corporate Social Responsibility and the Head of Health & Safety and this group regularly reports to the MD and CEO.
- For the climate risk management sub-metric, companies generally performed well on this sub-metric with all companies, bar Taiheiyo, receiving 32/40 or more. Heidelberg, CRH, CEMEX and Cementos Argos all received top marks, demonstrating that climate risks threatening all their operations are reported to the board at least every six months and this climate-risk management is clearly integrated throughout the organization.
- Taiheiyo receive a low score as they are uncertain of their climate-risk time horizon and do not disclose in significant depth how climate-risk management is integrated through all levels of operations.

Figure 51: Board level climate management⁽ⁱ⁾

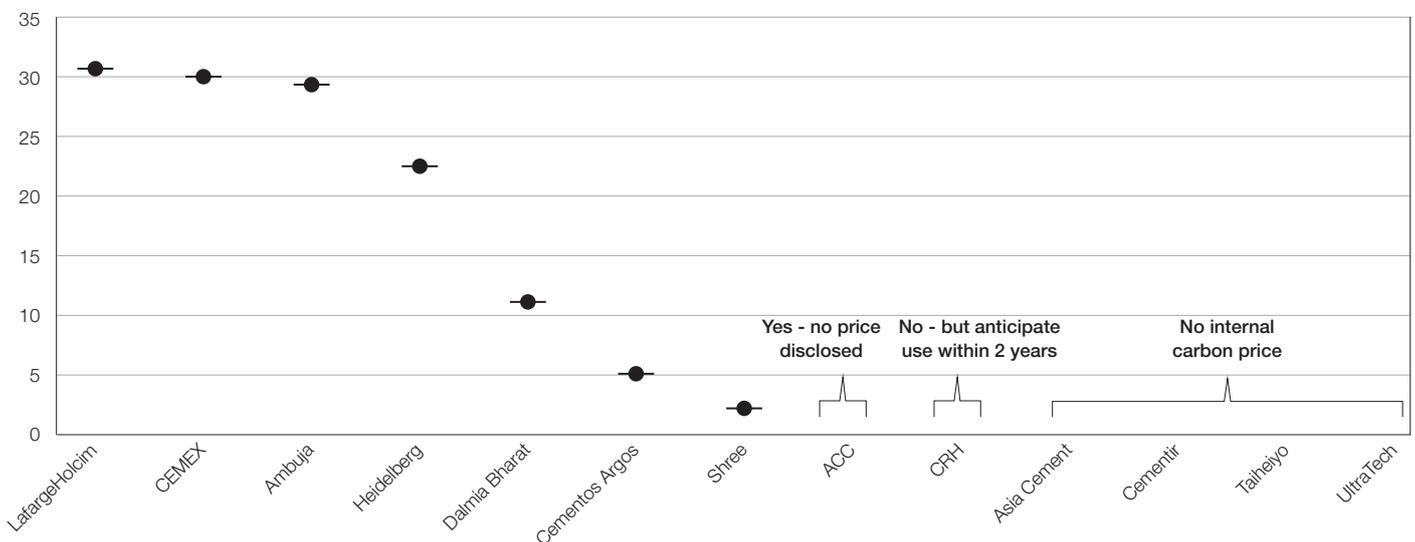


(i) Scored out of 100. The higher scores receive higher rankings.
Source: CDP, company reporting

Internal carbon price

- More than half of the companies use an internal carbon price with LafargeHolcim displaying the highest level at just over US\$ 30 per tonne of carbon. This is in line with their 2030 plan which promotes the use of a Social and Environmental P&L methodology as a fundamental tool to assess future investments to achieve the company’s sustainable development targets.
- CEMEX has the second highest carbon price of US\$ 30 per tonne of CO₂ which they use in their mid-term planning to better assess the robustness of their business strategy and identify strategic opportunities for emission reductions.
- Ambuja is a very close third with an internal carbon price on carbon of US\$ 29.41, utilized across all manufacturing locations.
- The only companies to not have an internal carbon price are Asia Cement, Cementir, Taiheiyo, UltraTech and CRH, though CRH claim that they anticipate using one within two years.
- With increasing pressure to ramp up future carbon pricing legislation to align with a below 2-degrees future, companies already considering the impacts of carbon pricing are likely to be better positioned to deal with regulatory changes.

Figure 52: Internal carbon price⁽ⁱ⁾



(i) Price in US\$
Source: CDP, company reporting

Assessment of Risks and Opportunities for the Cement Sector

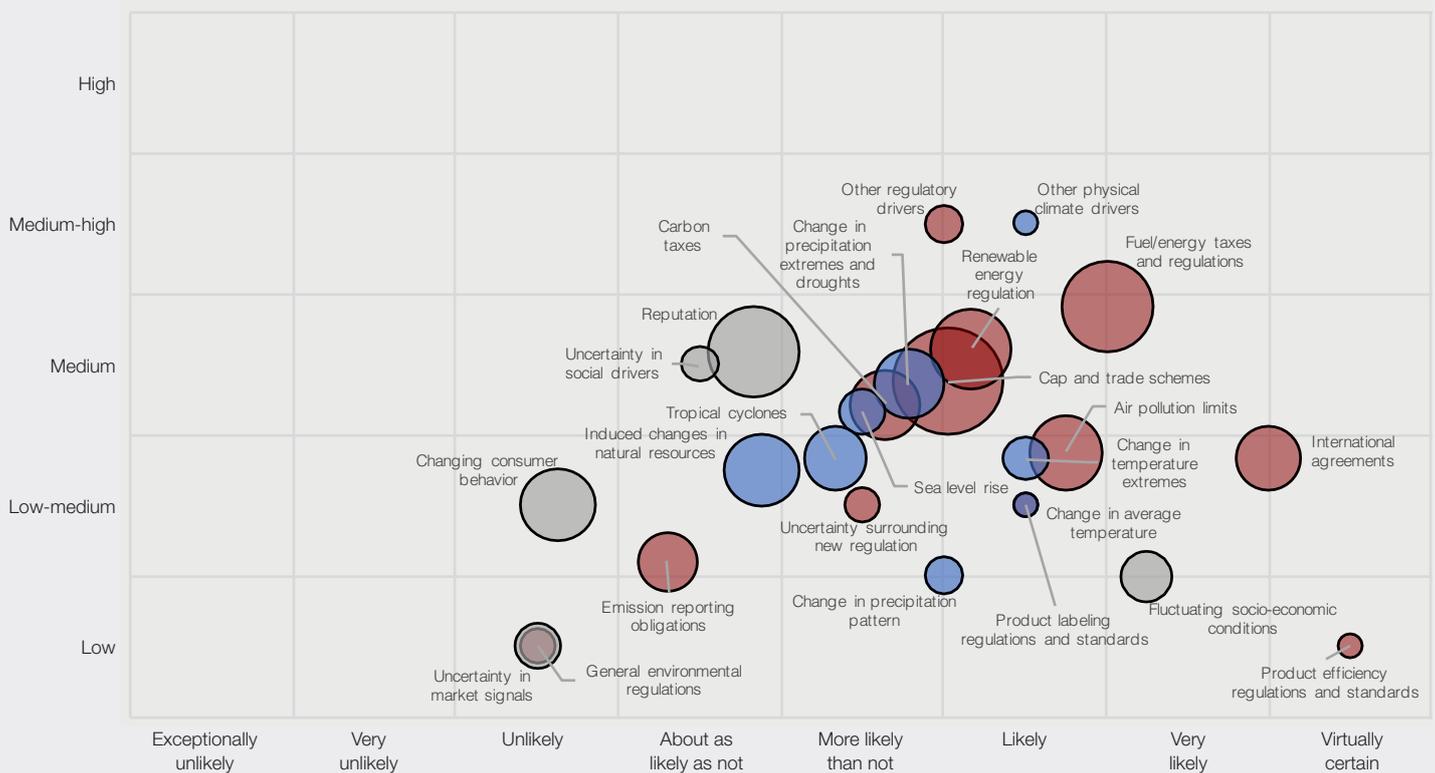
The cement industry has a number of large global companies, although, the economics of the business are often driven by local and regional market dynamics. Global companies can be thought of as multi-regional players, acquiring assets in different markets as part of a market diversification strategy. The strategies being adopted by these large players will have a significant influence on low-carbon transitions given their market shares and presence in markets where cement demand is expected to grow based on development trends.

The industry is capital intensive with long life assets with an ongoing program of investment to upgrade plant efficiency. The main challenge in decarbonizing the cement industry is that of clinker, an intermediate product in cement production which has high carbon process emissions and is essential to traditional Ordinary Portland Cement. Although the clinker ratio can be diluted by using substitutes or alternative materials, there is a limit to the dilution of clinker within blended cements which leaves cement companies with a high base level of carbon emissions. These emissions have to be captured through technologies such as carbon capture and storage (CCS) or carbon capture and use (CCU) or availability of another binding material without the same carbon intensity. Both strategies are currently hard to implement as the latter is still in pilot stage and not scalable and/or economic and new product development for green cement is also not seen to be scalable by incumbents.

Against this backdrop, we map the drivers seen by companies to present risks (Figure 53) and opportunities (Figure 54) for the sector, based on answers in the CDP questionnaire. The drivers for risks and opportunities are similar and include a number of regulatory drivers and instruments, physical risks related to climate change as well as market drivers such as change in consumer behavior or reputation risk. Companies are asked to respond to the perception of the level of risk as well as to the likelihood of occurrence.

In our mapping of risks, there is a wide disparity in perception of companies of some of these risks occurring from unlikely to virtually certain. However, a number of triggers of risks occurring are clustered in the “more likely than not” classification and thought to be of medium risk.

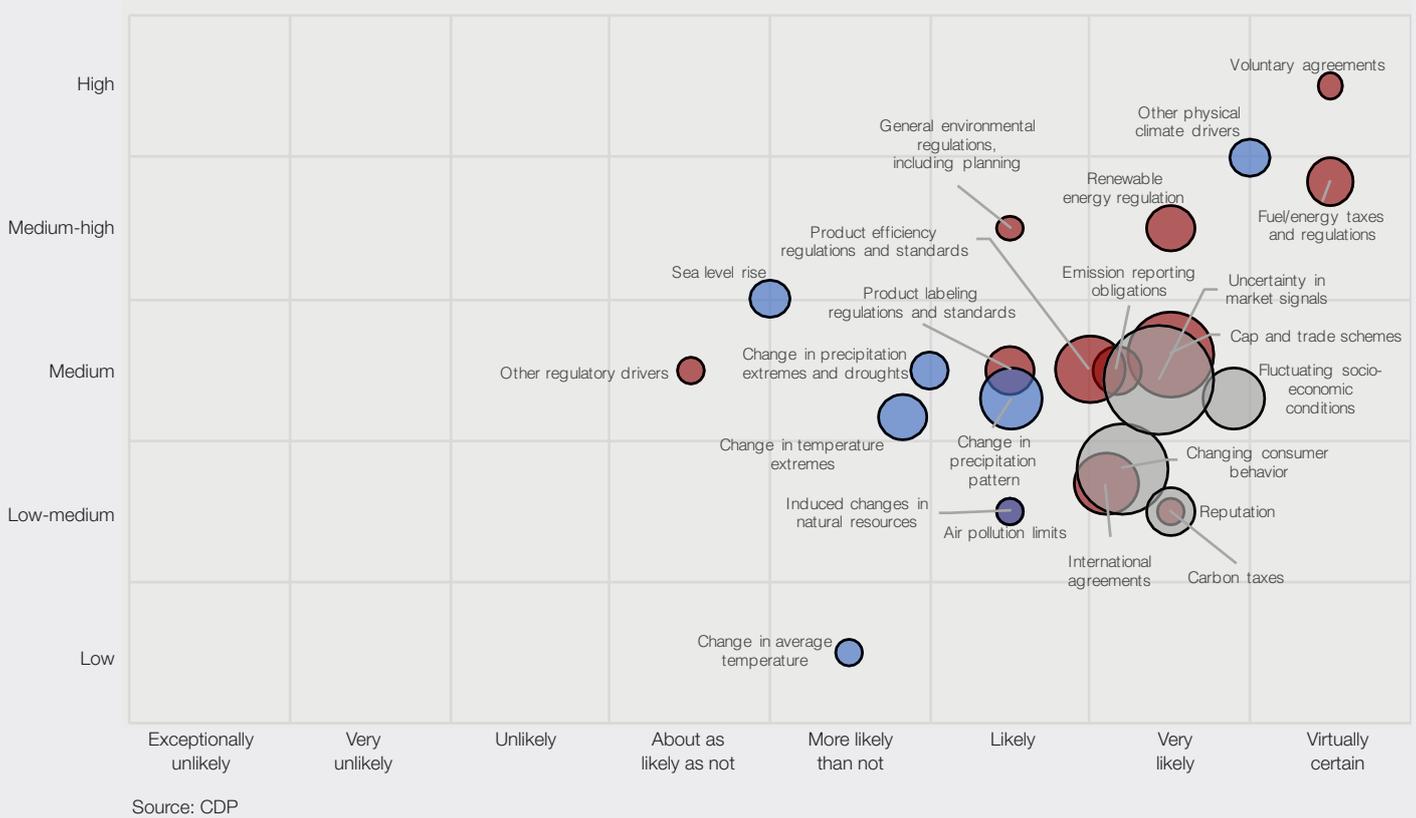
Figure 53: Companies’ perceptions of climate-related risks: classes of risks, impact and likelihood



Source: CDP

However, when mapping these drivers for opportunities, companies see a much higher likelihood of opportunities occurring based on the same drivers with a clustering under the “very likely” classification. Interestingly, market drivers such as changing consumer behavior, which is seen as unlikely as a risk driver, is cited as very likely under an opportunities framing. There also appears to be a general trend of drivers having a higher impact on the opportunities rather than risk side of the equation suggesting a tendency of companies to downplay these risks while seeking opportunities.

Figure 54: Companies' perceptions of climate-related opportunities: classes of opportunities, impact and likelihood



Furthermore, the time frames for opportunity drivers are seen by companies as materializing in the short term within a 1 to 3 year time frame (Figure 56), however, risks are seen to materialize at a later stage. This skew between risks and opportunities would suggest that companies are looking to capitalize on opportunities short term while pushing out risks.

