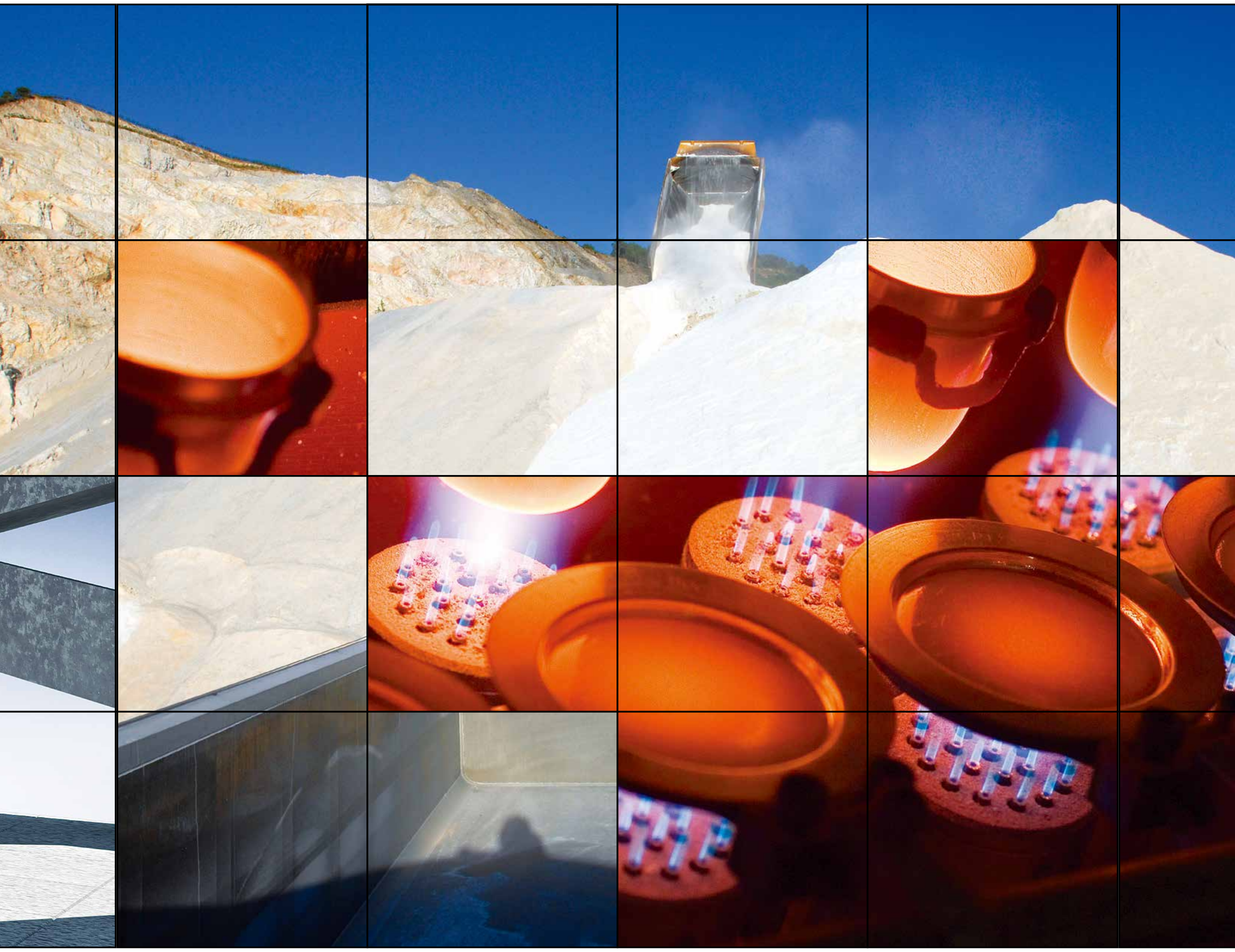
Low Carbon Technology Partnerships initiative



Cement

The LCTPi cement will deliver a reduction of 1 giga ton of CO_2 by 2030, about the same as the total CO_2 emissions of Germany

LCTPi Led by wbcsd

CEO Statement

Concrete plays a vital part in our daily lives, through many diverse applications and usages. It is, in fact, the most used man-made material in the world, with three tons used annually for each man, woman and child.

Thanks to its properties (strength, durability, thermal mass, affordability and abundance of raw materials), concrete can enhance the sustainability of the built environment (from schools, hospitals and housing, to roads, bridges, tunnels, runways, dams and sewage systems), as it offers wide flexibility to construction professionals to achieve their sustainability goals.

Cement is the essential "glue" in concrete. It reacts with water to bind aggregates (crushed stone and gravel) and sand.

Cement production accounts for approximately 5% of worldwide man-made CO_2 emissions:

- About 60% of these emissions come from the raw materials used in the manufacturing process of cement, the basic chemical de-carbonation of limestone into lime releasing CO_2;
- About 40% of these emissions come from the energy required for the above chemical reaction and to heat the materials to a temperature of about 1450°C.

A long-term committed effort to mitigate the CO_2 emissions from the cement sector

Aware of the vital role that concrete plays and will continue to play in the future of our modern society (with increasing urbanised population and mobility needs development), and aware of the significant challenge that mitigating the CO_2 emissions from the cement sector represents, some forward-thinking, leading cement companies gathered together in 1999 to create the Cement Sustainability Initiative (CSI), a CEO-led project operating under the auspices of the World Business Council for Sustainable Development (WBCSD).

Since 1999, climate change mitigation has been at the heart of CSI strategy and work program and the project has realised the following achievements:

- Develop a common Energy and CO_2 reporting Protocol for the cement sector, based on the well-known GHG protocol designed in cooperation by the WBCSD and the World Resources Institute (WRI);
- Set-up the most comprehensive sectoral database of CO_2 emissions, enabling a rigorous monitoring of the CO_2 emissions of the sector (2015 was the 8th consecutive reporting year);
- Develop technology roadmaps in partnership with the International Energy Agency (IEA) and with the financial support of the International Finance Corporation (IFC) in order to:
  - Identify the available and developing technologies, including breakthrough advancements;
  - Evaluate their potential and their needed implementation level to remain within the 2°C temperature increase in 2050.

As early as 2009, the WBCSD and the IEA issued the very first sectoral Carbon Technology Roadmap, paving the way for other sectors to follow.

- Scale-up the implementation of these technologies through:
  - cooperating with national and regional cement trade associations,
  - expanding the CSI membership (it grew up from 10 companies in 1999 to 25 companies in 2015 and others will soon join), and
  - developing regional technology roadmaps (India, Brazil, Egypt…) to better fit to the local contexts and focus on implementation.

A collaborative effort both within and beyond the sector is necessary

Beyond the tremendous efforts already being undertaken by our cement companies worldwide, in particular through the collaborative approach of CSI, we believe that **further action is needed.**

We established a shared statement of ambition, by which **CO_2 emissions should be reduced in the range of 20 to 25% by 2030 compared to business as usual,** an average emission rate equivalent to the emissions of the best-in-class CSI company 2020 targets.

