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If recent comments released by the European Bank for Reconstruction and Development (EBRD) and McKinsey ever get put into practice, then the cement industry might well benefit in the years up to 2030. The EBRD has welcomed what it terms ‘a new ground-breaking digital platform’, the International Infrastructure Support System (IISS), designed to dramatically speed up the delivery of infrastructure in the public sector across the developing world (January 2016). The Bank has said that infrastructure investors want to better understand where to invest in emerging markets, which projects are being prepared, and when such projects are coming to market. The global IT solution from IISS seeks to increase knowledge, lower the transaction costs of preparing projects and ultimately holds out the promise of accelerated infrastructure investment. It is said that the system’s comprehensive features would help speed up tenders for infrastructure projects, and ensure that they are awarded and built more quickly. This is of great importance in a world with a rapidly increasing population and enormous infrastructure needs. Just look at urban expansion in China and the European migrant crisis.

The new McKinsey report: Financing change: How to mobilize private-sector financing for sustainable infrastructure, which was published last month, suggests that while business groups, development banks and governments have all pledged significant increases in funding and research for sustainable infrastructure, the scale of the challenge is enormous. From now to 2030 global demand for new infrastructure could amount to more than US$90 trillion, almost double the estimated US$50 trillion value of the world’s existing stock. The world needs to find an extra US$4.7 trillion annually, in addition to today’s US$3 trillion spend, over the next 15 years to pay not only for additional infrastructure but also for sustainable projects which are typically more expensive than traditional ones. McKinsey’s projections show that this sustainability premium could add US$14 trillion to overall infrastructure costs between 2015 and 2030, made up of US$9 trillion in low-carbon power generation and US$5 trillion in energy efficiency. Reduced capital expenditures could result from projected savings of US$6 trillion in reduced fossil-fuel costs, US$3 trillion via more compact urban footprints, and US$30.3 trillion in reduced electricity transmission and distribution.

Of course nobody disagrees over the need for infrastructure investment. Cement manufacturers and other industry suppliers want to hear that finance is forthcoming from the private sector and institutional investors. From the cement industry’s point of view, it could do with a boost after two miserable years of slowdown and fragility. Recent estimates suggest that the prospects for this year may only be slightly better than 2015. The McKinsey report reminds us that at the Paris summit in December 2015, world leaders committed themselves to sustainable economic development and to heightened demands of climate policies. The acceleration of the flow of private capital into sustainable energy, water and transport systems will be a fundamental element of any realistic effort to achieve the ambitious goals touched on earlier. Let’s hope that investors, business groups, development banks and governments are able to fulfil their promises.
Cemex to divest operations in Bangladesh and Thailand

On 10 March 2016 Cemex announced that it will be divesting its operations in Bangladesh and Thailand.

The company announced that it has signed an agreement for the sale of its operations in Bangladesh and Thailand to Siam City Cement Public Company Limited, for approximately US$53 million.

The proceeds from the transaction will primarily be used for the reduction of debt as well as for general corporate purposes.

The closing of the agreement is subject to the satisfaction of the standard conditions for this type of transaction – it is expected that the divestiture will be finalised at some point during 2Q16.

UltraTech Cement to acquire cement units of Jaiprakash Associates

UltraTech Cement Limited has entered into a binding Memorandum of Understanding with Jaiprakash Associates Limited for the acquisition of its identified cement plants, having total cement capacity of 22.4 million tpy, situated in the states of Madhya Pradesh, Uttar Pradesh, Himachal Pradesh, Uttarakhand Andhra Pradesh and Karnataka.

The assets will give the company access to the newer markets of Satna, UP East, Himachal Pradesh and Coastal Andhra where it does not have a presence currently. Upon consummation of the proposed transaction, the company’s cement capacity will stand augmented to 90.7 million tpy. The parties have agreed to an Enterprise Value of Rs.16 500 crore.