Figure 55: Companies perception of climate-related risks: timing of occurrence and classes of risks

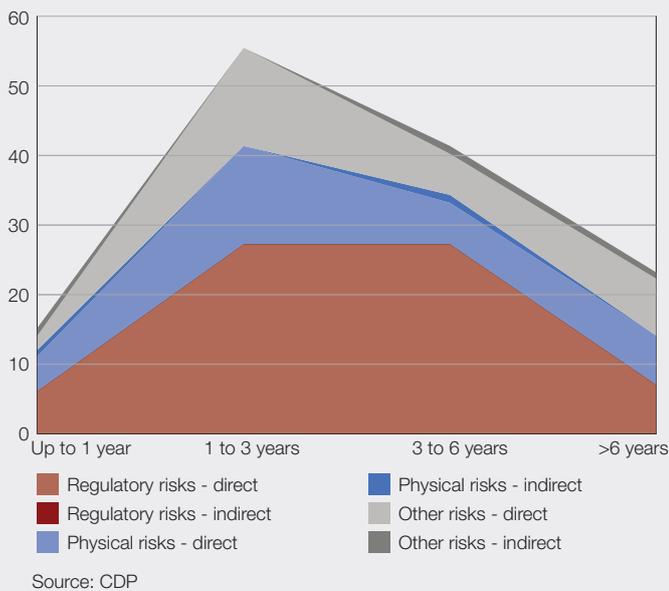
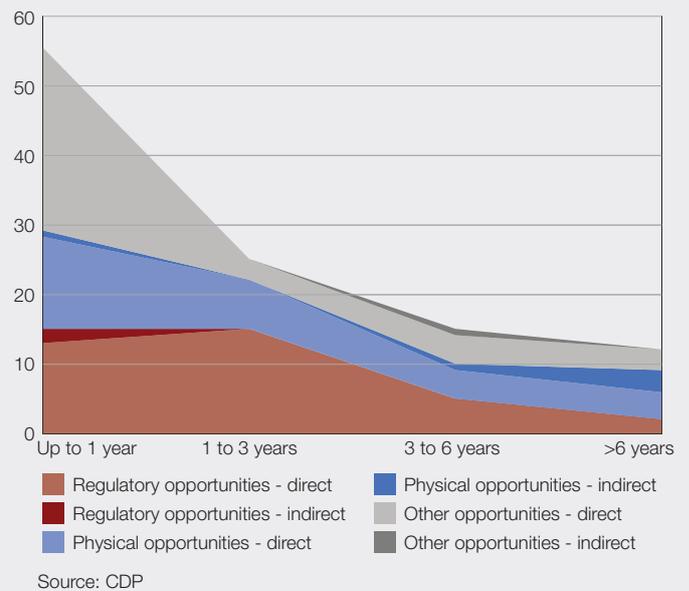


Figure 56: Companies perception of climate-related opportunities: timing of occurrence and classes of opportunities



In terms of risks, the skew towards the medium term for risks versus opportunities could delay the sector from investing in solutions to reduce their carbon intensity and risk further lock in to business-as-usual strategies.

On the positive side, this analysis would suggest that companies are expecting a number of regulatory drivers to present opportunities for the sector. If this leads the sector to innovate and find low-carbon alternatives to high clinker Ordinary Portland Cement, then this would be seen as an overall win for economies looking to transition to a low-carbon economy. However, if this opportunity is viewed as the increased use of cement for adaptation, for example, in flood defenses, this would be harder to justify as an overall positive for transitioning if a solution such as CCS was not mitigating the emissions resulting from the higher cement production.

The built environment

- Embodied emissions account for around a fifth of a building's life-cycle emissions, however this is expected to grow as operational emissions decline. Should regulators and customers shift their focus on building materials as a source of emissions, this will put additional pressure on cement companies.
- Currently two-thirds of buildings globally are not subject to energy performance standards. This is set to change, as countries take actions to comply with their Nationally Determined Contributions. Europe has some of the most advanced regulatory frameworks, and some cities and certifications are starting to include embodied emissions in their assessment method.
- There is a clear business case to be made for green buildings, based on changing customer preferences, lower operating costs and higher valuations and yields. Additionally, the risk of stranding for obsolete buildings is real, with buildings' impairments estimated to represent around half of the world's total impairments in a 2-degrees world (IRENA, 2017).

In this section we focus on the downstream stages of the cement value chain and the built-environment. We look at the building life-cycle assessment (LCA) and we assess how regulation and other sustainability considerations on buildings and infrastructure may affect upstream material producers.

The life-cycle emissions of a building

The global building sector is responsible for around one-third of global final energy consumption and for approximately a quarter of global carbon emissions: including emissions related to the building materials would take the built environment's carbon footprint to more than a third of global emissions.

The life cycle of a building can be viewed as being composed by six phases: raw material extraction and manufacturing, transportation, construction, operation, refurbishment and demolition. The carbon emissions attributable to a building can be divided into two broad categories depending on where in the lifecycle they originate: operational carbon emissions (OCE) are related to the use of the building and embodied carbon emissions (ECE) are related to all the other phases.

OCE have traditionally accounted for the dominant share of the life-cycle emissions, making these emissions the focus for reductions in the sector, for example by improving insulation or energy efficiency. The progressive reduction in buildings' operational emission intensity which resulted from these efforts increased the relative importance of ECE, leading to a growing interest in building materials carbon intensity and the initial phases of the life-cycle.

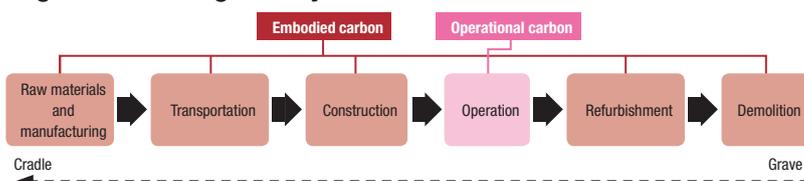
Some scholars also argue that strategies targeting ECE may be preferable as they offer more immediate and predictable savings³⁷ being less dependent on variables which could be over-estimated, such as life expectancy building and occupancy rate.

Embodied emissions: a growing role in the building life-cycle

The ratio of embodied to operational emissions varies by structure type and project to project. A study of emissions in the UK's built environment³⁸ shows OCE at around 70-80% of total life cycle emissions. However, including the potential from decarbonization of the grid, ECE could be higher at 31%-42%, particularly as the improving building fabric employed to achieve better thermal performance could require the use of more materials. For the UK, the Green Construction board estimate that ECE reductions of 21% by 2022 and 39% by 2050 relative to 2010 baselines are required in tandem with OCE reductions of 85% for domestic properties and 77% for non-domestic properties to meet sector targets.

Granular data to assess the breakdown of ECE is not easy to gather but below is an assessment by the study based on data from two different groups for the UK construction sector which clearly indicates that product manufacturing is the main contributor to embodied emissions.

Figure 57: Building's life-cycle emissions



Source: CDP

37. Ibn-Mohammed et al. (2013): Operational vs. Embodied Emissions in Buildings - A Review of Current Trends

38. Giesekam et al., 2016, The greenhouse gas emissions and mitigation options for materials used in UK Construction

The growing focus on ECE in both the private and public sector is reflected in the adoption of ECE calculation, disclosure and targets from some leading codes/certifications and real estate companies. Land Securities includes the reduction of embodied carbon among its four principles for sustainable design, having recently introduced an ECE analysis across their procurement of building materials and set out targets including an at-least-15% reduction across the business. British Land reports ECE, requires architects and contractors to measure and report on ECE, and since 2014 sets out internal targets for ECE reduction. The Crown Estate also calculates embodied carbon and assesses potential areas for improvement on a project basis.

Operational emissions: intensity reducing but absolute levels still growing

Buildings energy intensity per square meter improved globally at roughly 1.5% per year since 1990, as energy efficiency policies and technologies developed, and mandatory/voluntary energy codes have been implemented across several countries. However, this improvement was more than off-set by a 3% growth in buildings area,³⁹ as growing global wealth lead to demand for larger spaces and increased demand for energy services. Population growth also played a major role, with building energy intensity per capita broadly stable since 1990 at around 5MWh per person. Regional differences are still wide, with OECD countries constant around 11MWh and 3.3MWh in non-OECD countries.

On average, space heating and water heating still account for the majority of energy consumption (65% in OECD and 50% in non-OECD). Improving living standards in developing economies, however, are increasing demand for cooling, lighting and household

Figure 58: Breakdown of embodied emissions in two UK studies

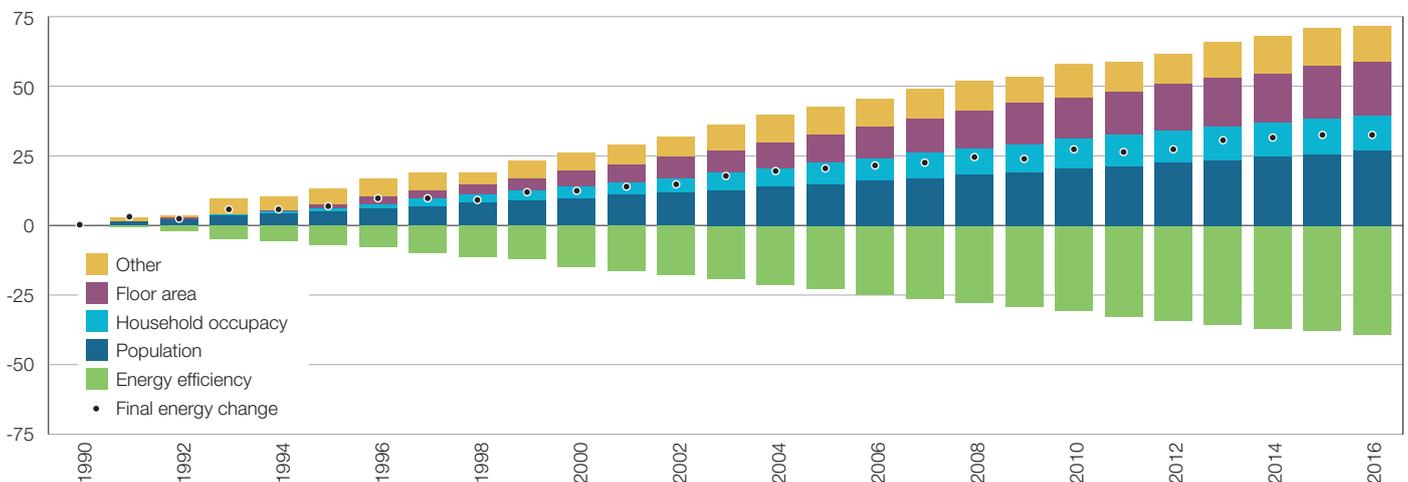
	Innovation & Growth Team MtCO ₂	%	Green Construction Board MtCO ₂	%
Total emissions attributable to Built Environment	298		190	
Embodied emissions	51.9	17%	33.6	18%
Operational emissions	246.1	83%	156.4	82%
Breakdown of Embodied Emissions				
Product manufacture	45.2	85%	18.1	54%
Distribution	2.8	5%	3.4	10%
Operation on site	2.6	5%	6.7	20%
Design	1.3	2%	1.7	5%
Refurb/other	1.3	2%	3.7	11%
Total	53.2		33.6	

Source: The greenhouse gas emissions and mitigation options for materials used in UK Construction – Jannik Gieseckam, John Barrett, Peter Taylor, Anne Owen

appliances. Electricity demand in OECD countries has remained relatively stable in recent years thanks to efficiency improvements (although it is up 75% since 1990), while electricity consumption in non-OECD increase 4.5 times between 1990 and 2014.

Deep energy renovation in OECD countries and high qualification for new constructions in non-OECD are fundamental to avoid lock-in emissions of inefficient buildings. The main steps towards improving building efficiency include: building orientation, thermal mass and shape; high-performance envelop qualifications; maximization of passive features (daylighting, heating, cooling, and ventilation), and the highest possible efficiencies and adequate sizing of individual energy-using devices.

Figure 59: Development of global final energy demand and its components



Source: IEA, 2017, ETP

39. IEA, 2016, ETP

Additionally, important performance improvements can be achieved with appropriate technologies, covering household appliances and lighting, smart meters and grids, digital building automation, fuel cells and heat pumps.⁴⁰ Cost saving of 30-50% compared to standard practices of new commercial buildings (or 50-80% for more advanced technologies) can off-set the extra capital spends. Retrofits can achieve 25-70% savings in total energy use.⁴¹

Progress in the regulatory framework is key to avoid locked-in emissions

Codes, standards and certifications are key tools to drive down emissions in the building industry. Green building regulations (in the form of codes and standards) are statutory instruments to ensure that specific policies set out in the legislation are carried out. These typically relate to the conservation of fuel and power by specifying e.g. minimum insulation values, air permeability of the structure, heating efficiency of boilers, controls for heating appliances, hot water and lighting efficiency (like in the case of Part L in the UK). One of the limits of current regulation is that it mainly focuses on new buildings, which particularly in OECD countries represent only a small percentage of the existing stock.

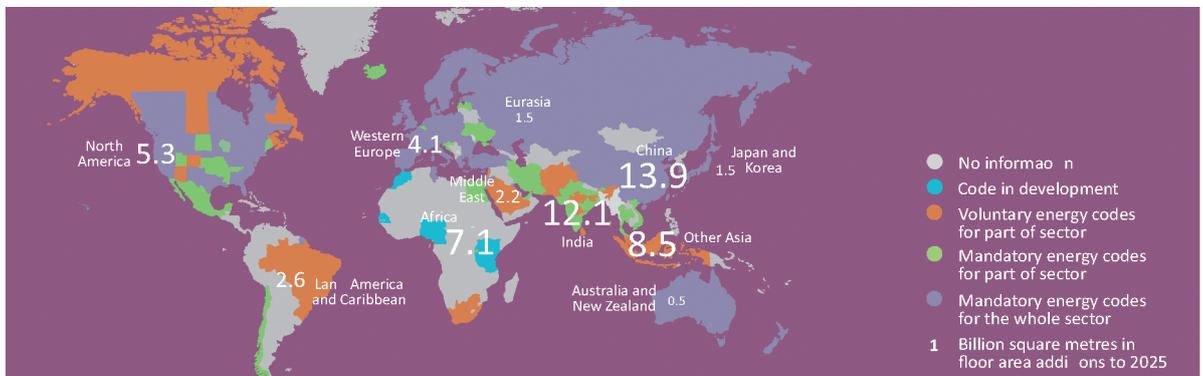
Green certificates on the other hand are voluntary and reward performance above regulation which delivers environmental, comfort and health benefits. The role of green certificates is crucial in leading the market by setting standards that over time push governments ambitions on building codes.⁴²

This mandates high level targets and framework, including the fact that all new buildings must be nearly zero energy buildings by 31 December 2020 or the fact that energy performance certificates are to be included in all advertisements for the sale or rental of buildings. Individual countries and cities then drive the implementation and add layers of codes on specific areas, such as planning requirements, energy targets, incentives systems.