To move forward towards this aspirational goal, we, CEOs of the cement companies represented below, invite the whole sector to join and set-up the following action plan:

1. **Enhance the coverage of the sector's CO_2 emissions and energy consumption database,** with a specific focus on China (about 60% of cement worldwide production).
2. **Enhance overall energy efficiency** of the cement manufacturing process.
3. Scale-up the **collection, availability and usage of good quality alternative fuels and raw materials,** including relevant waste from other sectors in a circular economy approach.
4. **Further reduce the clinker content** in cement to minimize the share of the energy-intensive part of the process.
5. **Develop new cements** with reduced net CO_2 emissions over the full life cycle.
6. **Engage the full building and infrastructure value chain** in local markets to identify and maximize the avoided emissions by usage of cement and concrete products.
7. **Evaluate cross-sectoral initiatives,** particularly on the opportunity to capture, use and store carbon (CCS-U).

The success of these actions is dependent on policy-makers' ability to:

- Agree on a long-term, universal climate agreement in Paris in 2015 to enable the private sector to undertake appropriate long-term investments. **We expect it.**
- Strengthen international cooperation to gather reliable, industry-level energy and emissions data, as well as the development of life cycle assessment (LCA)-related tools and databases for all construction and infrastructure projects. **Our experience in the CSI proves that what gets measured gets managed.**
- Unlock data disclosure barriers in countries where they still exist, such as China. **We need it to ensure a better representation of the whole sector.**
- Develop a concerted strategy on adaptation to climate change in order to match the societal challenges ahead of us. **We believe that adaptation and mitigation should be looked at in conjunction.**
- Review and update regional, national and local level legislation, to ensure the use of alternative fuels and biomass is incentivized by policy. **We favour local, customized initiatives, as there is no one-size-fits-all solution.**
- Develop, revise and strengthen adequate standards, codes and public procurement policies promoting low-carbon products. **Composition-based standards are often the biggest hurdle for the introduction of products with a smaller CO_2 footprint.**
- Promote the development of regulatory and financial incentives for innovative low-carbon cements. **Industry is active, but further support is crucial.**
- Establish financial incentive mechanisms for funding research, pilot and demonstration of CCS-U projects, leading to commercial-scale demonstration plants. **Sectoral cooperation, such as CSI, has proven to be successful. We believe it is time to expand it to cross-sectoral collaboration and confirm our interest to be involved in the process.**

ARGOS

CEMEX

CNBM

华润水泥控股有限公司
China Resources Cement Holdings Limited

CRH

Dalmia
BHARAT CEMENT

GCC

HEIDELBERGCEMENT

InterCement

Italcementi Group
A world class local business

LafargeHolcim

SCG
CEMENT

SECIL

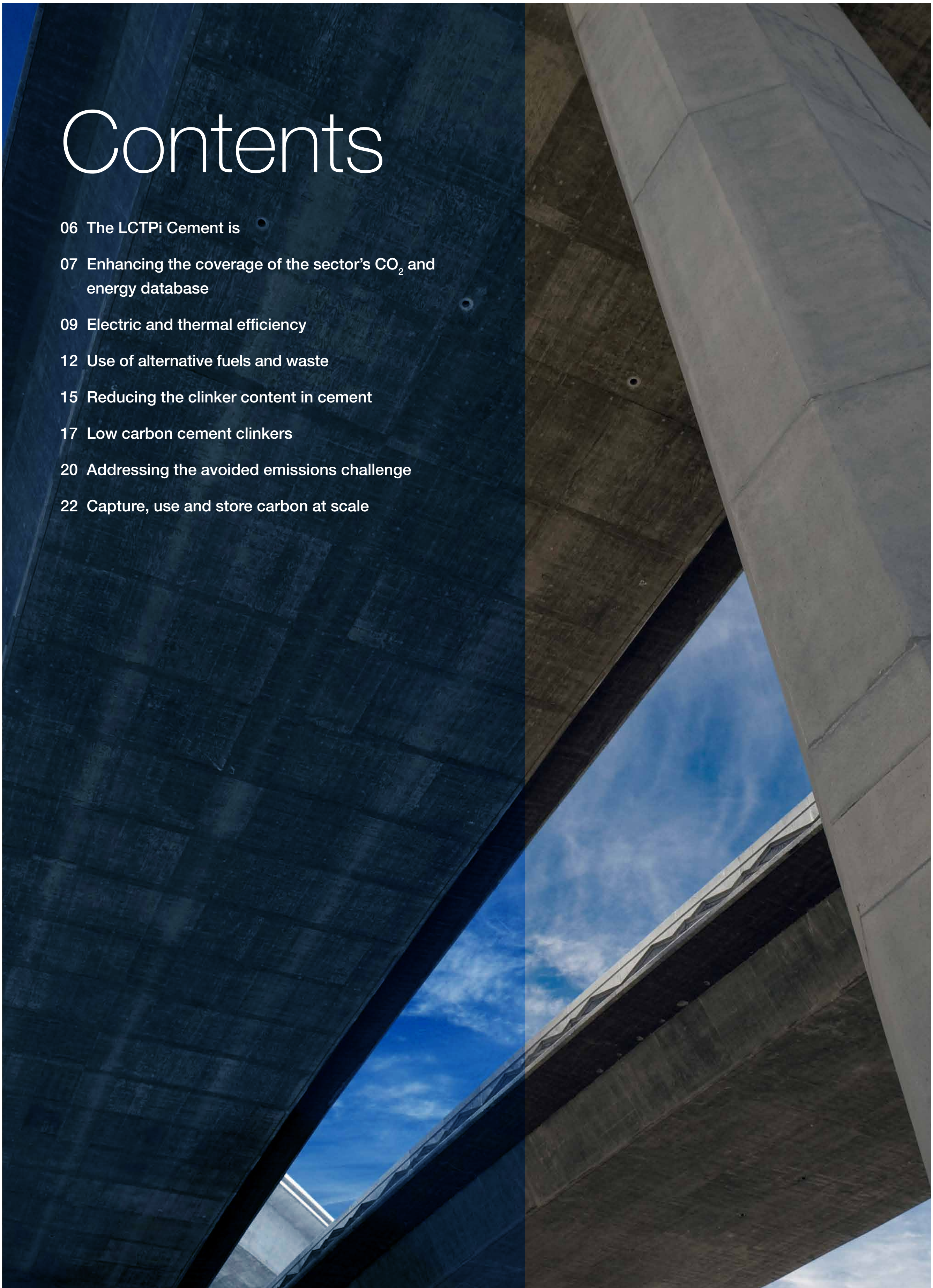
Shree Cement

TITAN

ADITYA BIRLA
UltraTech

Votorantim
Cimentos

中国西部水泥有限公司
WEST CHINA CEMENT LIMITED



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LCTPi
Led by wbcsd

CEMENT

The LCTPi Cement is:

An ambition

Scale-up CO_2 emission reductions of the cement sector in the range of 20 to 25% in 2030 compared to business as usual, based upon Cement Sustainability Initiative's (CSI)[1] best in class 2020 targets.