The transaction is subject to definitive agreements and regulatory approvals as may be required.

LafargeCanada names its ‘EcoDome’

LafargeCanada Inc. has announced it will name its dome in Exshaw the EcoDome. The name was submitted by two entrants in the competition to name the most talked-about feature of the expansion project. Jim Petersen and Bruce Brinkworth will each receive US$1000 to go towards their charity of choice. The contest was open to all Bow Valley Residents, and approximately 300 submissions to the contest were received before it closed on 23 February 2016. Lafarge employees had the chance to review all names, and selected EcoDome as the winning entry.

The Dome helps to minimise dust on the site, and it stores and blends all of the raw materials needed to make high quality cement. When the contest was launched, Lafarge said that the winner would receive:

- Their name on a plaque outside the dome.
- A VIP tour of the dome and plant expansion.
- US$1000 donated to a charity they choose.
- Bragging rights.

Four Bow Valley entrants will also have the chance to make US$500 donations toward their favourite non-profit organisations:

- Most creative: The Mixing Bowl, Daryl Mikalson, Justin Francis.
- Most humorous: The Duster Buster, Taryn Wagar.

**EVENTS**

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| Munich, Germany | Nürnberg, Germany | Nanjing, Jiangsu Province, China |
| www.bauma.de | www.powtech.de | www.cementtech.org |

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**WEAR PROTECTION PACKAGES FOR ROTARY VALVES**

<table>
<thead>
<tr>
<th>MINERALS</th>
<th>PROTECTION PACKAGE</th>
<th>HOUSING</th>
<th>ROTOR</th>
</tr>
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<tbody>
<tr>
<td>Non-abrasive</td>
<td>Standard</td>
<td>Grey cast iron/steel</td>
<td>Steel</td>
</tr>
<tr>
<td>Low abrasion</td>
<td>DuroProtect 1</td>
<td>DuroChrom</td>
<td>Steel</td>
</tr>
<tr>
<td>Slightly abrasive</td>
<td>DuroProtect 2</td>
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<tr>
<td>Medium abrasion</td>
<td>DuroProtect 3</td>
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<td>Very abrasive</td>
<td>DuroProtect 4</td>
<td>DuroChrom</td>
<td>DuroKarb</td>
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<tr>
<td>Highly abrasive</td>
<td>DuroProtect 5</td>
<td>DuroKera</td>
<td>DuroKarb</td>
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* Depending on the bulk material properties and the operating conditions.

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Ash Grove Cement Seattle earns ENERGY STAR certification

In 2015 Ash Grove Cement Seattle earned the US Environmental Protection Agency’s (EPA) ENERGY STAR certification, recognising the plant’s performance in the top 25% of cement manufacturing facilities nationwide for energy efficiency and meeting the strict energy efficiency performance levels set by the EPA.

ENERGY STAR certification highlights Ash Grove Seattle’s status within the top 25% of manufacturers regarding energy performance. Ash Grove Cement Seattle improved its energy performance by strategically managing energy and making cost-efficient improvements to its plants.

- Automated the plant compressed air system, saving 1 million kilowatt hours in one year.
- Upgraded plant lighting, saving 540 000 kWh.
- Adjusted the raw material blend to improve mill efficiency, saving 3.5 million kWh.

Ohorongo Cement supports the provision of community driven houses

True Public Private Partnership became a reality when three private companies joined forces to support the provision of community driven houses for low income families, by pledging N$3 million to SDFN/NHAG in Otavi.

The escalating demand for low cost housing in Namibia has reached a crisis point and requires urgent assistance, not only from Government, but also from the Private Sector.

Housing affordability has deteriorated significantly in recent years and Namibia is currently facing multiple major housing challenges. The national housing backlog is estimated to be in excess of 100 000 units, and is increasing by 3700 units on average per annum.