Green certifications such as BREEAM or LEED are applied at asset level, following an assessment that can take place at different stages of the built environmental life cycle, from design through to refurbishment. They typically focus on a wide range of areas, from energy and materials down to waste and transport, whereby a score is assigned to each area and the total drives an overall score for the building.

Traditionally, building regulation and environmental certificates have focused on the operational phase of the building's lifecycle, with comparatively less attention to the earlier (and later) stages of the lifecycle. This however may change in the future as operational emissions are reduced (both the EU and the UK have zero-emission targets for new buildings over the next few years). An example of this trend is the latest London planning consultation document which makes explicit reference to proposals to reduce embodied emissions, and the latest BREEAM consultation⁴³ which considers the possibility of increasing the emphasis put on embodied emissions in the scoring system.

Figure 60: Building energy codes around the world



Source: IEA, 2017, ETP

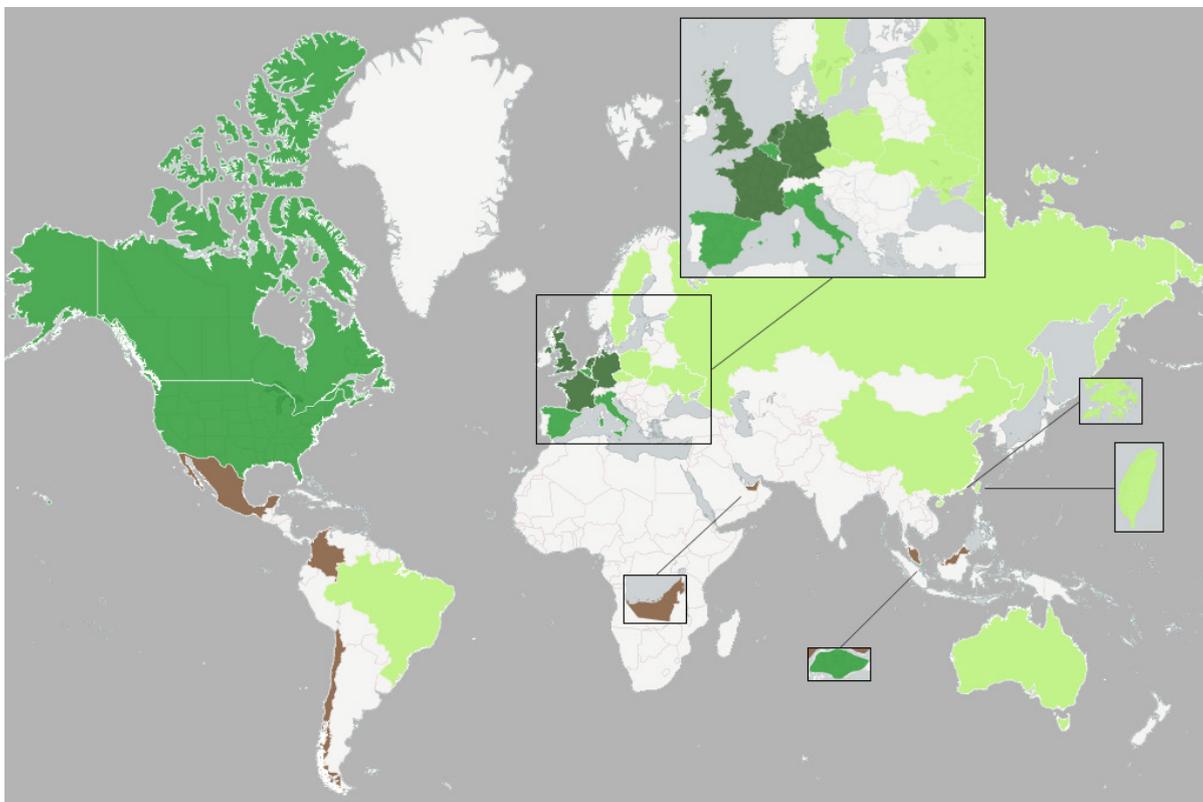
Globally, around two-thirds of existing buildings energy use is still not subject to minimum energy performance standards and half of global stock additions to 2060 are estimated to take place in countries that at the moment do not have mandatory building codes.

Building regulation is often mandated at different levels, from national level down to individual councils. For example, in the European Union the Energy Performance of Building Directive and the Energy Efficiency Directive are the main legislations covering the reduction of energy consumption in buildings.

European countries tend to lead on green building regulation and certification. In a survey on sustainable buildings, Baker & McKenzie⁴⁴ assess a sample of countries on a number of factors, including the presence of green certification, regulation, and energy performance certificates (EPC). Germany, the UK, Netherlands and France top the list with a consistent performance across all metrics. The US, China, Brazil and Australia rank middle of the pack, with Mexico, Malaysia, UEA and Chile at the bottom.

40. IPCC, 2014, Fifth Assessment Report
 41. Harvey, 2009, Reducing Energy Use in the Buildings Sector: Measures, Costs, and Examples
 42. IEA, ETP, 2017
 43. BREEAM UK, 2018, New Construction Draft
 44. Baker Mckenzie, 2016, Global Sustainable Building Index

Figure 61: Baker & McKenzie survey results by jurisdiction (maps)



Source: Baker & McKenzie, 2016

Figure 62: Baker & McKenzie survey results by jurisdiction (country scores)

	Green Certification	EPC & MES	IGR	CO2 & Energy Targets	Renewable Energy	Regulation	Financing	Planning	Green Leases	Total	Rank	Band
Germany	2	1	2	1	1	1	1	1	2	12 (=)	1	Category 1
United Kingdom	2	1	3	2	1	1	1	1	1	13 (↓)	2	
Netherlands	2	1	1	1	2	2	1	2	2	14 (=)	3	
France	2	1	2	1	1	2	2	2	2	15 (↓)	4	
Italy	2	1	1	1	1	2	2	1	4	15 (↑)	4	Category 2
Belgium	2	1	1	1	3	2	2	2	2	16 (NEW)	5	
Singapore	1	1	1	2	4	3	4	1	1	18 (=)	6	
Spain	2	1	1	1	1	3	3	3	3	18 (=)	6	
Canada	2	1	3	2	1	2	3	3	1	18 (↑)	6	Category 3
United States	2	2	2	1	2	3	2	2	2	18 (=)	6	
Australia	2	3	2	3	2	3	2	2	1	20 (↑)	7	
Brazil	2	3	3	2	3	3	2	1	3	22 (↑)	8	
China	2	2	2	2	3	3	2	2	4	22 (=)	8	Category 3
Czech Republic	3	2	3	2	1	2	4	3	2	22 (↓)	8	
Sweden	2	1	4	2	1	2	3	4	3	22 (NEW)	8	
Ukraine	2	3	3	3	3	3	2	2	3	24 (NEW)	9	
Taiwan	2	3	3	3	2	3	4	1	4	25 (NEW)	10	Category 4
Hong Kong	2	1	4	2	4	4	4	3	3	27 (↑)	11	
Poland	2	2	4	3	3	4	4	2	3	27 (NEW)	11	
Russia	2	3	3	3	3	3	3	3	4	27 (NEW)	11	
Colombia	3	3	4	3	4	2	2	3	4	28 (NEW)	12	Category 4
Mexico	4	4	3	4	2	3	2	4	3	29 (↑)	13	
Malaysia	2	3	4	3	4	3	4	4	3	30 (NEW)	14	
United Arab Emirates	2	4	4	3	3	4	4	4	4	32 (=)	15	
Chile	3	4	4	4	4	4	4	4	4	35 (NEW)	16	

Source: Baker & McKenzie, 2016

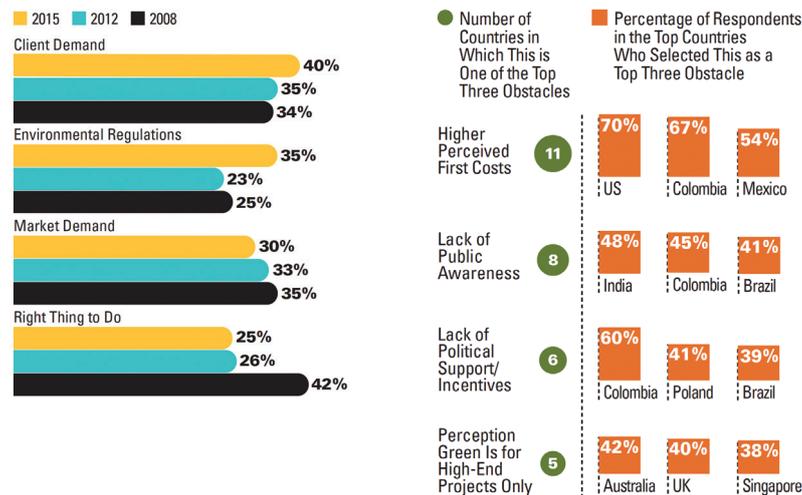
The business case for green buildings

Together with the pull-factor of standards and regulation, the transition towards a green built environment also occurs as a result of a variety of push-dynamics, including market and commercial considerations. A business case for green buildings can be made, based on shifting customer preferences, lower running costs, and the potential for higher valuation and rental yields. Below we look in more details at these drivers.

Developers are reacting to these trends, as shown in a recent survey on green buildings,⁴⁵ where the percentage of firms expecting to have more than 60% of their projects certified green doubled from 18% currently to 37% by 2018.

45. Dodge Data & Analytics, 2016 , World Green Buildings Trends

Figure 63: Drivers and barriers to green buildings



Source: Dodge data & analytics, 2016

Demand drivers

Green buildings are increasingly more attractive to a growing group of corporate, institutional and private buyers. Occupancy rates are on average higher for certified buildings than traditional ones, with a median increase of 2.5% for retrofit/renovation, and 6.4% for new green projects.⁴⁶ Tenants of certified buildings report better productivity and reduced absenteeism⁴⁷, together with health benefits.⁴⁸ Two-third of American corporate leaders believe their customers have needs for sustainability services, and 60% of them believe that sustainability leads to market differentiation and improved financial performance.⁴⁶

Asset valuations and yields

“Green” buildings are more likely to command a premium on both transaction value and chargeable rent, in both the commercial and residential space. Premiums between 7% and up to 16% were observed⁴⁹, outweighing the incremental building costs (around 4% to 8%). Rental rates also tend to be higher than otherwise comparable buildings. From a buyer’s perspective, the direct benefits of owning a green building include lower running costs. However, capitalizing these savings only explain a portion of the transaction premium, indicating that there the buyer is willing to pay an intangible value (reputational/ marketing) for the ownership.

Lower operating costs

Lower operating costs consistently ranks among the top factors in driving green construction activity and has the least variation across countries. In the US, costs are seen improving on average 8.5% for retrofitting and 13.6% for new green projects⁴⁶. Green buildings are generally more expensive to build and lower running costs allow for a pay-back over a period of around eight years⁴⁹.

46. McGraw Hill, 2011, Green Outlook
 47. Watson, 2011, Green Building and Market Impact Report
 48. Business Insurance, 2011, Group health care costs rise 6.1%
 49. Dodge Data & Analytics, 2016, World Green Buildings Trends
 50. Caldecott et al., 2014, Stranded generation assets: Implications for European capacity mechanisms, energy markets and climate policy
 51. Lloyds, 2017, Stranded assets: transition to a low carbon economy
 52. IRENA, 2017, Stranded assets and renewables

Benefit	New Green Building		Green Retrofit Response	
	2012	2015	2012	2015
Decreased Operating Costs Over One Year	8%	9%	9%	9%
Decreased Operating Costs Over Five Years	15%	14%	13%	13%
Increased Building Value for Green versus Non-Green Projects (According to AEC Firms)	7%	8%	5%	7%
Increased Asset Value for Green versus Non-Green Projects (According to Owners)	5%	7%	4%	7%
Payback Time for Green Investments	8 Years	8 Years	7 Years	6 Years

Can buildings become stranded?

Stranded assets are assets that have suffered from unanticipated or premature write-downs, devaluation or conversion to liabilities⁵⁰. Climate-related regulation is an important driver of possible stranding of buildings, although other sources exist. We summarize the main ones below:

Regulatory risks: mandatory energy efficiency regulation can cause retrofitting or substitution of buildings equipment and envelopes before the end of their technical lifetime. Regulation can also affect the buildings’ economic returns by setting limitations on lettings.

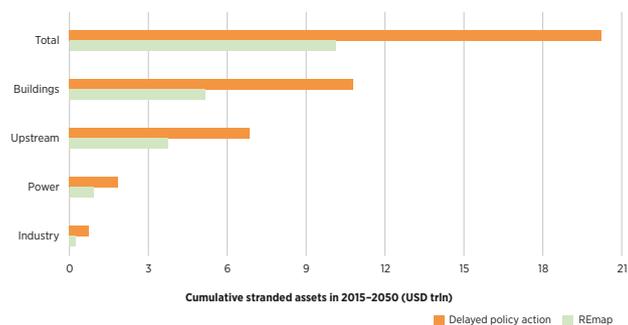
Physical risk: a building’s functionality may become impaired due to physical impact from climate/weather changes. This includes both direct impact (e.g. increased levels of water, storms damages) and indirect risks (e.g. disruptions to supply chain, labor).

Liability/legal risk: insurers and banks may refuse to insure and finance developments or transactions exposed to climate change risk (physical or regulatory). Real estate professionals could be sued for negligence for not disclosing or misleading on climate change impacts to property investors should the building become obsolete or impaired because of climate change⁵¹.