An agenda of actions

Based on the prospective work in partnership with the International Energy Agency (IEA)[2], including:

1. Enhancing the coverage of the sector's CO_2 and energy database, with a specific focus on China (representing about 60% of cement worldwide production);
2. Enhancing energy efficiency of the cement manufacturing process;
3. Scaling up the collection, availability and usage of good quality alternative fuels and raw materials, including waste from other sectors in a circular economy concept;
4. Further reducing clinker content in cement to minimize the share of the energy-intensive part of the process;
5. Developing new cement with lower energy and calcination requirements;
6. Engaging the full building and infrastructure value chain in local markets to identify and maximize the avoided emissions by usage of cement and concrete products; promoting for instance concrete pavement; and
7. Evaluating cross-sectoral initiatives, particularly on the opportunity to capture, use and store carbon at scale.

A reporting mechanism to monitor progress on each of the above actions will be set up, to reach the shared ambition.

This report aims at describing the key solutions of the cement LCTPi and how it will be delivered; which barriers it tackles, why it is new and important, what will be done, by whom and by when, how the actions will be monitored. For the resources required, please refer to the LCTPi macro analysis and outlook.

As a general policy ask we strongly encourage policies for predictable, objective, level-playing and stable CO_2 constraints and incentives as well as energy frameworks on an international level.

[1] www.wbcsdcement.org

[2] www.iea.org

Enhancing the coverage of the sector's CO_2 and energy database, with a specific focus on China

Background

The LCTPi cement ambition is to implement the solutions identified and developed by CSI members beyond CSI membership and to scale up their benefits by expanding implementation in different regions.

In particular, the use of robust and proven tools - such as the CO_2 and Energy Accounting and Reporting Standard for the Cement Industry[1], the Getting the Numbers Right (GNR)[2] and the Cement Technology Roadmaps[3] developed by the CSI should be suggested and offered to other key countries and regions, such as China by reaching Chinese companies and authorities, to identify the specific solutions applicable to China.

[1] www.wbcsdcement.org/CO2protocol
[2] www.wbcsdcement.org/GNR
[3] www.wbcsdcement.org/technology

Although its exact size is up for debate, China has the largest cement industry in the world. Providing China with the internationally-proven tools that the CSI (in partnership with other stakeholders) has developed throughout the years to support CO_2 emissions mitigation strategies for cement companies, would enhance their ability to identify and implement the levers aimed at reducing an important amount of CO_2 emissions globally. In addition, involving China is key for scaling-up some technologies while reducing their development costs and commercial prices.

Actions

The development of a low-carbon technology roadmap for the Chinese cement industry, consistent with the global WBCSD/IEA roadmap developed in 2009 and the various regional roadmaps developed in India and being developed in Brazil and Egypt, is essential to identify the technology levers that can mitigate the emissions of the cement sector in China and their respective contribution to this overarching goal.

The first element to achieve in that process is to set up a baseline of emissions data, from which a reduction potential can be evaluated, this could be achieved for instance by expanding GNR coverage in China.

To implement the CSI tools, increase GNR coverage and possibly develop a low-carbon technology roadmap in China, the following actions need to be implemented:

- Further enhance co-operation with the local trade associations, i.e. the China Cement Association (CCA)[1] and the China Building Material Federation (CBMF)[2] to reach a substantial number of Chinese cement companies to promote the CSI tools;
- Participate in various forum, widespread knowledge and best practice experience;
- Build up database for China. Training and support could be organized by CSI China-headquartered companies and international ones already reporting to the GNR;
- Strengthening international cooperation to:
  - Gather reliable, industry-level energy and emissions data;
  - Support effective policy development;
  - Track performance, and
  - Identify regional and national performance gaps and best practice benchmarks, for example, through the CSI GNR database; and
- Attract new Chinese members for the CSI.

Policy asks

- Strengthen international cooperation to gather reliable, industry-level energy and emissions data; supporting effective policy development; tracking performance, and identifying regional and national performance gaps and best practice benchmarks.
- Governments (particularly the French Government and its agencies in charge of organizing and hosting the upcoming COP21 in December 2015) and the Office of the United Nations Secretary General should coordinate with the Chinese authorities in charge of climate change to unlock data disclosure barrier to international third parties for the sake of developing a Chinese low-carbon technology roadmap.

Barriers

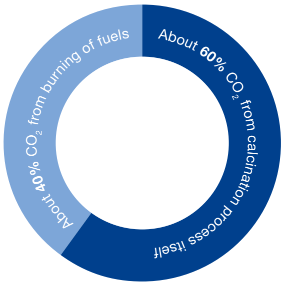
- Unavailability of reported data.
- Cultural reticence in disclosing information.
- Linkage with national development of Intended Nationally Determined Contributions (INDCs) and carbon trading schemes.

Stakeholders

- CSI members having operations in China and the CSI Chinese member companies to promote the CSI initiatives.
- Any government having direct relationship with the Chinese authorities (and particularly the French Government in charge of organizing and hosting COP21) and the Office of the United Nations Secretary General to unlock data disclosure barrier.
- The local cement trade associations (CCA and CBMF) to give support spreading the CSI's messaging, mobilizing the whole cement and building industry in the country and helping identifying local partners.
- Local academics (e.g. technical experts and universities), possibly China Building Materials Academy (CBMA)[3] to lead or contribute to the development of technical papers identifying the various available (or to be developed) technologies.
- Financial community like International Finance Corporation (IFC)[4] supporting companies to be able to implement the use of our tools and adapt it to the local market.

[1] www.chinacca.org
[2] www.cbmf.org
[3] www.cbma.cn
[4] www.ifc.org

Enhancing electric and thermal efficiency



Background

The cement manufacturing sector is responsible for more than 5% of man-made CO_2 emissions. This is constituted of two main parts:

- The calcination process itself, by which calcium carbonate (CaCO3) coming from limestone, marl or chalk is transformed into Lime (CaO), the associated chemical reaction emitting CO_2:
  - About 60% of the emitted CO_2 come from the process itself.
- The energy needed to accomplish the calcination and transformation of lime into clinker, maintaining at temperature of 1450°C inside the cement kiln through the burning of various types of fuel:
  - About 40% of the emitted CO_2 come from the burning of fuels.

Actions

To increase electrical and thermal efficiency in cement plants, the following actions need to be implemented:

- Appropriate and regular training to ensure that plants are operated and maintained in order to ensure the optimum efficiency in operations;
- Increase use and production of renewable energy including waste heat recovery (WHR);
- Research and development (R&D):
  - A significant increase in R&D over the long term is needed within the cement industry. Investment along the whole chain of innovation, from college level training to industrial-scale innovations, must come from academia, the industry, equipment suppliers and governments;
  - Creation of public-private partnerships to help minimize technological risks and create options to increase energy efficiency or reduce CO_2 emissions;
- Phase-out inefficient long-dry kilns and wet production processes in both developed and developing countries;
- Develop and implement international standards for energy efficiency and CO_2 emissions in the cement industry;
- Share best practice policies for the promotion of energy efficiency and CO_2 emissions reductions in the cement industry; and
- Conduct regular energy audits;
  - Have standard measurement and verification (M&V) procedure, cement companies and technology suppliers must work together to agree upon the standard mechanism of replacement of retrofits. For instance, fan replacement.