Empathy for fellow Namibians and supporting Government initiatives were the driving factors that motivated Ohorongo Cement, The FNB Namibia Foundation and The Pupkewitz Foundation to join hands in the fight against poverty eradication, by supporting the Shack Dwellers Federation Namibia (SDFN)/Namibia Housing Action Group (NHAG).

The fiscal and economic benefits that accrue when communities encourage the development of affordable homes are rarely taken into account. Healthy communities build a healthy nation and a strong economy.

Supporting initiatives to assist in supplying housing to the underprivileged improves educational outcomes, increases health and wellbeing, boosts economic activity and lowers social service costs for government.

The core competencies of the three private partners are not purely Corporate Social Investment (CSI) driven, as it forms merely a smaller part of its investment and business existence. Instead of trying to run independent in-house initiatives, the three partners decided to work hand in hand with reputable organisations like NSDFN/NHAG, who clearly have a winning recipe when looking at their results and outcomes to date.

Titan America LLC has announced that project economics no longer support the construction of a cement plant in Castle Hayne, NC. Company officials say the evolution of supply and demand balances in the specific regional market no longer support the significant cost involved in constructing a new cement plant. All existing operations will continue to run the way they have; no jobs will be affected.

The Supervisory Board of KHD Humboldt Wedag International AG informed the KHD Management Board of the resignation of Mr. Johan Cnossen as Chief Executive Officer and member of the Management Board, with immediate effect. Mr. Cnossen has chosen to step down for personal reasons. His responsibilities will be taken over by other Management Board members in the interim period.

Caterpillar Inc. and the Caterpillar Foundation have announced a US$500 000 donation to The Finca Vigia Foundation to restore and preserve Ernest Hemingway’s home, documents and historical artefacts in Cuba. The donation will support the construction of an on-site conservation laboratory with archival storage facilities at the Hemingway Museum in Havana, known as the ‘Taller’ building.
Reducing CO$_2$ Emissions: The Next Steps

Prof Karen Scrivener and Rob Fielding, EPFL (École Polytechnique Fédérale de Lausanne), Switzerland, explore how the use of Limestone Calcined Clay Cement as a supplementary cementitious material reducing the amount of clinker could significantly decrease the CO$_2$ emissions produced during the cement making process.

Impact of cement blends on CO$_2$ emissions

If we really want to make an impact on GHG (greenhouse gas) global emissions, significant percentage reductions in essential industrial processes are needed. To some extent the energy industry has ‘cleaned up’ and the cement industry has improved efficiency since 1990, with process optimisation and reducing the clinker factor, alongside the addition of SCMs (Supplementary Cementitious Materials). Process optimisation for the best available technology is now approaching a limit. There is further potential to reduce the clinker factor, but, as seen in Figure 1, the trend seems to be levelling off.

Cement is the most commonly used man-made material. On a unit basis, it actually has lower embodied energy and associated CO$_2$ emissions than common alternatives. However, it has an undeservedly poor environmental reputation, as the huge quantities produced mean that it is responsible for 5 – 8% of global emissions of CO$_2$. Given the anticipated increase in demand, particularly in developing economies such as India, Africa and Latin America, the CO$_2$ emissions from cement will inevitably increase. The forecast is that, even though the demand in China is leveling off, by 2030 India will increase four-fold from present levels of about 280 million tpy to over 1 billion tpy. Other
developing countries combined are likely to double their requirement from 1 – 2 billion t. The world’s population needs more and better homes and roads, but this is not good news for our planet.

Materials to meet global demand for infrastructure
The sheer size of the global demand for materials at a level of buildings and infrastructure, means that there is no practical alternative to compete with cement. Cement is a very flexible, all purpose material for construction, forming the basis not only of reinforced concrete, but also blocks, mortars and renders. For the aspiring home owner in many emerging markets a house made of concrete blocks has a high status value. Cement is, and will continue to be, the most abundantly used material for the built environment from social housing through to hydroelectric dams.