The International Renewable Energy Agency⁵² estimated the risk of impairment/stranding from regulatory risk. The assessment is based on two scenarios out to 2050, both achieving the below 2 degrees target: the first assumes immediate action, the second integrates a delayed action starting in 2030. The level of impairment is determined as the book value of assets that have to be prematurely retired in order to achieve 2050 decarbonization targets (reconstruction, retrofit, substitution).

The results of the analysis show that buildings are the most affected assets globally, with a cumulative of US\$ 5 trillion assets stranded in the immediate action scenario and US\$ 10.8 trillion in the delayed action scenario. This represents respectively 50% and 55% of system impairments (compared to e.g. 40% and 35% of the upstream energy sector). The gap between the immediate and the delayed action scenarios is due to the fact that about half of the building floor space in 2050 is yet to be constructed.

Figure 64: Stranded assets by sector, under immediate action (REmap) and delayed action.



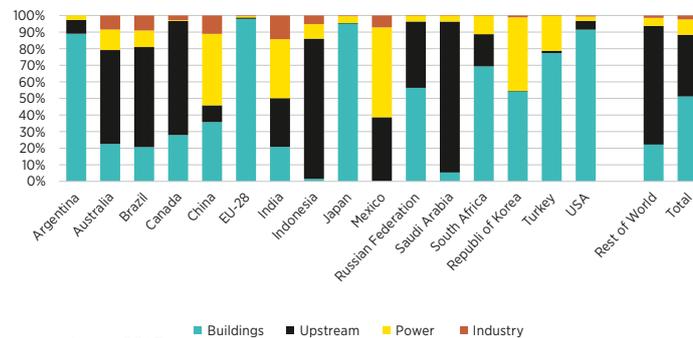
Source: IRENA, 2017

Geographically, while this risk is higher in developed markets due to the low stock turnover of buildings, emerging markets have scope to significantly reduce the risk of stranding by acting immediately. Additionally, high average property values and extensive mortgage liabilities make the US, Europe and Japan particularly exposed to buildings stranding, which represents 95% of their total stranded value in these countries.

What the Paris agreement means for the built environment

Efforts to achieve the Paris Agreement's goals will affect cities and the built environment in multiple ways, tackling both embodied and operational emissions. Focus for embodied emissions will be on upstream industries, primarily the cement and steel sector, but also the mining and other building material industries. We looked at the implications for the cement industry in the Overview section of this report, and we covered the impact for the miners and steel companies in our reports Digging Deep and Nerves of Steel. Below we look at the implications for end-buildings and their operational emissions.

Figure 65: Stranded assets by sector and country in the immediate action

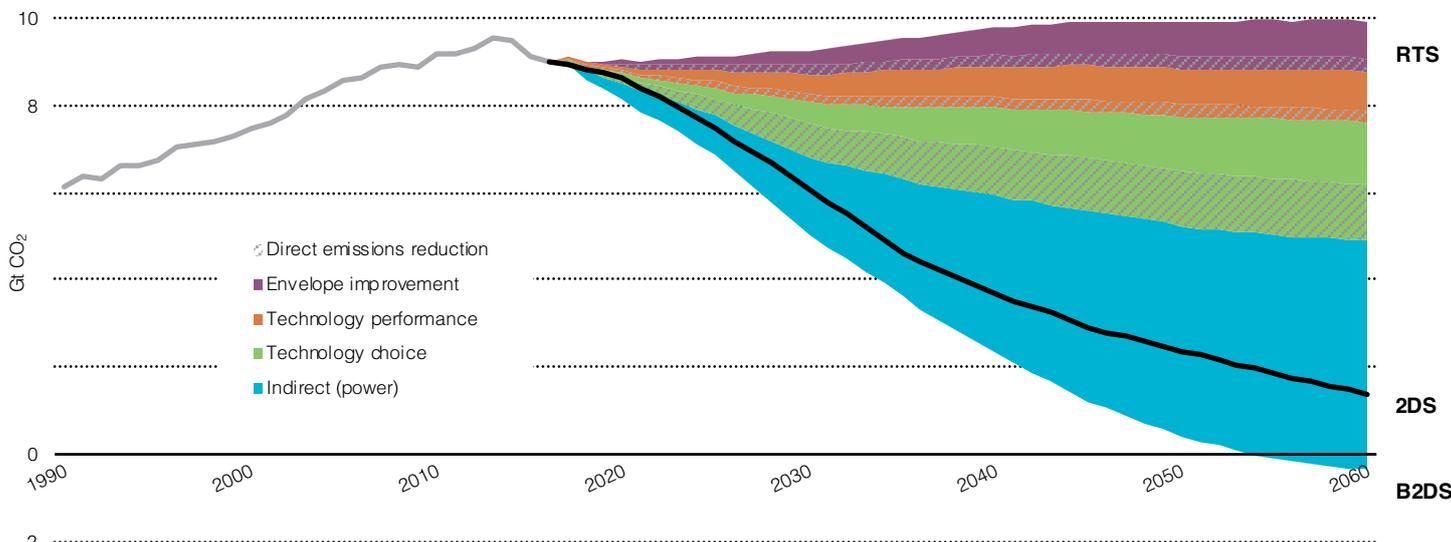


Source: IRENA, 2017

Based on IEA estimates, buildings operations are currently responsible (directly and indirectly) for 9Gt CO₂ per annum, or 26% of global emissions. In a reference scenario, where no aggressive decarbonization measures are taken, buildings' emissions are estimated to grow to 10Gt CO₂ in 2060. To stay below the 2-degrees level, buildings emissions need to be close to zero in 2050 and slightly negative by 2060. Almost half of the reduction against the reference scenario is attributable to buildings' efficiency measures, including envelop improvements, technological choices (such as equipment and fuel choice) and technology performance. The remaining half of total reduction is derived from the building Scope 2 emissions improvements (power sources).

Since the Paris Agreement, almost 90 countries (including the EU) have put forward buildings-related actions in their nationally determined contributions (NDCs). These actions include commitments to reduce emissions from buildings, construction supply chains, increase renewables and adopt or strengthen energy policies.

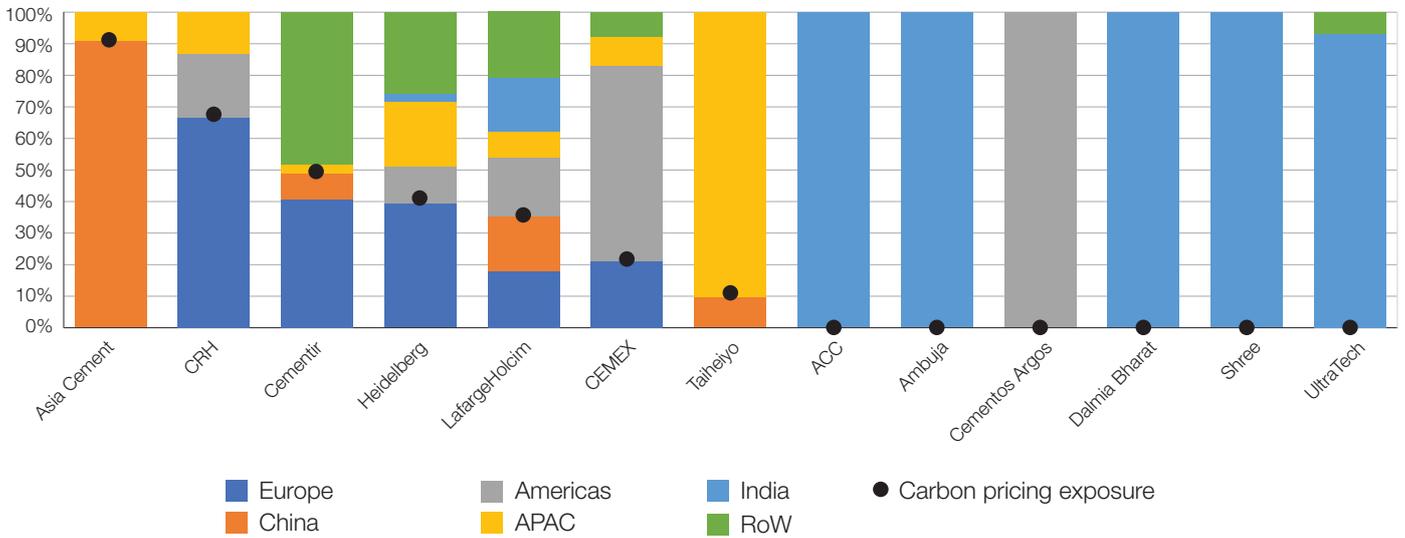
Figure 66: Key contributions to CO₂ emission reductions in buildings under different decarbonization scenarios (2DS) and beyond 2 degree (B2DS)



Source: IEA, 2017, ETP

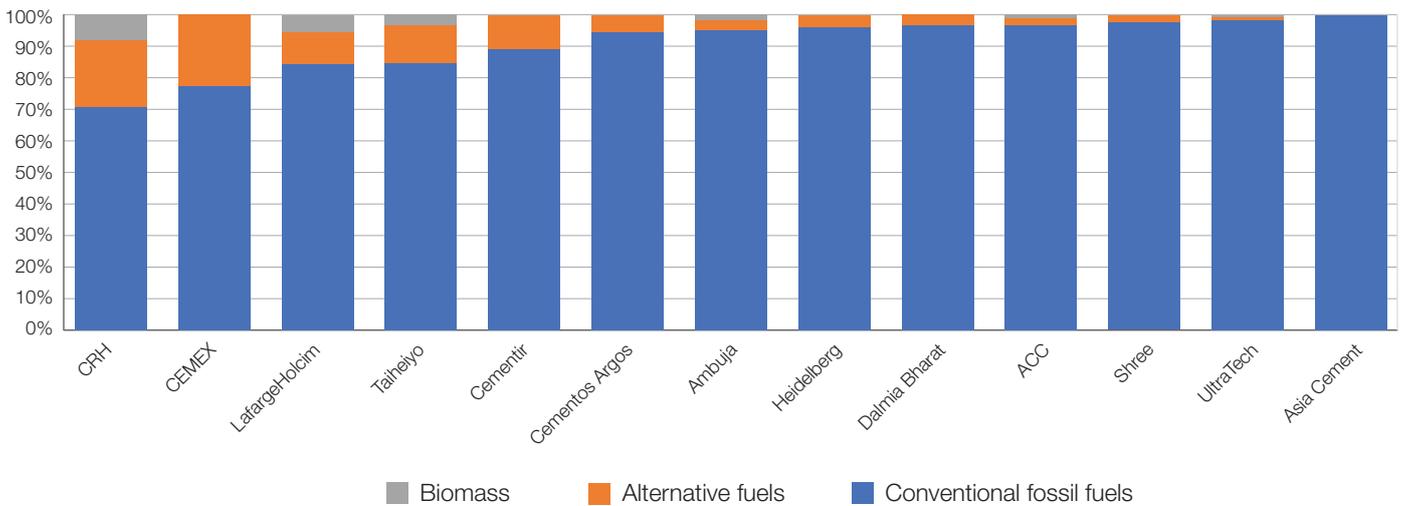
Supplementary figures

Figure 67: Emissions breakdown by region



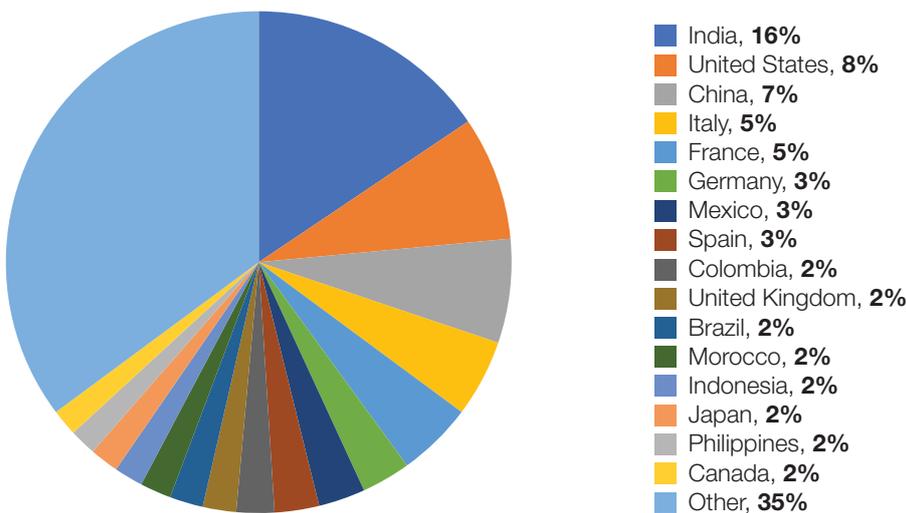
Source: GDP, company reporting

Figure 68: Alternative fuel use breakdown



Source: GDP, company reporting

Figure 69: Company plant locations



Source: Global Cement Directory

Appendix I: Company performance traffic light chart

Company performance overview

League Table rank	1	2	3	4	5	6	7	8	9	10	11	12	13	Metric Area
Companies	Dalmia Bharat	Ambuja	Cementos Argos	Shree	LafargeHolcim	Heidelberg	CRH	ACC	Ultratech	CBMEX	Taiheiyu	Cementir	Asia Cement	
Transition risks rank	1	3	7	2	8	9	6	4	5	12	11	10	13	35%
Emissions intensity	1	3	5	2	6	8	7	4	9	11	12	10	13	45%
Thermal energy intensity	5	4	12	2	9	11	8	3	1	13	6	7	10	25%
Clinker ratio	1	3	4	2	8	6	5	7	9	11	10	12	13	15%
Financial flexibility	9	1	9	3	8	6	6	2	4	13	9	5	12	10%
Downstream regulation	1	1	8	5	6	9	11	3	4	13	10	7	12	5%
Physical risks rank	9	11	2	13	6	7	4	10	12	8	1	5	3	10%
Acute physical risks	9	11	3	13	6	5	4	10	12	8	2	1	7	50%
Water stress risk	6	11	2	13	5	7	4	9	12	8	3	10	1	40%
Water usage & management	8	2	10	1	7	12	5	11	4	6	3	9	13	10%
Transition opportunities rank	2	12	7	3	4	1	5	6	10	8	11	9	13	25%
Alternative materials	1	9	11	2	7	5	10	3	4	12	6	8	13	40%
Alternative fuel	8	6	7	10	4	2	1	11	13	3	9	5	12	20%
Financial scope	6	11	5	3	9	1	12	7	4	2	10	8	13	20%
Innovation scorecard	10	11	4	12	2	1	4	6	8	3	13	7	9	20%
Climate governance & strategy rank	4	1	2	7	3	5	9	10	8	6	12	13	11	30%
Emission reduction targets	2	4	1	6	3	7	10	12	8	11	9	12	5	25%
IEA gap analysis	1	2	8	4	3	9	6	7	5	10	12	11	13	25%
Emissions data verification	5	3	9	7	10	11	1	2	8	12	4	13	6	5%
Climate-related remuneration	9	2	1	11	10	6	4	7	3	5	11	11	8	15%
Board-level climate management	9	4	1	2	7	8	10	3	5	6	10	13	10	10%
Internal carbon price	5	3	6	7	1	4	8	8	10	2	10	10	10	15%
CDP Score	9	7	5	6	2	1	10	8	11	3	12	13	4	5%
Total	7	8	4	7	4	4	2	5	1	3	3	1	2	
	5	5	6	6	6	7	6	3	6	6	3	2	3	
	4	5	7	2	8	7	9	7	7	5	7	7	2	
	3	1	2	4	1	1	2	4	5	5	6	9	12	



Source: CDP

This heat map is designed to help investors pinpoint priority areas for engagement.