Policy asks

- Ensure investments in energy efficiency are rewarded in proportion to their societal benefits:
  - Create a new Market Mechanism (MM) to replace the previous Clean Development Mechanism (CDM) framework facilitating the funding of energy efficiency projects and the transfer of technology and knowledge when appropriate.
  - Both rewarding clean energy investments, for example, fiscal incentives for WHR; and penalizing poor energy investments, for example, reducing subsidies if energy generation is inefficient.
  - Make sure that economic and financial mechanisms put in place avoid emissions and production leakage in countries or regions that would benefit from more favourable conditions.

Barriers

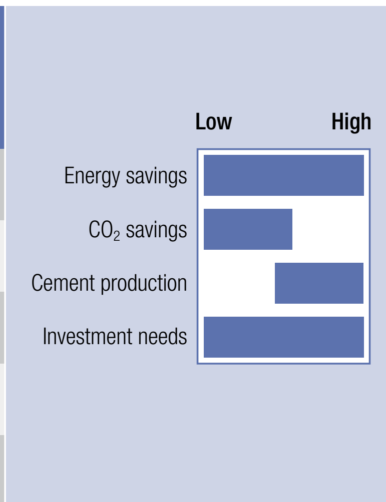
- Huge capital investment costs, particularly to replace the production line (wet to dry kiln for instance).
- Long return on investment.
- No price on carbon (except through local or regional mechanisms, e.g. EU Emissions Trading System (EU ETS)[1].
- Limited possibility of retrofitting ancient technology with new one.
- No global strategy for a company as efficiency is a function of initial and subsequent cement plant investments, which are often dictated by local energy prices.
- Lack of availability of sustainable and affordable energy.
- Low capacity to generate on site electricity with renewable energy.
- Other reduction levers can be negatively correlated with energy efficiency, for example, clinker substitutes such as slag and fly ash reduce CO_2 emissions in the clinker production process but generally require more energy for grinding cement finely.
- Tightening of environmental requirements can increase power consumption (e.g. dust emissions limits require more power for dust separation regardless of the technology applied).
- Lowering investment barriers for WHR and making an easier grid connection for WHR power generation or self-consumption is an import topic in terms of barriers to overcome. Incentives for initial investment in order to lower typical payback periods for the technology are required.
- The demand for high cement performance, which requires very fine grinding and uses significantly more power than standard cement.

Partner roles

item/partner	industry	industry suppliers	governments	universities	research institutes
best practice	x	x			
technology research	x $	x $	$	x	x
technology diffusion	x $	x	$		
institutional structure	x	x	x	x	x
performance data	x				

x = leadership role and direct involvement required
$ = funding source

Potential impacts

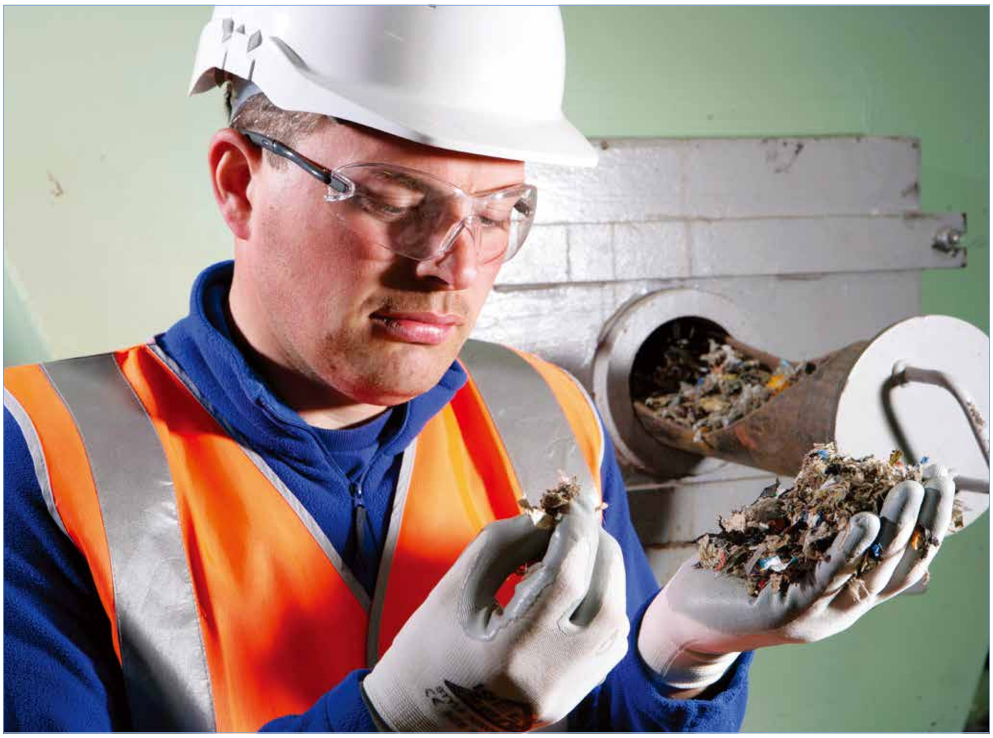


[1] ec.europa.eu/clima/policies/ets/index_en.htm

Stakeholders

- The **industry itself** when building new cement plants, manufacturers to install the most recent technologies, which are also typically the most energy efficient:
  - Thermal efficiency of an installation is largely defined by its original engineering design;
  - However, after installation, efficiency at which the machinery is operated and maintained is key to ensuring that maximum potential operational efficiencies are achieved. This operational efficiency varies by technology, and is hard to measure, but is an important aspect of energy and emissions management.
- **Energy providers** to ensure availability of appropriate fuel and electricity at prices that are consistent with the pursuit of energy efficiency.
- **Authorities and regulators** that influence the price of energy and make the strategic decisions in the energetic mix of a country or a region.
- **Financial community** has a clear role to play in supporting companies to be able to ensure these huge long-term capital expenditures while remaining profitable.
- **Market and economic forces** generally trigger the closure of inefficient facilities as more advanced technologies are commissioned.
- **ESCO and building operators** should enhance their efforts for developing and offering mechanical, building and infrastructure components that reflect the latest state-of-the-art efficient technology.