Related to the environmental impact, cement production is also facing the prospect of resource depletion. Reserves of high-grade accessible limestone, required for the production of Portland clinker, are becoming harder to find in some countries, most notably India. The main reason for the leveling off of clinker factors, seen in Figure 1, is that the production of the commonly used clinker substitutes, slag and flyash, is limited compared to clinker production and the demand for cement. For example, the amount of blast furnace slag produced worldwide is now less than 5% of clinker production. The demand for steel is not increasing as fast as the demand for cement and an increasing amount of steel comes from recycling, so this percentage will decrease in the future. Similarly, flyash comes from coal fired electricity production and there are important questions as to whether we want to continue increasing our consumption of coal from the perspective of reducing CO₂ emissions. Even today there are many parts of the world where neither blast furnace slag nor flyash are available in significant quantities.

As discussed in previous keynote articles (August 2015), there is a lot of activity in the cement industry to reduce CO₂ emissions from cement production. It will take a combination of many different technologies. LC³ (Limestone Calcined Clay Cement) is a promising new cement blend that has interesting characteristics.

**LC³ technology: New cement blends**
Finding alternative SCMs in quantities that can compare to Portland clinker is critical for the production of sustainable cements for the foreseeable future, to ensure that the emission reduction trend is reestablished by continuing to reduce the clinker factor.

The only material with the potential to make any significant impact, and which is available in viable quantities, is clay, the most reactive being clays containing kaolinite. Kaolinite is one of the most common minerals and, in its pure form is used in the production of china clay ceramic products. Calcination of clay at around 700 – 850°C, produces a pozzolanic product, which can be used in cement. The main use of high grade calcined, kaolinitic clays (metakaolin) today is in the production of paper which contributes to the gloss on some grades of coated paper. The cost of Metakaolin is typically 3 – 4 times that of cement. But we have shown that the calcination of clays with much lower kaolinite content (down to 40%) can still give a material which reacts well in cement. There are already abundant amounts of such low grade clays discarded as worthless overburden in quarries producing china clay. Furthermore we have shown that a combined substitution of such low grade calcined clay with ground limestone can substitute up to 50% of Portland clinker to give cements which still have excellent engineering properties. We have christened this ternary combination LC³ – Limestone Calcined Clay Cement.

Laboratory and field tests of LC³, have produced remarkably good results. Not only are the characteristics of PC (Portland Cement) matched or exceeded, LC³ blends have the potential to reduce CO₂ emissions by more than 30% compared to cements based on high levels of clinker (OPC or CEM I types). Even higher
Evolution of the chain ...

- **hand forging**
  (18th century)

- **electric resistance welding**
  (since 1900)

- **friction welding**
  (21st century)
savings are feasible to create a general purpose cement that will meet mass market demands for a basic construction material.

**Historical background**

The substitution of Portland Clinker by calcined kaolinite clay or ground limestone individually, is not a new technology. Cements incorporating fine limestone are the largest single category of cement now sold in Europe. It is reported that Metakaolin was first used as a SCM for construction purposes in the 1960’s in Brazil in Jupia Dam. In India, Ramachadran also mentions the use of finely ground calcined clays for the construction of Bhakra Dam, during the same period. However, the industrial use of calcined clays for cement is, at present, marginal compared to other SCMs, due to the cost and energy required for calcination.

The combination of both these SCMs together allows much higher levels of substitution as the alumina in the clay can react with the limestone (calcium carbonate) to produce new hydration products, which fill space and contribute to strength and durability.\(^1\) With clays containing 40% or more of kaolin, the strength of the reference Portland cement may be exceeded with a blend containing only 50% clinker from around seven days. The possibility to incorporate higher amounts of limestone offsets the cost and energy required to calcine the clay.