Green = good performance
Yellow = reasonable performance
Orange = monitor performance, possible concern
Red = area of concern, engage with company

We have not assigned a uniform number of green, yellow, orange and red colours across the metrics according to rank. Instead, we have reviewed the results of each metric in detail and assigned the above colours according to the underlying values for each metric.

Appendix II: Company summaries

Asia Cement

Average market cap 2017: US\$ 3 bn

Stock exchange listing: Taiwan SE

Production 2016: 33.54 Mt

Ticker	League Table rank	Transition risks rank	Physical risks rank	Transition opportunities rank	Climate governance & strategy rank
1102 TT	13	13	3	13	11

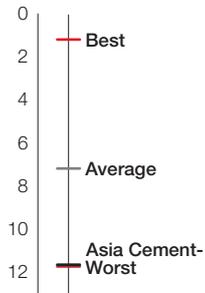
Company strengths

- Has the lowest exposure to water stress risk and ranks third overall on physical risks. On water stress in particular, it is expected that in 2030 only a quarter of their capacity will be in medium or higher risk water stress areas, compared to an average for the group of 63%.
- It scores above average on quality of emission targets, being one of only three companies that have more than one emission reduction target.
- It is one of only four companies to verify 100% of its Scope 3 emissions.

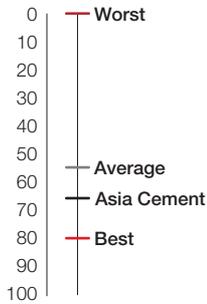
Company weaknesses

- Ranks last in transition risks, with the highest clinker ratio (92%) and Scope 1 emissions intensity (779 kg/T cementitious product), and the weakest net debt/ EBITDA (at 6.4x).
- Ranks last in transition opportunities, with the lowest use of alternative materials (1%) and fuel (0%) and the lowest level of R&D expenditure (close to 0%).
- Third last on governance metrics, with no internal carbon pricing, largest gap to IEA 2-degrees and limited link between remuneration and climate risk management.

Emissions intensity weighted rank

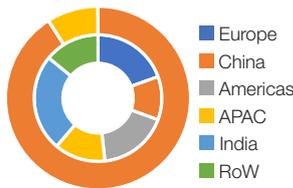


Emissions targets score

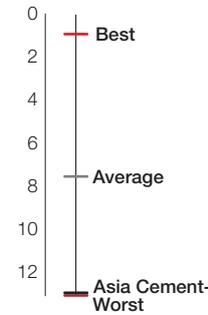


Emissions by region

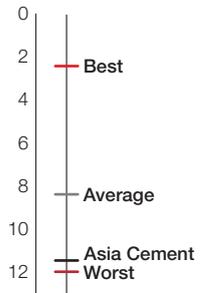
Outer circle: Asia Cement
Inner circle: Average for 13 companies



Alternative materials weighted rank



Alternative fuels weighted rank



Cementir

Average market cap 2017: US\$ 1 bn

Stock exchange listing: Borsa Italiana

Production 2016: 10.11 Mt

Ticker	League Table rank	Transition risks rank	Physical risks rank	Transition opportunities rank	Climate governance & strategy rank
CEM IM	12	10	5	9	13

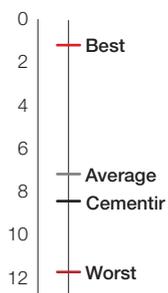
Company strengths

- Ranks in the top quartile in the physical risk. It benefits from the lowest exposure to acute physical risk in the group, although this is partly off-set by high level exposure to future water stress risk.
- It performs above average on financial flexibility, thanks to a relatively low net debt / EBITDA (2.2x) and gearing (26%).
- It ranks fourth on the rate of improvement of alternative material use, although the absolute level is well below average.

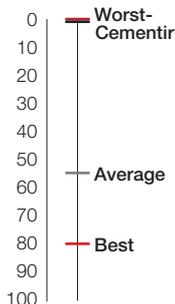
Company weaknesses

- Ranks last on governance & strategy. It currently does not have emission reduction targets, there is no link between remuneration and climate-metrics, and they do not disclose any information suggesting a board/executive climate committee.
- It has the third largest gap to IEA 2-degrees target.
- It ranks fourth last on transition risks, with the second worst performance in clinker ratios (due to a high and increasing absolute level) and above average emission intensity.

Emissions intensity weighted rank

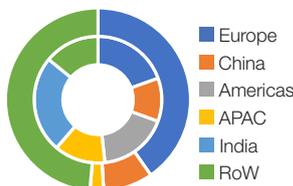


Emissions targets score

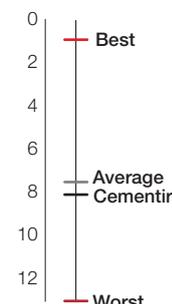


Emissions by region

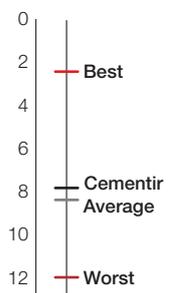
Outer circle: Cementir
Inner circle: Average for 13 companies



Alternative materials weighted rank



Alternative fuels weighted rank



Taiheiyo

Average market cap 2017: US\$ 5 bn

Stock exchange listing: Tokyo SE

Production 2016: 32.00 Mt

Ticker	League Table rank	Transition risks rank	Physical risks rank	Transition opportunities rank	Climate governance & strategy rank
5233 JP	11	11	1	11	12

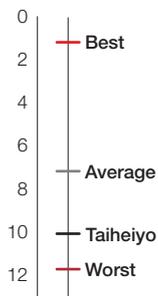
Company strengths

- Scores best on physical risk, with the second-lowest exposure to acute physical risk and third-best for exposure to water stress areas.
- It ranks fourth on data verification with 100% of their Scope 1+2+3 emissions verified.

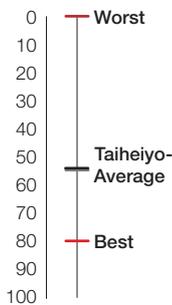
Company weaknesses

- It performs second worst overall for governance & strategy. The company does not disclose how it links remuneration to climate metrics nor how climate-risk management is integrated through all levels of operations.
- It has the second largest gap against the IEA 2-degrees targets.
- It is the third worst on readiness for transition risks, with the second highest Scope 1 emissions intensity (715 kg / t cementitious product) and limited financial flexibility due to high level of gearing (53%) and net debt / EBITDA.

Emissions intensity weighted rank

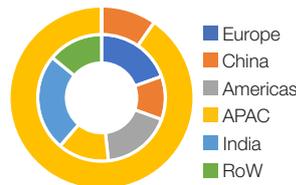


Emissions targets score

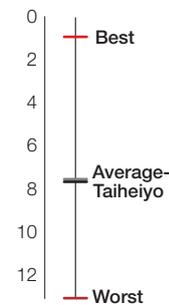


Emissions by region

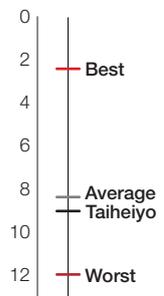
Outer circle: Taiheiyo
Inner circle: Average for 13 companies



Alternative materials weighted rank



Alternative fuels weighted rank



CEMEX

Average market cap 2017: US\$ 13 bn

Stock exchange listing: Mexico SE

Production 2016: 66.71 Mt

Ticker	League Table rank	Transition risks rank	Physical risks rank	Transition opportunities rank	Climate governance & strategy rank
CEMEXCPO MM	10	12	8	8	6

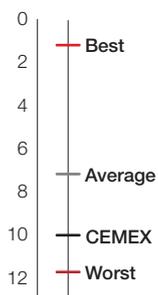
Company strengths

- Benefits from the third-best EBIT margins.
- Uses the second highest carbon price in the group, at US\$ 30 per tonne of CO₂ which they use in their mid-term planning to better assess the robustness of their business strategy.
- Has the second highest current alternative fuels usage (25%), but this has been declining since 2012.

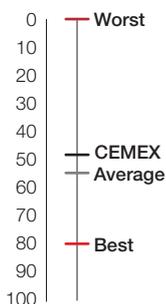
Company weaknesses

- Has the highest level of thermal energy intensity, and this level has increased over the period.
- Is the least financially flexible, with gearing at around 60% and high level of net debt/ EBITDA.
- Has the highest exposure to potential tightening from downstream regulation due to their production in the US and close to C40 cities in Central/South America.
- Ranks second lowest on their usage of alternative materials.

Emissions intensity weighted rank

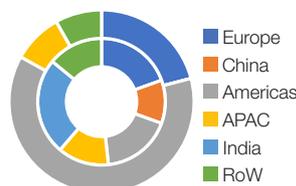


Emissions targets score

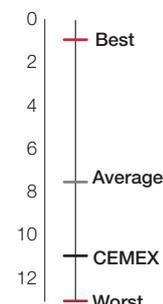


Emissions by region

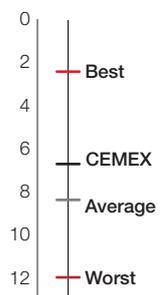
Outer circle: CEMEX
Inner circle: Average for 13 companies



Alternative materials weighted rank



Alternative fuels weighted rank



UltraTech

Average market cap 2017: 17 US\$ bn

Stock exchange listing: NSE India

Production 2016: 47.91 Mt

Ticker	League Table rank	Transition risks rank	Physical risks rank	Transition opportunities rank	Climate governance & strategy rank
UTCCEM IN	9	5	12	10	8

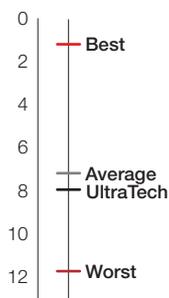
Company strengths

- ▾ Ranks third in climate-related remuneration, with incentive packages including targets relating to emission reduction, energy reduction and efficiency improvement projects, all linked to the KPIs of business unit managers.
- ▾ Also benefits from better than average board level climate management.
- ▾ Rank first for thermal energy intensity, with the current lowest level which has declined since 2012.

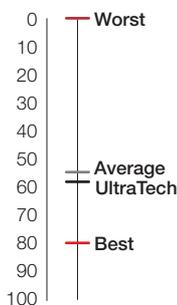
Company weaknesses

- ▾ Ranks second last in exposure to physical risk, with 27% and 55% of their capacity at high acute physical and water stress risk respectively.
- ▾ Ranked last for alternative fuel use, with only 2% of their fuel mix being waste/biofuel.
- ▾ Does not use an internal carbon price.
- ▾ Has above average Scope 1 emission intensity level and this has increased over the period.

Emissions intensity weighted rank

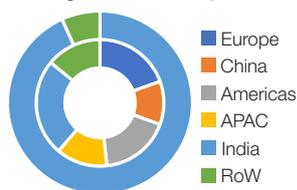


Emissions targets score

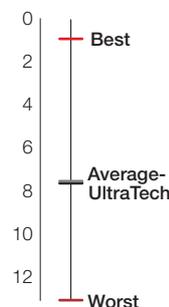


Emissions by region

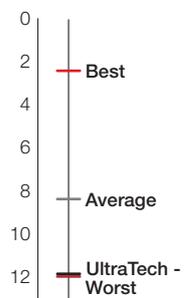
Outer circle: UltraTech
Inner circle: Average for 13 companies



Alternative materials weighted rank



Alternative fuels weighted rank



ACC

Average market cap 2017: US\$ 5 bn

Stock exchange listing: NSE India

Production 2016: 23.18 Mt

Ticker	League Table rank	Transition risks rank	Physical risks rank	Transition opportunities rank	Climate governance & strategy rank
ACC IN	8	4	10	6	10

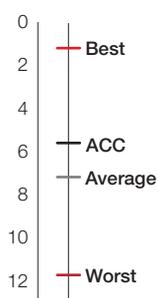
Company strengths

- ▾ Scores well on transition risk metrics, with the second-best level of thermal energy intensity (although this has been increasing over the period), and it ranks fourth-best in emissions intensity.
- ▾ Benefits from the third highest level of alternative material usage, at 22%.
- ▾ Ranks second-best on financial flexibility, with negative gearing and net debt/EBITDA.
- ▾ Performs third-best on board level climate management, with climate-related committees at board/executive level.

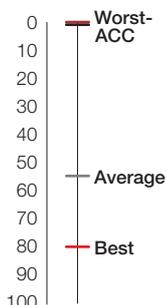
Company weaknesses

- ▾ States that it uses an internal carbon price but does not disclose what it is and scores average on climate-related remuneration.
- ▾ Suffers from high exposure to acute physical and water stress risk, and performs poorly on water usage & management.
- ▾ Scores average overall on transition opportunities, with only 3% alternative fuel usage and average performance in financial scoping.