Scaling up the use of alternative fuels and waste

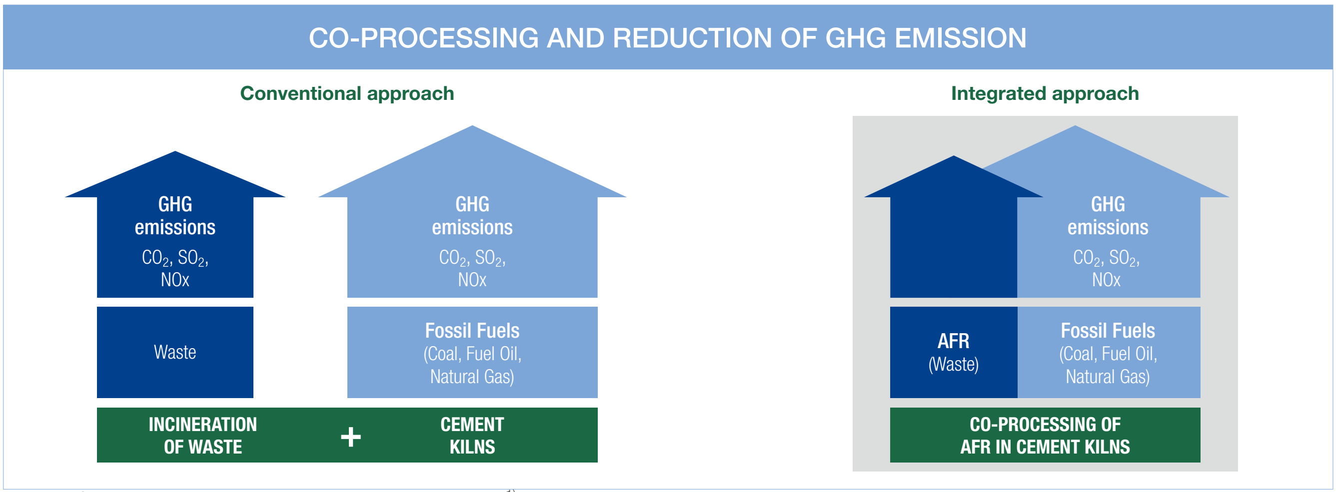


Background

Alternative fuels use entails replacing conventional fuels (mainly coal and / or petcoke) used to operate the cement kiln by unconventional fuels such as wastes and biomass fuels that are less carbon intensive. Carbon intensity of individual fuels is typically some 20% (e.g. plastic waste, waste oil) and 100% (biomass) lower than that of solid fossil fuels, and individual plants have achieved savings exceeding 50% across the fuel mix.

Cement kilns are the best available solution for handling waste streams that cannot be recycled and are therefore important for the development of the circular economy: compared to landfilling, burning wastes in cement kilns saves land, avoids potential leakage problems, avoids the transformation of organic carbon into methane, and recovers both the energy & the material in the wastes. Compared to combustion in a dedicated incinerator, the cement kiln allows for a much higher net substitution of fossil fuels and a full recovery of the material at similar levels of non-Greenhouse Gas (GHG) emissions.

Co-processing in cement kilns reduces CO_2 emissions from cement plants and, simultaneously, reduces CO_2 and other pollutant emissions that would have been emitted from dedicated incinerators and landfills.



source: The European Cement Association (CEMBUREAU)[1]

Actions

To scale the collection, availability, pre-treatment and usage of good quality alternative fuels and raw materials, including waste from other sectors in a circular economy concept, the following actions need to be implemented:

- Promotion of co-processing in cement kilns in developing countries, for instance partnering with United Nations Industrial Development Organization (UNIDO)[2], and enabling widespread expertise in using alternative fuels;
- Partner with other industrial sectors to raise the availability of suitable waste streams for the cement industry;
- Review and potentially update regional, national and local level legislation to ensure the use of alternative fuels and biomass is incentivized by policy;
- Develop resource use indicators, possibly partnering with World Resources Forum (WRF)[3];
- Promotion of social acceptance, diffusion of the CSI co-processing and stakeholder engagement guidelines and ensuring operators follow common sets of guidelines on alternative fuel use to guarantee adequate processes, e.g. providing induction and retraining, documenting and monitoring, for employees and contractors;
- Organize workshops aiming at sharing knowledge and showcasing best practices in the usage of alternative fuels (e.g. CSI Forum 2012 in China); and
- Inventorize and categorize waste streams needed in some countries.

Policy asks

- Policy-makers facilitate stakeholder and public understanding of the role of alternative fuel use in emissions reduction.
- Governments introduce the concept of industrial ecology and promote the concept of a recycling-based society. Legal and regulatory frameworks must support the development of regional processes.
- Partner with national trade associations to promote enabling policies and legislation banning landfilling or making landfilling financially unattractive. Government-industry discussions to investigate the concept of mining landfill sites to generate alternative fuels and raw materials (e.g. because of space needed for urban expansion).
- Build capacity within authorities so they will ensure training and selection of civil servants with adequate technical background to be responsible for permits, control and supervision.
- Recognize emissions of biogenic CO_2 as climate-neutral.
- Offer tax and financial incentives for power generation using alternative fuels and relevant regulatory framework.
- Facilitate processes in issuing permitting for the use of alternative fuels.
- Create corporate social responsibility funds, clean energy fund – money to be made available for use of alternative fuels.

[1] www.cembureau.eu
[2] www.unido.org
[3] www.wrforum.org

Barriers

- Adverse waste management policy. Waste management legislation significantly impacts availability of waste as a source of alternative fuels. Higher fuel substitution only takes place if local or regional waste legislation restricts land-filling or dedicated incineration, and allows controlled waste collection and treatment of alternative fuels.
- In some countries, the authority applies the legislation for waste incinerators to cement kilns conducting co-processing activities. The temperature, residence time and level of final residues clearly demonstrate that a cement kiln has operating conditions and constraints far different than the ones of incinerators.
- Inadequate local waste collection networks.
- Availability of waste. Alternative fuel costs are likely to increase with higher CO_2 costs. It might then become increasingly difficult for the cement industry to source significant quantities of good quality biomass at acceptable prices.
- Public opposition. The level of social acceptance of co-processing waste fuels in cement plants can strongly affect local uptake. People are often concerned about harmful emissions from co-processing, even though emissions levels from well-managed cement plants are the same with or without alternative fuel use and awareness-raising will be key.
- Lack of fair access to and capacity for resources.

Stakeholders

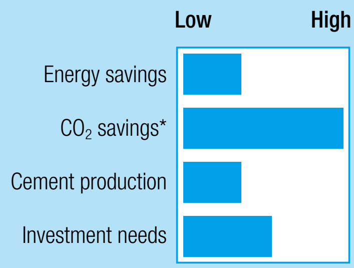
- **Other industry sectors** to ensure proper supply of waste / secondary materials**.**
- **UNIDO** to promote co-processing in cement kilns in developing countries.
- **Multilateral development banks, e.g. World Bank Group**[1] to support companies implementing the required technologies.
- **Reputable international organization, e.g. WRF** to develop resource indicators.
- **National trade associations** to help advocating required policies and legislation with respective local authorities.
- **Governments** to implement the needed legal and policy framework and to unlock the existing adverse ones.

Partner roles

item/partner	industry	industry suppliers	governments (including local municipalities)	universities	research institutes
best practice	x	x			
technology research	x $	x $	$	x	x
technology diffusion	x $	x $	$		
institutional structure	x	x	x	x	x
performance data	x				

x = leadership role and direct involvement required
$ = funding source

Potential impacts



** Range given depends on the definition of alternative fuel used*

[1] www.worldbank.org

Further reducing the clinker content in cement

Background

Clinker is the main component in most types of cement. It gives cement its binding properties and also accounts for by far the largest part of its CO_2 footprint. Other mineral components also have similar hydraulic properties such as blast furnace slag (a by-product from the iron or steel industry), fly ash (a residue from coal-fired power stations) and some natural volcanic materials (i.e. Pozzolana) which can be used to partially substitute for clinker in cement, therefore reducing the volumes of clinker used.