**The LC\(^3\) Project**

With this new technology, researchers in Switzerland, India and Cuba have shown the potential for new cements with reduced CO\(_2\) emissions. The Swiss Agency for Development and Cooperation has recognised the potential of calcined clay with limestone and is funding the Low Carbon Cement project, with the aim to bring LC\(^3\) cements to the market. The project is led by the Laboratory of Construction Materials, in the École Polytechnique Fédéral de Lausanne, in Switzerland.

**Composition of LC\(^3\) blends**

The key material in LC\(^3\) is Kaolin Clay. Research has shown that suitable clays can be found in deposits across a band of the earth centred on the equator and extending to subtropical regions. This corresponds with the zones predicted to have the most economic growth over the coming decades. Clays with 40 – 70% Kaolin content are most suitable for calcination. Heating to between 700 and 850°C produces a fine powdered reactive material which is intermixed with fine limestone, ground clinker and gypsum. We are currently focusing on two blends of LC\(^3\) using clay samples from around the world.

LC\(^3\) – 50 consists of 50% of Portland clinker with 30% calcined clay, and 15% ground limestone, with gypsum as an addition, is the most CO\(_2\) efficient. Such a high percentage of substitution does not currently fall within the standard for cement in many countries, for example those following the EU standard, and India.
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However, even in these countries, it can be used to make building components. High quality performance has been demonstrated in the fabrication of cast window frames, concrete blocks and pavers. A complete pilot house (Figure 2) has been made using both in situ and precast LC3 cement in the concrete.

LC3 – 65 is a blend that falls within the existing EU standards followed by many countries around the world (for example South Africa, Brazil, Malaysia). In this case 65% Portland Clinker is supplemented with 20% calcined clay and 15% ground limestone, as well as with gypsum.

The characteristics of LC3
What is particularly attractive about calcined clay is that there can be 50% or more saving in energy in the production process compared to clinker. Instead of 1450°C the optimum calcination range for the clay is between 700 – 800°C. Heating or calcining clay compared to clinker production involves no release of ‘chemical’ CO2 in the reaction. Existing cement kilns can be readily modified to calcine clays without high capital investment in new plant and equipment. Kilns for small scale artisan production are feasible. Clays may also be calcined in vertical calcination units, fluidised beds or static ovens.

Rigorous laboratory testing of a range of suitable clays is providing evidence that LC3 can match and, in some cases, outperform OPC in the recognised tests for cement properties: early strength, durability, shrinkage and creep, workability and resistance against chloride and susceptibility to carbonation. There is a linear relationship between the percentages of kaolinite in the calcined clay with compressive strength.

The Production
A total of 500 t of LC3 has been produced in industrial trials with project partners in India and Cuba. The LC3 product has been shared with commercial cement companies and standards authorities for their own research and testing.

Concrete has been cast and is now subject to comparative environment testing with fly ash blends at 10 sites around India. Exposure sites in the sea for chloride testing have been completed in Cayo Santa Maria, Cuba.

Building products are being made in Jhansi, India, including those which were used in the construction of the pilot house (Figure 2).

LC3 cement was also used in the Autoclaved Aerated Blocks (AAC) for the high profile new building at the Swiss Embassy in Delhi, incorporating and demonstrating low energy and low carbon construction (Figure 5).

Application of LC3 to SME (Small Scale Enterprises)
The scope of Limestone Calcined Clay blends is varied and has a wide range of applications. It can be produced by large cement companies, and also by medium to small scale companies. In India and Africa there are many SME’s in the cement production sector which have a significant share of the market at a local scale. Most of them produce around 400 – 1000 tpd of cement. They are equipped with small grinding units, conveyer belts and silos for storage and bagging.

Most of these units procure clinker from large integrated cement plants. They have varied cement qualities and types catering to the fluctuating market demand. In most of the cases they have a small laboratory to check the production quality.

The low carbon cement formulations pose an excellent opportunity for these small cement companies. In most cases, they have access to the required raw material of raw limestone and china clay. With the production of calcined china clay, these small cement companies can increase their output to double the amount of cement while retaining the same quantity as with clinker. This is expected to reduce the production cost and save on natural resources by using non-cement grade materials. Additionally, quality cement will be available at the local scale, boosting local economy, creating more job opportunities and reducing global emissions.