Emissions intensity weighted rank

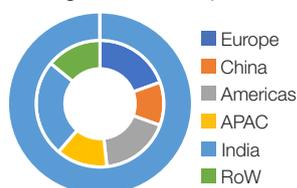


Emissions targets score

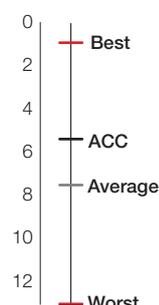


Emissions by region

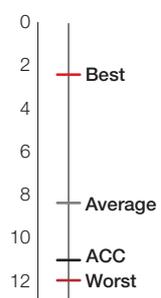
Outer circle: ACC
Inner circle: Average for 13 companies



Alternative materials weighted rank



Alternative fuels weighted rank



CRH

Average market cap 2017: US\$ 30 bn

Stock exchange listing: Irish SE

Production 2016: 34.00 Mt

Ticker	League Table rank	Transition risks rank	Physical risks rank	Transition opportunities rank	Climate governance & strategy rank
CRH ID	7	6	4	5	9

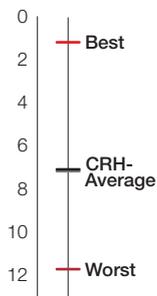
Company strengths

- Has the highest use of alternative fuels, at 34%, and displayed a positive trend over the period.
- Benefits from a low exposure to acute physical and water stress risk thanks to the locations of its plants in Europe and US.
- Performs best on emissions data verification, with reasonable assurance of its Scope 1, Scope 2 and Scope 3 emissions.

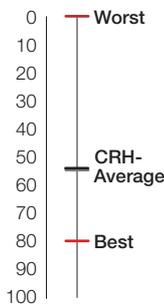
Company weaknesses

- Uses no internal carbon pricing (although they intend to introduce one in the next 2 years).
- Scores poorly on board level climate management, as CRH does not have any climate experts on their board and does not disclose any information suggesting that they have either a board or executive level climate-risk committee
- It performs average on transition risk metrics.

Emissions intensity weighted rank

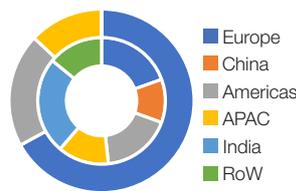


Emissions targets score

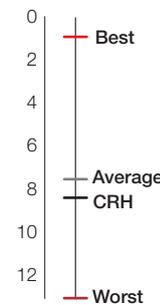


Emissions by region

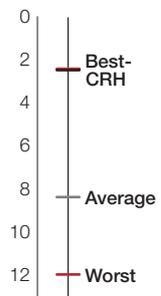
Outer circle: CRH
Inner circle: Average for 13 companies



Alternative materials weighted rank



Alternative fuels weighted rank



Heidelberg

Average market cap 2017: US\$ 19 bn

Stock exchange listing: Deutsche Borse

Production 2016: 124.98 Mt

Ticker	League Table rank	Transition risks rank	Physical risks rank	Transition opportunities rank	Climate governance & strategy rank
HEI GR	6	9	7	1	5

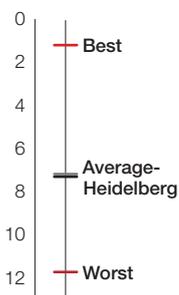
Company strengths

- Ranks best in terms of transition opportunities, as a result of their leadership in CCS, the highest level of R&D spend in the group, and relatively high margins.
- Performs well on alternative fuel use, with 22% of their fuel-mix from waste/biofuels.
- At EUR 20, it uses the fourth-highest internal carbon price.

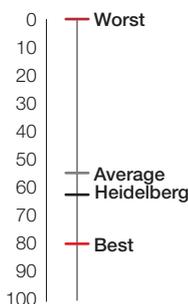
Company weaknesses

- Ranks poorly on thermal energy intensity, with the third-worst intensity level and limited improvement over the period
- Scores average on Scope 1 emissions and clinker ratio.
- Performs average on exposure to physical risks and marginally worse than average on exposure to risks from the built environment.

Emissions intensity weighted rank



Emissions targets score

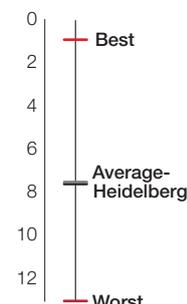


Emissions by region

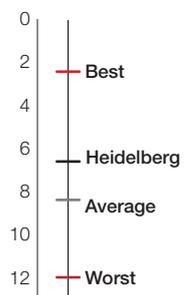
Outer circle: Heidelberg
Inner circle: Average for 13 companies



Alternative materials weighted rank



Alternative fuels weighted rank



LafargeHolcim

Average market cap 2017: US\$ 35 bn

Stock exchange listing: SIX Swiss SE

Production 2016: 233.00 Mt

Ticker	League Table rank	Transition risks rank	Physical risks rank	Transition opportunities rank	Climate governance & strategy rank
LHN SW	5	8	6	4	3

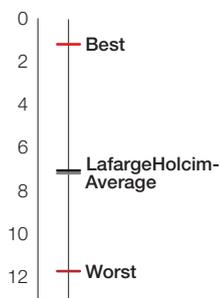
Company strengths

- Performs well on governance & strategy. The company uses the highest internal carbon price just above CHF 30 and has the third-best emission reduction targets and emission intensity performance against IEA 2-degrees targets.
- Is one of three companies to have both short- and long-term emission reduction targets (although they are currently performing poorly against these).
- Scores fourth on transition opportunities thanks to efforts on CCS, investments in low-carbon cement products such as Solidia and Aether, and R&D spend.

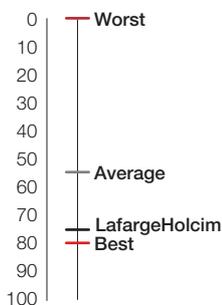
Company weaknesses

- Scores below average on transition risk metrics due to higher thermal energy intensity and indebtedness. The company's clinker ratio and emission intensity are average.
- Performs averagely on use of alternative materials and financial scope, with relative lower EBIT margins and higher capex intensity.
- They are currently lagging behind their own emissions reduction targets.

Emissions intensity weighted rank

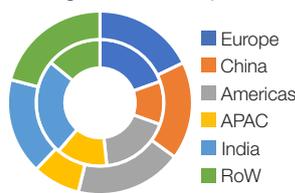


Emissions targets score

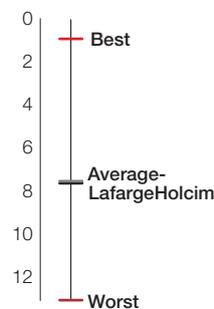


Emissions by region

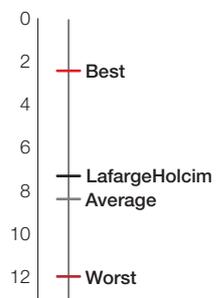
Outer circle: LafargeHolcim
Inner circle: Average for 13 companies



Alternative materials weighted rank



Alternative fuels weighted rank



Shree

Average market cap 2017: US\$ 9 bn

Stock exchange listing: NSE India

Production 2016: 20.29 Mt

Ticker	League Table rank	Transition risks rank	Physical risks rank	Transition opportunities rank	Climate governance & strategy rank
SRCM IN	4	2	13	3	7

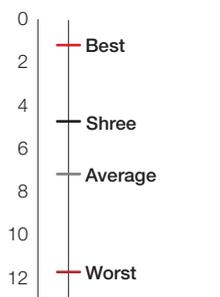
Company strengths

- Ranks second overall in the transition risk metrics, with the second-best Scope 1 intensity and clinker ratio.
- Benefits from the second-best performance in thermal energy intensity. The company has the third-best gearing level and net debt/EBITDA.
- Has the second-highest board level climate management, with the most climate-competent board of directors.
- Its extrapolated emission profile is broadly in line with the IEA 2-degrees target levels.
- Benefits from the second-highest EBIT margins.

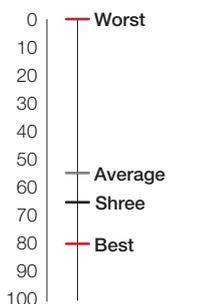
Company weaknesses

- Suffer from the highest exposure to both acute physical risk and water stress risk, with 46% of its capacity currently at high risk from acute physical risks and 67% at high or extremely high risk from water stress.
- The company has a below-average level of R&D investment.

Emissions intensity weighted rank

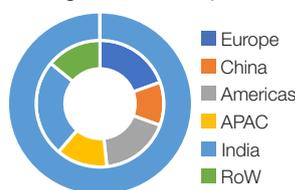


Emissions targets score

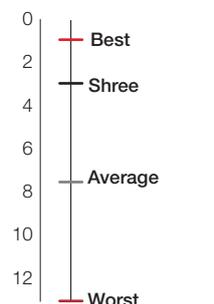


Emissions by region

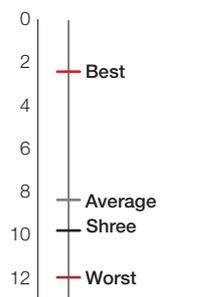
Outer circle: Shree
Inner circle: Average for 13 companies



Alternative materials weighted rank



Alternative fuels weighted rank



Cementos Argos

Average market cap 2017: 5 US\$ bn

Stock exchange listing: Colombia SE

Production 2016: 14.00 Mt

Ticker	League Table rank	Transition risks rank	Physical risks rank	Transition opportunities rank	Climate governance & strategy rank
CEMARGOS CB	3	7	2	7	2

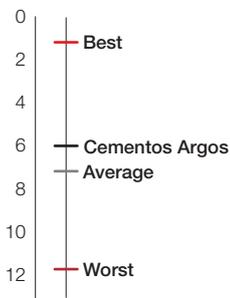
Company strengths

- Performs best on emissions reduction targets, with the highest annual emissions intensity reduction implied, and is currently performing best relative to this.
- The company scores second-highest on governance metrics, with the best board level climate management and executive remuneration, being the only company to incentivize long-term climate-risk management through compensation.
- Benefits from the third-lowest exposure to acute physical risks.

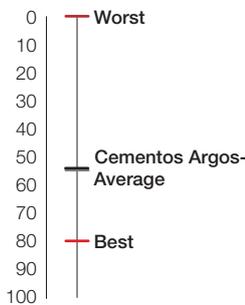
Company weaknesses

- Scores third-lowest on usage of alternative materials, with only 7% used.
- Has among the lowest financial flexibility, with comparatively high level of gearing and net debt/EBITDA. It also has one of the highest capex intensity levels.

Emissions intensity weighted rank

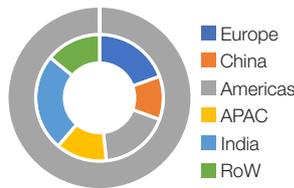


Emissions targets score

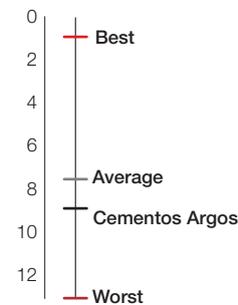


Emissions by region

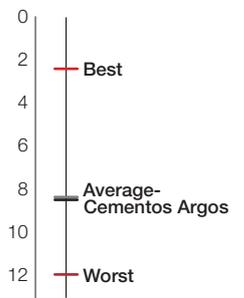
Outer circle: Cementos Argos
Inner circle: Average for 13 companies



Alternative materials weighted rank



Alternative fuels weighted rank



Ambuja

Average market cap 2017: US\$ 8 bn

Stock exchange listing: NSE India

Production 2016: 21.19 Mt

Ticker	League Table rank	Transition risks rank	Physical risks rank	Transition opportunities rank	Climate governance & strategy rank
ACEM IN	2	3	11	12	1

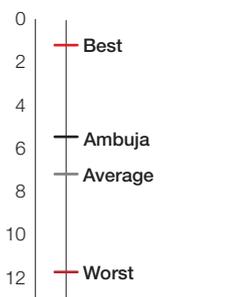
Company strengths

- Ranks third-best on emissions intensity, with strong performance in clinker ratio (66% against group average of 75%) and better than average thermal energy efficiency.
- Scores first in the governance section, scoring well across all metrics. The company has the second-best emissions profile against IEA targets (2017-30), the second-best executive remuneration, and good quality emission reduction targets and board level climate management. Ambuja also uses the third highest internal carbon pricing.
- Benefits from the best financial flexibility, with negative gearing.

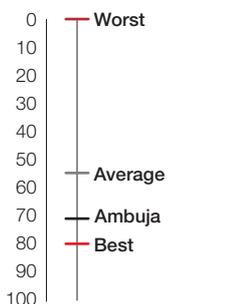
Company weaknesses

- Has from the second-lowest level of R&D spend, with limited or no investments in CCS and low-carbon products.
- Suffers from high exposure to physical and water stress risk. The company has 19% of its capacity at high acute physical risk and 31% at high or extremely high water stress risk.

Emissions intensity weighted rank



Emissions targets score

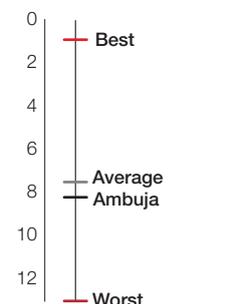


Emissions by region

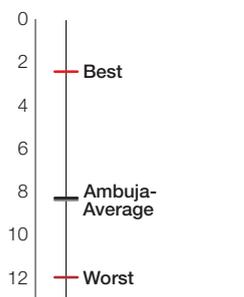
Outer circle: Ambuja
Inner circle: Average for 13 companies



Alternative materials weighted rank



Alternative fuels weighted rank



Dalmia Bharat

Average market cap 2017: US\$ 3 bn

Stock exchange listing: NSE India

Production 2016: 15.30 Mt

Ticker	League Table rank	Transition risks rank	Physical risks rank	Transition opportunities rank	Climate governance & strategy rank
DBEL IN	1	1	9	2	4

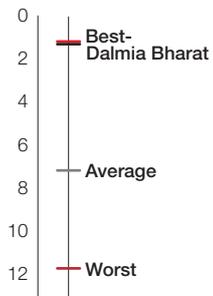
Company strengths

- Scores best on Scope 1 emissions intensity, with both the lowest absolute level and the steepest decline since 2012. The company benefits from the lowest clinker ratio, at 60% vs 75% average for the group.
- Is the only company to have an emissions reduction target beyond 2030 with a target based on 2050. Dalmia also has the third-best annual reduction target and is second on the way to achieving its target, being 8% ahead of where it needs to currently be.
- Has the best emissions profile against IEA 2-degrees targets out to 2030.
- Has the fifth highest internal carbon price.
- Benefits from the highest use of alternative materials, at 30%.