Currently the cement industry is carrying out a number of R&D projects that are expected to result in a lower clinker-to-cement ratio or even in the absence of the traditional active components mentioned above, e.g. by increasing the reactivity of clinker or better understanding the role of inactive components such as ground limestone.

Actions

To further reduce the clinker content in cement the following actions need to be implemented:

- R&D in processing techniques. Documented assessment of substitution material properties is needed to understand and communicate which substitute are best fitted for which intended applications.
- Cross-sectoral collaboration. Develop and cross-reference roadmaps for different industries which are linked to the cement industry by the production of clinker substitutes. This will enable forecasting of the effects of mitigation technologies in one industry impacting mitigation potential in other industries.
- Develop best practice guidelines and increase acceptance. Independent environmental impact studies (EIS) on the use of key substitution materials by the cement and other industries to show where to achieve the highest potential emissions reductions.
- R&D into processing techniques for potential clinker substitutes that cannot currently be used due to quality constraints.

- Promote international training events with national standardization bodies and accreditation institutes to exchange experiences on substitution, concrete standards, long-term concrete performance of new cements, and environmental and economic impacts.
- Consider standards that allow the use of blended cements and concrete with high recycled content.
- Establish hierarchy for recycled content in new building code - mandatory codes.

Policy asks

- Develop adequate public procurement policies that do not give undue preference to cement types with higher clinker contents.
- Enabling policies and legislation. Develop new, or revise existing product standards and codes in some countries to allow more widespread use of blended cement, for example, basing standards on performance rather than composition, and ensuring they are accepted by local authorities.
- Increase the government's role in promoting environment friendly green cement.
- Incentivize low ash fuels.
- Incentivize long distance transport for fly ash & granulated blast furnace slag use.

Barriers

From a technical point of view, low clinker cement ratios are possible for a wide range of certain concrete products, but other non-technical factors can create barriers:

- Regional availability of clinker-substituting materials. There is uncertainty around future availability of clinker substitutes, which may be impacted greatly by environmental policy and regulation. For example, with any future decarbonation of the power sector, the availability of fly ash could be constrained, or when DeNOx techniques are applied in coal-fired power stations to reduce NOx emissions, resulting fly ash may be unusable as a clinker substitute due to excessive NH3 (ammonia) concentrations;
- Increasing prices of substitution materials;
- Properties of substitution materials and intended application of the cement / concrete;
- National standards for Ordinary Portland Cement (OPC) and composite cements in addition with slow change of construction codes;
- Market and regulator acceptance which includes common practice and acceptance of the composite cements by construction contractors and customers;
- Lack of general policies spurring innovation;
- Market readiness;
- Lack of systemic urgency;
- Quality and quality variation of fly ash / granulated blast furnace slag.

Stakeholders

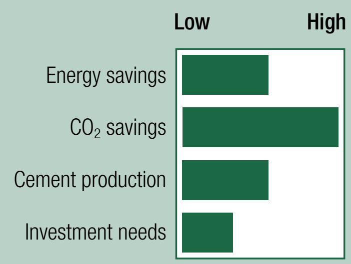
- The **cement value chain** to promote the market acceptance of the low-carbon cements.
- **Standard bodies** to promote the market acceptance of the low-carbon cements.
- **Public procurement bodies** to promote the market acceptance of the low-carbon cements.
- **Financial institutions** to support innovative research.
- Multi-stakeholder **research initiatives**.

Partner roles

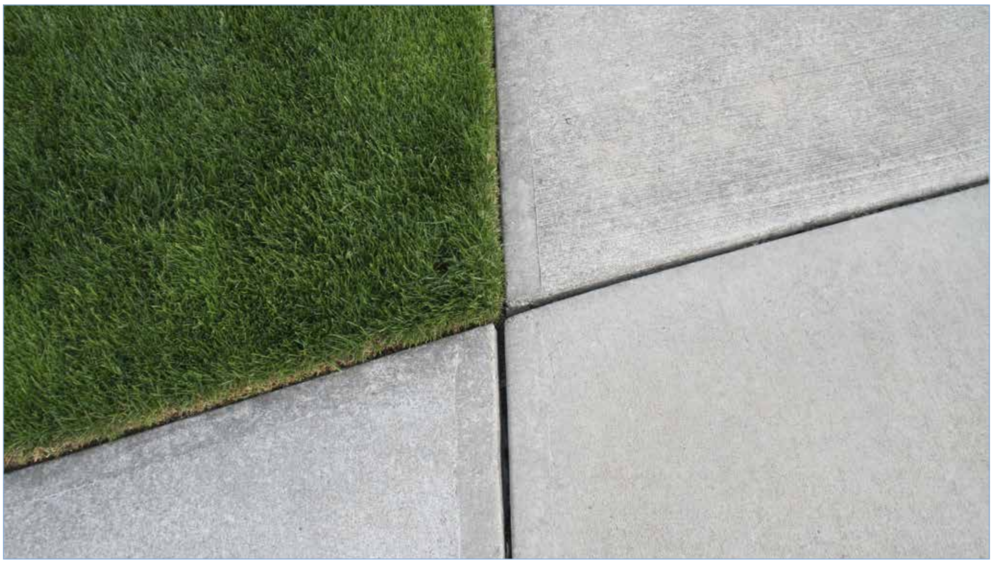
item/partner	industry	industry suppliers	governments (in this case including national laboratories)	universities	research institutes	standardi-sation bodies
best practice	x	x	x	x	x	x
technology research	x $	x	$	x	x	x
technology diffusion	x $	x	$		x	x
institutional structure	x	x	x	x	x	x
performance data	x		x			x

x = leadership role and direct involvement required
$ = funding source

Potential impacts



Development of new types of low carbon cement clinkers



Background

Clinker is the main component in most types of cement and its manufacture is responsible for all the direct and most of the indirect emissions of CO_2 related to cement/concrete use. Traditional OPC are ground and mixed with gypsum and other mineral or cementitious materials such as ground blast furnace slag (a by-product from the iron or steel industry), fly ash (a residue from coal-fired power stations) and/or natural volcanic materials, and then added to concrete along with sand, aggregate, admixture chemicals and water where a hydration reaction occurs and the mixture hardens into concrete.

Direct emissions of CO_2 from the manufacture of OPC clinker are principally caused by calcination of limestone and combustion to supply thermal energy. To produce OPC clinker, limestone as the main ingredient of OPC clinker, must be calcined to form lime which reacts with silica, alumina and iron to form calcium silicates which give cement its desired properties. This calcination reaction also requires a great deal of thermal energy which is supplied by conventional fuels such as coal, coke, oil, and natural gas; the combustion of these fuels also results in large quantities of CO_2 emissions.

The development of new types of clinker follows two basic approaches:

1. Developing new types of cement clinkers with a lower lime requirement would result in lowering both the emissions due to calcination and lower the energy requirement resulting the need to use less fuel and therefore lowering the associated quantity of CO_2 from combustion.
2. The calcium silicates formed during the manufacture of OPC clinker react with water to form calcium-silicate-hydrates (C-S-H) which are the hardened glue in concrete. Some types of calcium silicates can be reacted under the right conditions with CO_2 to form C-S carbonates which can have similar hardened properties to C-S-H.