Conclusion
This work is still in both the large and small scale pilot phase. The results are extremely promising and there is enormous potential to increase production in large plants with the expectation of gaining a wider market acceptance. Most characteristics are compatible with OPC and PPC, which will facilitate acceptance into the construction sector at all levels.

References
Volker Hoenig and Marco Lindemann Lino, VDZ, Germany, discuss strategies for optimising energy efficiency in the German cement industry.

Introduction
The production of cement is one of the most energy-intensive production processes in the manufacturing industry. For this reason, cement companies have always recognised energy efficiency as crucial and a subject of major interest, long before the term sustainability became a worldwide issue. As a consequence, energy efficiency in cement plants is already high and potential for further improvements is limited.

The energy required to produce one t of cement is closely connected with technological and market issues, as well as with environmental regulations and emission level constraints.

In 2014, the fuel energy consumption of all cement works in Germany amounted to more than 90 million GJ, with the firing of alternative fuels representing a share of 63.4% of total fuel energy consumption. In the same period, cement works in Germany had a specific power consumption of 110 kW-hours per t cement, which corresponds to approximately 3.5 tW-hours, or in other words, an annual electricity cost of around €250 million for the entire sector. These figures reveal that small improvements with regard to energy efficiency can not only provide significant economic and competitive gains, but also represent small but nevertheless meaningful steps with regard to the sustainable manufacture of cement. However, only by conducting a simultaneous examination of the interactions between the energy performance of individual process steps (e.g. clinker cooling or cement milling) and the entire process chain, including the product portfolio, is it possible to further optimise energy efficiency in cement production in the long term under certain given constraints. For this reason VDZ has developed a structured and scientifically substantiated approach to analysing the energy performance of cement plants to define improvement potentials and measures.
**Present and future trends concerning energy demand**

Over the past years, the German cement industry has been continually challenged with regard to decreasing energy consumption. The changes that the German cement industry has experienced in the past decades, such as the increasing demand for cements of higher fineness, the rise in firing of alternative fuels (considered crucial in order to reduce production costs and CO₂ emissions) and compliance with new environmental regulations, have more than counterbalanced the energy efficiency gains achieved in the same period. For this reason, the specific energy demand per t of cement in Germany has barely changed over the past decades (Figure 1).

A VDZ expert group has compiled a study with the main objective of looking at the various developments that can be expected up to 2030 in the German cement industry and to assess their potential impact on energy demand. Four main variables were identified as major players concerning energy efficiency:

- Optimisation of process/plant technology.
- Influence of the cement portfolio (fineness and clinker to cement ratio).
- Use of alternative fuels and increase of thermal substitution rate.
- Implementation of environmental protection measures due to new regulations.

The study concluded that the maximum theoretical potential reduction of energy demand in 2030 in the German cement industry, based on the absolutely unrealistic scenario that all kiln and grinding lines would be replaced by new ‘greenfield’ BAT installations, would only amount to approximately 14% relative to the year 2011 (Figure 2). Usual technical developments (here called ‘BAU’ - business as usual) – under certain market and emission regulation constraints – would only offer a reduction potential of 6.8%.

Technology changes in a cement plant, such as the replacement of singular outdated major equipment (e.g. clinker cooler, cement mills, etc.) by others with higher efficiency, or even the construction of new BAT kiln lines, can provide considerable gains in terms of energy efficiency. However, both strategies require a considerably high investment and profitability must be carefully assessed on a case-by-case basis. The energy saving potential following this strategy has already been described in detail in the CSI/ECRA Technology Papers. Process optimisation without major technology changes is, for this reason, the most common strategy followed by plant managers with regard to the increase in energy efficiency. Strategies that may lead to a stepwise optimisation of the process, and to an increase in energy efficiency without significant investment, are described below.