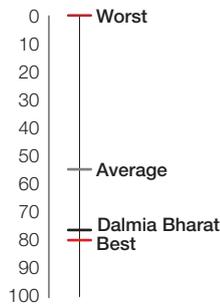
Company weaknesses

- Has the third lowest level of R&D spend, with limited or no investments in CCS and low-carbon products.
- Has a high level of gearing levels, and above average net debt / EBITDA multiple.

Emissions intensity weighted rank

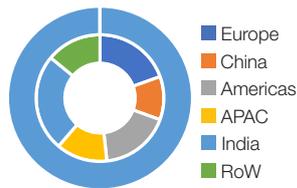


Emissions targets score

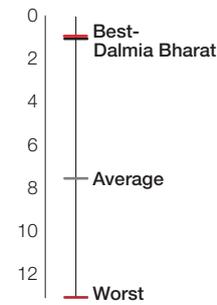


Emissions by region

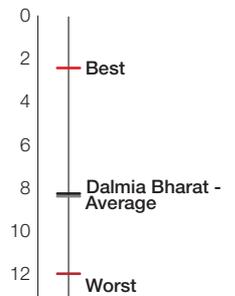
Outer circle: Dalmia Bharat
Inner circle: Average for 13 companies



Alternative materials weighted rank



Alternative fuels weighted rank



Appendix III: Methodology and limitations

Where relevant, our analysis was based on metrics defined by the WBCSD CSI, as this provided a consistent and robust pool of data. In our universe, nine of the 13 companies in our universe are members of the CSI, which provides comparable figures for the period 2012-2016 (e.g. Scope 1 intensity, energy intensity, clinker ratio, alternative materials and fuels).

Transition risks

The overall transition risk performance ranks are determined as follows:

We combine the weighted ranks of the five metrics using the following weightings: emissions intensity 45%, thermal energy intensity 25%, clinker ratio 15%, financial flexibility 10% and downstream regulation 5%.

Metric 1) Emissions intensity

We combine the weighted ranks of all sub-metrics by applying the following weighting: Scope 1 intensity 90% and Scope 2 intensity 10%

Scope 1 intensity: Current level and trend (2012-16)

- ▼ We collate gross Scope 1 cement production emissions per tonne of cementitious material for the five-year period 2012-2016 from company sources or CDP response questionnaires.
- ▼ For Cementir we convert the intensity normalization factor from cement equivalent to cementitious material using a 7% reduction factor. This factor is the median ratio computed from companies who report cement production emissions intensity both per tonne of cementitious material and per tonne of cement equivalent and also crossed checked against and academic literature review.
- ▼ For companies which disclose only net emissions intensities we calculate gross intensity by applying the proportion of net to gross absolute emissions from public reporting.
- ▼ We then calculate the compound annual growth rate (CAGR) across all data points over the period (2012 to 2016).
- ▼ Companies which have reduced their emission intensities quicker (i.e. a more negative CAGR) are ranked higher.
- ▼ We collate Scope 1 (direct cement production) emissions per tonne of cementitious material for the two-year period 2015-2016 from company sources.
- ▼ We calculate the mean Scope 1 emissions intensity over the two-year period of 2015-2016 and use this as current level.
- ▼ Companies which have a lower mean are ranked higher.

We combine the weighted ranks of all sub-metrics by applying the following weightings: reduction in Scope 1 emissions intensity 30% and current Scope 1 intensity 70%

Scope 2 intensity: Current level and trend (2012-16)

- ▼ We collate Scope 2 absolute cement production emissions for the five-year period 2012-2016 from CDP questionnaire responses.
- ▼ We then collate production figures for each year in the period from Bloomberg data and company sources and convert these absolute emissions figures into intensities, normalising by production in each year across the period.
- ▼ We then calculate the compound annual growth rate (CAGR) across all data points over the period (2012 to 2016).
- ▼ Companies which have reduced their emission intensities quicker (i.e. a more negative CAGR) are ranked higher.
- ▼ We then calculate current Scope 2 emissions per tonne of cement for the two-year period 2015-2016 and use this as current level..
- ▼ Companies which have a lower mean are ranked higher.

We combine the weighted ranks of all sub-metrics by applying the following weightings: reduction in Scope 2 emissions intensity 30% and current Scope 2 intensity 70%

Metric 2) Thermal energy intensity

Current level and trend (2012-16):

- ▼ We collate thermal energy intensity (MJ/tonne of clinker) data for the period 2012 to 2016 from company sources.
- ▼ For those companies which report thermal energy intensity in Kcal we apply a conversion factor of 4.184 (Kcal to KJ).
- ▼ We then calculate the compound annual growth rate (CAGR) across all data points over the period (2012 to 2016).
- ▼ Companies which have reduced their thermal energy intensities quicker (i.e. a more negative CAGR) are ranked higher.
- ▼ We calculate the mean thermal energy intensity over the two-year period of 2015-2016 and use this as current level.
- ▼ Companies which have a lower mean are ranked higher.

We combine the weighted ranks of all sub-metrics by applying the following weightings: reduction in thermal energy intensity 30% and current thermal energy intensity 70%

Metric 3) Clinker ratio

Current level and trend (2012-16):

- ▼ We collate the clinker to cement ratio (%) data for the period 2012 to 2016 from company sources.
- ▼ We then calculate the compound annual growth rate (CAGR) across all data points over the period (2012 to 2016).
- ▼ Companies which have reduced their clinker cement ratio quicker (i.e. a more negative CAGR) are ranked higher.
- ▼ We calculate the mean clinker ratio over the two-year period of 2015-2016 and use this as current level.
- ▼ Companies which have a lower mean are ranked higher.

We combine the weighted ranks of all sub-metrics by applying the following weightings: reduction in clinker ratio 30% and current clinker ratio 70%.

Metric 4) Financial flexibility

Current level of gearing:

- ▼ We collate net debt and equity data for the two-year period 2015 to 2016 from companies' annual reports (where net debt is not given it is calculated as non-current borrowings less cash).
- ▼ We then calculate gearing as net debt/(net debt + equity) as a %.
- ▼ We calculate the mean gearing over the two-year period of 2015-2016.
- ▼ Companies which have a lower mean are ranked higher.

Current level of net debt / EBITDA:

- ▼ We collate net debt and EBITDA for the two-year period 2015 to 2016 from companies' annual reports (where net debt is not given it is calculated as non-current borrowings less cash).
- ▼ We then calculate gearing as net debt/EBITDA as a ratio.
- ▼ We calculate the mean ratio over the two-year period of 2015-2016.
- ▼ Companies which have a lower mean are ranked higher.

We combine the weighted ranks of all sub-metrics by applying the following weightings: current gearing 50% and current net debt to EBITDA ratio 50%.

Metric 5) Downstream regulation

- ▼ We collate geographical coordinates, ownership stakes and capacity data for company cement plants from the Global Cement Directory database.
- ▼ To account for the ownership stake each company has in an individual asset, total capacity figures are multiplied by the ownership stake percentage given by the Global Cement Directory database.
- ▼ We collate cities names, coordinates, commitments and action plans from the C40 database and the CDP Cities Actions database.
- ▼ Based on cities and plants coordinates, we match plants which are within a 150km radius from cities which are either part of the C40 network or cities that have in place an action plan on building regulation to reduce emissions. We then calculate the percentage of a group's capacity within a 150km radius of these cities.
- ▼ Companies with a higher percentage of capacity in proximity to cities with C40/building regulations are scored lower.

Limitations

- ▼ Whilst we account for significant M&A activity amongst the companies, some smaller acquisitions of disposals may not be adjusted for in the analysis.
- ▼ Asia Cement metrics in this section are calculated based on its Taiwanese plants only. The company does not disclose data related to their Mainland China plants.
- ▼ In our estimate of downstream regulatory risk, we do not account for import/exports. Our analysis is based on a simplification of the supply-demand dynamic as it assumes that city cement demand is met by plants within a 150km radius.
- ▼ We exclude any analysis of Scope 3 emissions in our assessment given that Scope 3 emissions calculations vary significantly in their scope and level of sophistication. Those companies that do report Scope 3 emissions indicate that these emissions contribute marginally to the total emissions profile of cement companies.

Physical risks

The overall physical risk performance ranks are determined as follows:

We combine the weighted ranks of the three metrics using the following weightings: acute physical risk 50%, water stress risk 40% and water usage & management 10%.

Metric 1) Acute physical risk

- ▼ We collate geographical coordinates, ownership stakes and capacity data for company cement plants from the Global Cement Directory database.
- ▼ To account for the ownership stake each company has in an individual asset, total capacity figures are multiplied by the ownership stake percentage given by the Global Cement Directory database.
- ▼ We use WRI's Aqueduct tool to assign a current acute physical risk classification for the individual plants based on their geographic location.
- ▼ The individual plant physical risk score is categorized into low risk, low to medium risk, medium to high risk, high risk, extremely high risk and arid conditions.
- ▼ Each site is weighted based on capacity relative to a company's total capacity (using Global Cement figures). This gives a greater precedence to sites with higher capacities.
- ▼ At a plant level, we identify the level of acute physical risk exposure by using the following variables (and their weightings) from the WRI aqueduct tool: inter-annual variability (20%), seasonal variability (20%), flood occurrence (30%) and drought severity (30%).
- ▼ The resulting weighted indicator plant score, which ranges from 0 (low risk) to 5 (high risk), corresponds to one of five risk categories and assigns a classification for each site.
- ▼ We calculate the total percentage of capacity each plant contributes to total capacity in each WRI risk category. Then we scale the number according to the following weighting: low=5%, low to medium=10%, medium to high=20%, high=30% and extremely high risk=35%. This approach assigns greater weight to plants facing higher acute physical risk.
- ▼ To account for the ownership stake each company has in an individual asset, total capacity figures are multiplied by the ownership stake percentage given by the Global Cement Directory database.
- ▼ We use WRI's Aqueduct tool to assign both a current water stress risk classification for the individual plants based on their geographic location.
- ▼ The individual plant water stress score is categorized into low risk, low to medium risk, medium to high risk, high risk, extremely high risk and arid conditions.
- ▼ Each site is weighted based on capacity relative to a company's total capacity (using Global Cement figures). This gives a greater precedence to sites with higher capacities.
- ▼ At a plant level, we identify the level of water stress risk exposure by using the WRI overall water risk indicator score weighted to the cement industry and based on the following metrics:
 - (i) Physical risks quantity (70%) based on baseline water stress, inter-annual and seasonal variability, flood occurrence, drought severity, upstream storage, and groundwater stress.
 - (ii) Physical risks quality (9%) based on return flow ratio and upstream protected land.
 - (iii) Regulatory and reputational risk (21%) based on media coverage, access to water and threat to amphibians.
- ▼ The score, ranging from 0 (low risk) to 5 (high risk), corresponds to one of five risk categories and assigns a classification for each site.
- ▼ We calculate the total percentage of capacity each plant contributes to total capacity in each WRI risk category. Then we scale the number according to the following weighting: low=5%, low to medium=10%, medium to high=20%, high=30% and extremely high risk=35%. This approach assigns greater weight to plants facing higher water stress risk.

Metric 2) Water stress risk

Current water stress risk

- ▼ We collate geographical coordinates, ownership stakes and capacity data for company cement plants from the Global Cement Directory database.
- ▼ We scale the percentage of production each plant contributes to total production in each WRI risk category according to the following weighting: low=5%, low to medium=10%, medium to high=20%, high=30% and extremely high risk=35%.

Future baseline water stress risk

- ▼ At a plant level, we identify the level of future baseline water stress risk exposure by weighting the scenarios defined by WRI as follows: optimistic (25%), business-as-usual (50%) and pessimistic (25%).
- ▼ We scale the percentage of production each plant contributes to total production in each WRI risk category according to the following weighting: low=5%, low to medium=10%, medium to high=20%, high=30% and extremely high risk=35%.

We combine the weighted ranks of all sub-metrics by applying the following weightings: current water stress risk 50% and future baseline water stress risk 50%.

Metric 3) Water usage & management

Water consumption intensity

- ▶ We collate water consumption figures for each company from 2012 to 2016 using data reported to CDP and company sources.
- ▶ We take the average of 2015 and 2016 as the current company water consumption intensity. Companies with lower water intensities of production are ranked higher.
- ▶ We calculate the compound annual growth rate (CAGR) across all data points over the period 2012–2016. Companies that have reduced their water intensity quicker (i.e. a more negative CAGR) are ranked higher.

Fresh surface water withdrawal

- ▶ Water withdrawal by source is collated for each company at a company level using data from the CDP water questionnaire, company sources and Bloomberg.
- ▶ We take the average of 2015 and 2016 data to give the current relative percentages of fresh-surface water (including rainwater), brackish surface water/seawater, groundwater, municipal supplies and other water sources including produced/process and wastewater.
- ▶ Companies are ranked based on their relative percentage of fresh-surface water. Companies with lower levels of fresh-surface water withdrawals are ranked higher.

Percentage of sites with water recycling

- ▶ Percentage of sites with water recycling is collated for each company at a company level using data from the company sources and Bloomberg.
- ▶ We take the average of 2015 and 2016 as the current percentage of sites with water recycling.
- ▶ Companies with a higher percentage of sites with water recycling are ranked higher.

We combine the weighted ranks of all sub-metrics by applying the following weightings: current water consumption intensity 35%, trend of water consumption intensity 15%, fresh surface water withdrawal 25% and percentage of sites with water recycling 25%.

Limitations

- ▶ The Global Cement Directory database may not be entirely up-to-date and accurate. However, there is a belief that the plant locations are generally accurate and generally represent well the locations of company plants.

Transition opportunities

The overall transition opportunities performance ranks are determined as follows:

We combine the weighted ranks of the four areas using the following weightings: alternative materials 40%, alternative fuel 20%, financial scope 20% and innovation scorecard 20%.