In the last few years, a number of companies have reported on R&D efforts that have led to the development of sulfoaluminate-clinkers that require lower levels of limestone and will emit less CO_2 due to lower calcination and energy requirements. Although successful on the R&D and during industrial trials, these cements have not yet been widely commercialized as their cost of raw materials, particularly higher levels of alumina, have not allowed them to be economically competitive with OPC. Other cements using mineralized forms of CaO have been limited by the availability of such materials in nature.

There have also been industrial scale tests and deployment of technologies that use carbonization rather than hydration for the development of the hardened concrete structure. To date, technologies that deploy carbonization using OPC have been able to only reach very modest levels of sequestration, and new C-S based cements that do sequester large quantities of CO_2 in concrete product applications are just being beginning to be commercialized.

The United Nation's Environment Programme's Sustainable Building and Climate Initiative (UNEP SBCI)[1] – a partnership of major public and private sector stakeholders in the building sector – established a working group to explore practical, low-cost solutions, to reduce the carbon footprint and increase resource efficiency of cementitious building materials industry. The ambition is to gather solutions capable to help industry avoid carbon capture storage and use as a mitigation strategy.

The group brings together multidisciplinary group of 30 experts from different countries, from academy, industry, non-governmental organizations (NGOs). It will focus its efforts on additional technical solutions to those addressed by the CSI's Cement Technology Roadmap. It will also search for mitigation opportunities down in the industry's value chain, by increasing the efficiency of the use of cement.

It should be however noted that the uncertainty around new types of clinker is very substantial; this is true for a number of key factors that determine the overall impact of these solutions (theoretical reduction potential, cost implications, raw material availability, speed of diffusion, need for changes to existing equipment etc.). For the development of the cement sector ambition a moderately conservative approach was followed that considers the potential of technologies in an advanced stage of development, but also recognizes challenges to their wide-spread implementation; the ambition does not assume any breakthrough technologies such as (nearly) carbon-neutral clinker types.

Actions

To develop new cement clinkers with lower energy and calcination requirements and new cements that sequester CO_2 through a carbonization reaction while hardening the following actions will be implemented:

- R&D in processing techniques. Documented assessment of potential to lower raw material costs for belite-calcium sulfoaluminate-ferrite clinkers. Further development of this class of materials to make them more competitive in cost to OPC;
- Sectors collaboration. Develop incentives for the concrete products industry which has little or no CO_2 emissions to enable adoption of new technologies that have the potential for mitigating CO_2 emissions from the cement industry;
- Develop best practice guidelines and increase acceptance. Independent EIS on the use of low clinker cements by the cement and other industries to show where to achieve the highest potential emissions reductions;
- Join new cements and cementitious materials research initiatives, e.g. École polytechnique fédérale de Lausanne (EPFL)[2] & UNEP SBCI initiative;
- Wide promotion of alternative sources of funding for low-carbon technologies in the cement industry, including export credit agencies and multilateral development banks (e.g., Climate Investment Funds[3] administered by the World Bank Group, International Finance Corporation (IFC)[4], European Bank for Reconstruction and Development (EBRD)[5], European Investment Bank[6] and energy services companies.

[1] www.unep.org/sbci

[2] www.epfl.ch

[3] www.climateinvestmentfunds.org

[4] www.ifc.org

[5] www.ebrd.com

[6] www.eib.org

- R&D into totally new classes of cement clinkers with the potential for lower energy and lower calcination emissions; and
- Promote international training events with national standardization bodies and accreditation institutes to exchange experiences on new types of cements, concrete standards, long-term concrete performance of new cements, and environmental and economic impacts.

Policy asks

- Develop adequate public procurement policies promoting new low clinker cements.
- Enabling policies and legislation. Develop new, or revising existing, cement standards and codes in some countries to allow for the use of low clinker cements. The standards should go beyond chemical composition and be open to performance as well chemistry.

Barriers

From a technical point of view, development of new clinkers and cements that sequester CO_2 while curing into concrete could succeed, but other non-technical issues can be barriers:

- Availability of raw materials. Many of the new clinkers require sources of alumina. Alumina waste materials such as spent catalyst can be a source, but the availability of such materials regional is sometimes challenged;
- National building standards or construction codes often do not allow for new materials to be substituted for standard concretes;
- Market and regulator acceptance which includes common practice and acceptance of the new cements by construction contractors and customers;
- Lack of general policies spurring innovation;
- Market readiness and acceptance; and
- Lack of systemic urgency.
- Intellectual property of R&D projects that could prevent scaling up of implementation.

Stakeholders

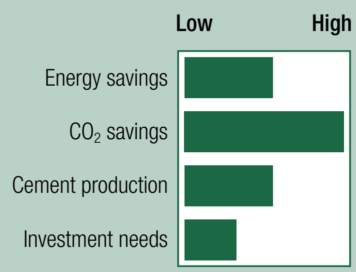
- The **cement value chain** to promote the market acceptance of the low-carbon cements.
- **Standard bodies** to promote the market acceptance of the low-carbon cements.
- **Public procurement bodies** to promote the market acceptance of the low-carbon cements.
- **Research initiatives, e.g. UNEP SBCI-related ones** to spur innovative solutions.
- **Financial institutions** to support innovative research.
- **Multi-stakeholder research initiatives.**

Partner roles

item/partner	industry	industry suppliers	governments (in this case including national laboratories)	universities	research institutes	standardi-sation bodies
best practice	x	x	x	x	x	x
technology research	x $	x	$	x	x	x
technology diffusion	x $	x	$		x	x
institutional structure	x	x	x	x	x	x
performance data	x		x			x

x = leadership role and direct involvement required
$ = funding source

Potential impacts



Addressing the avoided emissions challenge

Background

The cement industry produces approximately 5% of current man-made CO_2 emissions. These emissions are generally measured, monitored and reduced by applying the best available technologies. Being part of low-carbon technology value chain, various cement and concrete products aid the reduction of GHG emissions compared to conventional products or compared to the market average. Under the terminology of the GHG Protocol[1)] international accounting tool, emissions reduction of this kind are termed "avoided emissions". Thus CO_2 emitted during the production process, can be offset through the use phase of the materials which are key components of products and solutions that significantly contribute to the development of resilient infrastructure and the built environment.

Actions

To engage the full building and infrastructure value chain in local markets and maximize the avoided emissions by use of innovative cement and concrete products it will be necessary to increasingly base the selection of building materials and solutions on an assessment of impacts over the full life-cycle of buildings and infrastructure projects, covering extraction of raw materials, processing, transportation, construction, use phase and end-of-life (demolition / reuse) (cradle-to-grave / cradle-to-cradle); the following actions need to be implemented:

[1)] www.ghgprotocol.org

- Enhance and expand the benefits that concrete brings in terms of mitigation and adaptation, increase the associated awareness and knowledge about it;
- Support customers in their striving to implement more sustainable projects by providing expertise and consultancy;
- Support actively the use of life cycle assessment (LCA) methodologies, including but not limited to:
  - Constructive participation in the development of LCA-related standards, methodologies, tools, and best practices;
  - Provision of Environmental Production Declarations (EPDs) for concrete and other building products as key quantitative input for a meaningful impact assessment over the full life cycle of buildings and structures;
  - Increased use of LCA techniques for internal decision making (e.g. selection of technologies, processes, fuels, materials etc.);
- Develop a common methodology and a simplified life-cycle framework for buildings and materials;
- Identify breakthrough cooperation opportunities, at cross-sectoral level, to evaluate the complete life-cycle of the products from other sectors, including the possibilities that some outcomes of one sector could be inputs for other sector in a full circular economy approach; and
- Promote concrete pavements and demonstrate the avoided emissions over asphalt.

Policy asks

- Efforts to mitigate climate change should be accompanied by a concerted strategy on adaptation to climate change in order to match the societal challenges ahead of us. Identify the contribution that concrete can bring to the achievements of some Sustainable Development Goals (SDGs).
- Review of existing standards, revisit, strengthen and further implement building codes and criteria to develop infrastructure taking into account innovative solutions and the value of increased resilience.
- Establish a supra-national body to transfer competences, skills and resources to build resilience in developing countries, prioritizing people at the base of the pyramid, and ensuring direct involvement in the realization of resilience projects.
- Establish regulatory frameworks that foster the application of LCA over the full life cycle, particularly including the use phase, for all construction projects.
- Support the development of LCA-related tools and databases.
- Regulatory framework paving according to demand.
- Support LCA for public procurement and road concessions.

Barriers

- Lack of easy-to-use LCA tools and corresponding databases for key materials, products and processes.
- Market and regulator acceptance which includes common practice and acceptance of innovative products by construction contractors and customers.
- Lack of general policies spurring innovation.
- Market readiness.
- Capacity building for implementation of paving.
- No criteria for durability in pavement design.

Stakeholders

- **City planners, the chemical, the aluminium & steel sector, the building & infrastructure sector**, to develop common indicators on LCA and increase its resilience and the resilience of the communities on which it can have an impact.
- **Governments and policymakers** to revisit, strengthen and further implement building codes and criteria to develop infrastructure taking into account the value of increased resilience.
- **Financial community** to work with governmental institutions to better estimate the cost of climate change – including direct costs such as natural disasters and indirect cost such as insurances.
- **Universities and academic institutes** to enhance the knowledge and develop education courses on the importance of resilience when ensuring the qualification of future professionals of the built environment.
- **NGOs** to launch a joint campaign to raise awareness of the need to build resilience to climate change in developing countries.
- The **United Nation International Strategy on Disaster Reduction (UNISDR)**[1] to support and promote our messages globally.

[1] www.unisdr.org

Evaluate the opportunity to capture, use and store carbon at scale

Background

Cross-sectoral collaboration is central to accelerate innovation and achieve common objectives. In compliance with antitrust rules, sharing skill sets, ideas and leverages will facilitate the implementation of existing and breakthrough technologies. Thus, the energy-intensive sectors (cement, chemical and steel), have got together to scale innovative solutions in Carbon Capture Storage and Utilisation (CCS&U). The cement industry is already active in R&D, working on a pilot project of oxy-fuel technology driven by European Cement Research Academy (ECRA)[1)] for CO_2 capture.

Actions

To evaluate cross-sectoral initiatives, particularly on the opportunity to capture, use and store carbon at scale, the following actions will be implemented:

- Identify costs and benefits of Carbon Capture and Utilisation (CC&U) for the cement and steel sectors, transforming CO_2 and CO into fuels and other applications thanks to the chemical sector's solutions;
- Measure the CO_2 emissions from manufacturing processes and products;
- Cooperate with the proactive energy-intensive sectors to facilitate the implementation of existing and breakthrough technologies identified through this initiative, a cooperation with the LCTPi on CCS could be envisaged;
- Promote appropriate regulatory framework and financial incentives mechanisms;
- Expand efforts by government and industry to educate and inform the public and key stakeholders about CCS/U; and
- Investigate linkages into existing or integrated networks and opportunities for cluster activities in industrial zones. Enhance the collaboration by building local and global partnerships benefiting from the synergies between the various actors, scale up the implementation of business solutions to build a low-carbon society.

Policy Asks

- Agree on a long-term, binding, universal climate agreement in Paris in 2015 to enable the private sector to undertake appropriate long-term investments.
- Develop enabling policies and legislation and international collaboration on CCS/U regulation.
- Develop a backstop mechanism for liability associated with the long-term underground/underwater storage of CO_2.
- Develop financial incentives mechanisms. Government support for funding research, pilot and demonstration projects, leading to commercial-scale demonstration plants.

[1)] www.ecra-online.org

Barriers

- High costs and commercial availabilities.
- Political support for government incentives, funding for research, long term liability and the use of CCS/U as a component of a comprehensive climate change strategy.
- Complex permits and approvals procedures.
- Local residents' informed approval of proposed CCS/U projects in their communities.
- Create a new market mechanism to replace the previous CDM framework, facilitating the funding of energy efficiency projects, and the inclusion of CCS/U projects, and accepting credits from CCS/U in emissions trading schemes such as EU ETS.
- It is generally accepted that CCS/U is key to reducing CO_2 emissions, but has been estimated to increase power consumption by 50 to 120% at plant level (power for air separation, stripping, purification, CO_2 compression, etc.)
- Ensure that policies, with supportive monitoring, reporting and verification (MR&V) frameworks, incentivize CCS/U technology through the new market mechanism. A global market mechanism fund could be developed, for which CCS/U would be eligible (and assist the commercial viability of CCS/U in the medium to long term), or market mechanism project criteria could include sectoral benchmarking within the cement industry, in which market mechanism gives incentives to early CCS/U development.

Stakeholders

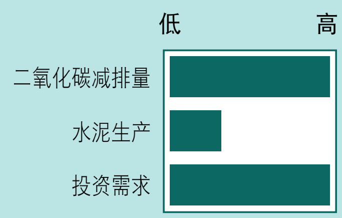
- **Financial community** to support the research and development of breakthrough technologies as well as the acceleration and scaling-up of proven efficient low-carbon technologies; a particular emphasis to developing countries will be addressed.
- **Universities and academic institutes** to enhance the knowledge and qualification of future professionals of the sectors and develop large scale research projects in partnership with public and private sectors as well as the financial institutions.
- **NGOs** to cooperate with stakeholders to raise awareness, understanding and acceptance of future breakthrough technologies.

合作伙伴的角色

项目/合作伙伴	行业	行业供应商	政府	大专学府	研究机构	参与碳捕集运输和储存的其他行业
最佳实践	x		x $（运输）		x	
技术研究	x $	x $	$	x	x	x
技术扩散	x $	x $	$	x	x	x
制度结构	x	x	x	x	x $	x
绩效数据	x	x	x	x	x	

x = 领导角色和要求的直接参与
$ = 资金来源

潜在影响



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World Business Council for Sustainable Development

Maison de la Paix, Chemin Eugène-Rigot 2,Case postale 246, 1211 Geneve 21, Tel: +41 (0)22 839 31 00

115 Fifth Ave, 6th Floor, New York, NY 10003

DLTA Complex, South Block, 1st Floor, 1 Africa Avenue, New Delhi 110 029, India, Tel: +91 11 3352 1527