Metric 1) Alternative materials

- ▶ We collate alternative material use figures for the five-year period 2012-2016 from company sources.
- ▶ We then calculate the compound annual growth rate (CAGR) across all data points over the period (2012 to 2016).
- ▶ Companies which have increased their alternative material use faster (i.e. a more positive CAGR) are ranked higher.
- ▶ We then calculate the mean alternative material use over the two-year period of 2015-2016 and use this as current level.
- ▶ Companies which have a higher mean are ranked higher.

We combine the weighted ranks of all sub-metrics by applying the following weightings: alternative material use trend 30% and current alternative material use 70%

Metric 2) Alternative fuel

- ▶ We collate alternative fuel use figures for the five-year period 2012-2016 from company sources.
- ▶ We then calculate the compound annual growth rate (CAGR) across all data points over the period (2010 to 2016).
- ▶ Companies which have increased their alternative fuel use faster (i.e. a more positive CAGR) are ranked higher.
- ▶ We then calculate the mean alternative fuel use over the two-year period of 2015-2016 and use this as current level.
- ▶ Companies which have a higher mean are ranked higher.

We combine the weighted ranks of all sub-metrics by applying the following weightings: alternative fuel use trend 30% and current alternative material use 70%

Metric 3) Financial scope

Current R&D spend

- ▶ We collate R&D expenditure and sales figures for the two-year period 2015 to 2016 from companies' annual reports.

▼ We then calculate the R&D margin by calculating R&D as a percentage of sales. In cases where the company reports this figure the reported percentage is used.

▼ We calculate the average R&D spend over the two-year period of 2015-2016 and use this as current level.

▼ Companies which have a higher average are ranked higher

Current EBIT margin

▼ We collate EBIT and sales for the two-year period 2015 to 2016 from companies' annual reports.

▼ We then calculate the EBIT to sales ratio.

▼ We calculate the average ratio over the two-year period of 2015-2016 and use this as current level.

▼ Companies which have a higher average are ranked higher.

Current capex intensity

▼ We collate capital expenditure and production data for the two-year period 2015 to 2016 from companies' annual reports and Bloomberg data

▼ We then calculate the capex intensity by dividing capital expenditure by production in each of the two years.

▼ We then calculate the average capital intensity over the two-year period of 2015-2016 and use this as current level.

▼ Companies which have a lower mean are ranked higher.

We combine the weighted ranks of all sub-metrics by applying the following weightings: current R&D spend 40%, current EBIT margin 40% and current capex intensity 20%.

Metric 4) Innovation scorecard

We collate information from the CDP questionnaire and company reporting on products and processes which could have a material impact on decarbonisation for the sector and rank companies using a scorecard approach.

▼ The four key areas in the scorecard are: CCS, R&D in low-carbon products, low-carbon product innovation and energy efficiency/renewable targets.

▼ We assess whether companies are involved in any CCS projects, the proportion of their R&D allocated to low-carbon products, the low-carbon products that companies are currently investing in and energy efficiency/renewable targets.

We combine the weighted ranks of all sub-metrics by applying the following weightings: CCS 70%, R&D in low-carbon products 10%, low-carbon product innovation 10% and energy efficiency/renewable targets 10%.

Limitations

▼ The analysis behind the innovation scorecard is relatively subjective with figures and data used as an aid in order to create scores and ranks. However, this was largely down to a lack of disclosure.

▼ Asia Cement metrics in this section are calculated based on its Taiwanese plants only. The company does not disclose data related to their Mainland China plants.

Climate governance and strategy

The overall governance & strategy performance ranks are determined as follows:

We combine the weighted ranks of the seven areas using the following weightings: emission reduction targets 25%, IEA gap analysis 25%, emissions data verification 5%, climate-related remuneration 15%, board level climate management 10%, internal carbon price 15% and CDP score 5%.

Metric 1) Emission reduction targets

We undertook a criteria-based scorecard approach, focusing on general requirements and recommendations cited by the SBTi for target validation.

Emissions coverage

▼ Emissions Scope (75%): Companies scored higher if their target focused on more than one Scope. Companies who had a Scope 1+2 emissions target scored higher than those whose target was only focused on their Scope 1 emissions. The greater coverage of the different Scopes by the target was viewed as a positive but was weighted according to the relative emissions associated with the different Scopes in the cement sector. A Scope 1 target thus scored 8 out of 10, with 80% of emissions in the cement sector related to Scope 1 whereas a Scope 1+2 target scored 8.5 out of 10 with Scope 1 (80%) and Scope 2 (5%) combined equalling 85% of emissions in the cement sector. The remaining 15% of emissions in the sector come from Scope 3 and thus if a target only had a Scope 3 emissions target then they would score 1.5 out of 10.

▼ % of emissions in Scope (25%): The percentage of emissions in a Scope captured by the emissions reduction target was assessed here. If a Scope 1 target focused on 100% of Scope 1 emissions then the company would score 10 out of 10, however if their target focused on only 80% of their Scope 1 emissions the they would score 8 out of 10.

Timeframe

- ▼ Base year (50%): Companies are assessed on when their base year is, with companies who have recent base years scoring better than companies whose base years have long since passed.
- ▼ Target year (50%): Companies are assessed on when their target year is, with companies who have target years further into the future scoring better than companies whose target years are much shorter term.

Ambition

- ▼ Absolute emissions change (20%): In the CDP questionnaire, question CC3.1c asks companies to indicate the change in absolute emissions the intensity target reflects. Companies score better if absolute emissions decrease over the time period of the emissions intensity reduction target.
- ▼ CAGR (40%): Companies are assessed on their calculated annual reduction requirement to reach their target. A higher CAGR scores better as it represents a higher proportional annual reduction in emissions intensity.
- ▼ Performance (40%): An assessment is made as to whether the companies' current intensity level is line with what their target suggests that their current intensity level should be. Using the CAGR, a base year with a base year emissions intensity and a target year and the targeted emissions intensity, emissions intensity levels are projected for all the years in-between. This sub-metric essentially examines whether companies are ahead or behind of their emissions reduction curve or not and by how much.

We combine the weighted ranks of all sub-metrics by applying the following weightings: emissions coverage 30%, timeframe 20% and ambition 50%.

Note: Companies with one target are scored for that target. If companies have more than one target, they are scored on all of their targets. Their 'main' target is the target with a target year furthest from now and that target is scored relative to other companies' main target. If a company has a second target, 25% of the score of the second target is added onto the 'main' target score. The same happens if a company has a third target and so if a company has three targets, the score will be the main target plus 25% of the second target plus 25% of the third target. This rewards companies for having more targets over time as they demonstrate both short-term and long-term emissions reduction planning.

Metric 2) IEA gap analysis

We assess the extent to which the companies' emissions reduction target profiles deviate from the level required to limit global temperature rise to 2-degrees (2DS) in the period 2017-30.

▼ To estimate the 2DS profile, we calculate the required emission intensities based on global cement production and global cement emissions data from the IEA's 2017 ETP 2DS.

▼ We then estimate companies target profiles by linearly interpolating companies' 2016 actual emission intensities and their 2030 emission intensity targets.

▼ Where companies' targets do not reach out to 2030, we linearly interpolate 2016 emissions to the existing target (e.g. in year 2025) and use the resulting CAGR (e.g. between 2016 and 2025) to extrapolate the profile out to 2030.

▼ Where companies do not have a target, we keep the current intensity profile flat out to 2030.

▼ We then compare the IEA 2DS intensity profile to each companies' profile and calculate the cumulative gap.

▼ Companies with smaller gaps score higher.

Metric 3) Emissions data verification

Companies are assessed on the verification of their Scope 1, Scope 2 and Scope 3 emissions data. The data for this metric is sourced from CDP climate change questionnaire CC8.5, CC8.6 and CC8.7 for Scopes 1+2 and CC14.2 for Scope 3 data.

Scope 1

▼ Assurance type (20%): Companies are assessed on the assurance type that they have for their Scope 1 emissions. High assurance receives the highest score of 10 out of 10, reasonable assurance scores 9, moderate assurance 8, limited assurance 7, third party verification/assurance underway 5 and no third-party verification scores 0.

▼ Proportion of Scope 1 emissions verified (35%): This measures what proportion of Scope 1 emissions are externally verified. This percentage is divided by ten to give a score out of 10 i.e. if 78% of Scope 1 emissions are externally verified a company would score 7.8 for this sub-metric.

▼ Uncertainty of Scope 1 verified (45%): Companies are assessed on the range of uncertainty of their Scope 1 verification. Uncertainty ranges of less than or equal to 2% score 10, more than 2% but less than or equal to 5% scores 9.5, more than 5% but less than or equal to 10% scores 9 and more than 10% but less than or equal to 20% score 8. After that, every 10% less certainty scores 1 mark less until more than 90% but less than or equal to 100% which scores 0.

Scope 2

- ▼ Assurance type (20%): Companies are assessed on the assurance type that they have for their Scope 2 emissions. High assurance receives the highest score of 10 out of 10, reasonable assurance scores 9, moderate assurance 8, limited assurance 7, third party verification/assurance underway 5 and no third-party verification scores 0.
- ▼ Proportion of Scope 2 emissions verified (35%): This measures what proportion of Scope 2 emissions are externally verified. This percentage is divided by ten to give a score out of 10 i.e. if 78% of Scope 2 emissions are externally verified a company would score 7.8 for this sub-metric.
- ▼ Uncertainty of Scope 2 verified (45%): Companies are assessed on the range of uncertainty of their Scope 2 verification. Uncertainty ranges of less than or equal to 2% score 10, more than 2% but less than or equal to 5% scores 9.5, more than 5% but less than or equal to 10% scores 9 and more than 10% but less than or equal to 20% score 8. After that, every 10% less certainty scores 1 mark less until more than 90% but less than or equal to 100% which scores 0.

Scope 3

- ▼ Assurance type (35%): Companies are assessed on the assurance type that they have for their Scope 3 emissions. High assurance receives the highest score of 10 out of 10, reasonable assurance scores 9, moderate assurance 8, limited assurance 7, third party verification/assurance underway 5 and no third-party verification scores 0.
- ▼ Proportion of Scope 3 emissions verified (65%): This measures what proportion of Scope 3 emissions are externally verified. This percentage is divided by ten to give a score out of 10 i.e. if 78% of Scope 1 emissions are externally verified a company would score 7.8 for this sub-metric.

We combine the weighted ranks of all sub-metrics by applying the following weightings: Scope 1 85%, Scope 2 5% and Scope 3 10%.

Metric 4) Climate-related remuneration

We assessed companies based on publicly available remuneration reports and responses to the CDP climate change questionnaire CC1.2 and CC1.2a. The focus was on senior executive remuneration (for short-term and long-term variable incentive programs) as well as company-wide remuneration practices (at a monetary level only excluding competitions and awards).

- ▼ At the senior executive level, we considered the quality of disclosure surrounding metric targets, historical performance against targets, climate-risk specificity of targets and overall proportion of variable incentives tied to climate performance.

- ▼ At a company-wide level we considered the overall quality of disclosure and practices.

The weighted rank for this metric is calculated by applying a 40% rank to executive short-term remuneration, a 40% rank to executive long-term remuneration and a 20% rank to company-wide remuneration initiatives.

Metric 5) Board level climate management

We assessed companies based on publicly available company reports and responses to the CDP climate change questionnaire (sections CC1.1 & CC2.2). The focus was on the level of climate expertise amongst board members, the quality of climate-related committees (at both board and executive levels) and the quality of the company's climate-risk management system.

- ▼ We developed a scorecard based on the level of climate expertise amongst board members. A 'climate experienced individual' was considered to be someone with direct experience of climate-related issues within business, policy or academia. We ranked companies on both the percentage of their board members that were considered to be 'climate experienced individuals' and their level of 'climate expertise'.

- ▼ A scorecard was developed to assess the quality of climate-related committees at both non-executive board (60% weighting) and executive (40%) levels. Companies that had separate climate-related committees at both board and executive levels received scores for both levels, as it demonstrates a stronger governance commitment to climate related risks and opportunities. Assessment of the quality of committees considered disclosure quality (of members, responsibilities and depth of climate-change focus) as well as proportion of independent members (for board level committees).

- ▼ A scorecard was also developed to assess the quality of companies' climate-risk management systems. Assessment considered frequency of reporting to the board, extent of geographical areas considered, extent of climate risk time horizon considered, quality of disclosure and degree of integration of the system throughout the company.

The weighted rank for this metric is calculated by applying a 20% rank to the number of climate-experienced directors on the board, a 40% rank to the quality of climate-related committees and a 40% rank to the quality of the company's climate-risk management system.

Metric 6) Internal carbon price

We collect data on the use of internal carbon prices from companies' responses to question CC2.2c and CC2.2d from the CDP climate change questionnaire.

- ▼ We rank companies according to whether they use an internal carbon price, whether they assess multiple scenarios, whether they disclose the price level(s) used and how high it is - with higher prices favored.

Metric 7) CDP score

- ▼ The 2017 CDP score (previously known as the CDP Performance Band) provides an aggregate measure of quality of climate-related disclosure and management systems addressing climate risks. CDP is committed to transparency and as such provides the full scoring methodology for every program online. In the next CDP reporting cycle (2018) CDP is moving to sector specific questionnaires which will align with TCFD recommendations.

Limitations

- ▼ In the IEA gap analysis, we do not take into consideration future changes in companies' market share, nor deviations between IEA's and companies' assumptions.
- ▼ The breakdown of both the short-term and long-term remuneration schemes (at the executive level) was often not disclosed very clearly or in some cases was not disclosed at all. For instance, for many sustainability metrics it remained unclear to what degree climate performance influenced potential payments. For this reason, we considered climate-risk specificity in ranking metrics as well as the quality of disclosure surrounding targets, historical performance and proportion of total variable incentives. A similar approach was taken to assessing company-wide climate related remuneration initiatives (at a monetary level only).
- ▼ Judgement of professional climate experience was based on publicly available biographies and board of directors' profiles. These searches may have failed to identify some relevant director backgrounds.
- ▼ Certain Asia Cement metrics in this section are calculated based on its Taiwanese plants only. The company does not disclose data related to their Mainland China plants.

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