The cement portfolio can affect both the thermal energy demands (indirectly) and the electrical energy demands (directly) of cement production. The reduction of the clinker to cement ratio, through the replacement of clinker by other constituents, generates a reduction in the cement-related thermal energy demand. On the other hand, some substitution raw materials, such as granulated blastfurnace slag (the primary clinker substitute material in Germany), are harder to grind than clinker and increase the electrical energy demand of the cement mills. Among all the variables identified as major contributors to energy efficiency, the lowering of the clinker to cement ratio is the one which presents the highest energy reduction potential. Potential losses in electric energy efficiency, e.g. due to lower grindability of mineral components like granulated blast furnace slag, are largely superseded by thermal energy gains from replacing clinker with unburnt materials. However, the reduction of the clinker to cement ratio is linked to the availability of substitute materials, which may limit the potential efficiency gains in the future. The availability of substitute materials becomes even more relevant in markets with increasing cement demand. Moreover, the market trend towards higher fineness cements, which can be observed in many European countries, tend to counterbalance energy efficiency gains.

Germany is a leading country in the use of alternative fuels in the cement industry. The whole
industry recognises the importance of firing alternative fuels, not only due to its economic, but also its environmental, benefits. However, the rise of firing alternative fuels has contributed to a certain increase in energy demand, mainly due to the moisture content of the fuels and other fuel constituents that can destabilise the clinker burning process (e.g. chlorine and sulfur). The cement industry therefore still prefers to purchase alternative fuels of high quality, characterised, for example, by a high calorific value and/or a low chlorine content, in an attempt to reduce CO₂ emissions and costs. It is not expected that alternative fuels of high quality, and with sufficient availability, will emerge on the market at competitive prices in the coming years. On the contrary, a falling calorific value and a rising moisture content of the alternative fuels are expected, which may consequently increase energy demand. Research is being carried out to counteract this foreseeable development by, for example, pre-treating the materials further compared to the current situation.

More stringent emission level regulations have led to the decrease of emissions from the cement industry over the past years. This decrease was only possible due to the investment in new environmental protection measures. The German ‘‘TALuft’’ technical guidelines and the ‘‘17. BImSchV’’ incineration of waste regulation define a new dust emission limit of 10 mg/m³ (10% O₂) from 2016 onwards. The new NOₓ limit in Germany from 2019 onwards will be 200 mg/m³; 10% O₂, and will particularly challenge the German cement industry due to the high investment costs entailed. New environmental protection measures will be necessary in order to comply with the new regulations and emission levels. The installation of SCR technology, as well as the replacement or retrofitting of process filters, may be required in several cement plants, which will lead to an increase in electric energy demand.

Strategies to optimise energy efficiency
Several research projects are nowadays being conducted worldwide under the umbrella topic of enhancing energy efficiency in the cement industry. Innovative products and more efficient technologies related to cement manufacturing are therefore expected to appear on the market in the future, but still need a significant amount of time. Despite these new technologies, some methodologies and a wide range of services, which can directly or indirectly enhance energy efficiency, will continue to be employed by the cement plants:

- Performance of internal and/or external energy audits.
- Continuous education and training of the workforce.
- Implementation of an Energy Management System in accordance with ISO 50001.

‘Energy management involves the systematic tracking, analysis and planning of energy use, and

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enables companies to maximise energy savings and improve energy performance continuously through organisational and technology changes. In spite of the factors affecting energy demand in cement production being well known, the influence of their interactions needs to be taken into account. These factors include:

- Available raw materials and fuels, along with other main constituents of cement in addition to clinker (market constraints).
- The installed plant technology (technological constraint).
- The required clinker and cement properties (market and normative constraints).
- The specifications of the cement, as well as concrete standards (normative constraint).
- Environmental legislation (regulatory constraints).

In order to attain a higher level of energy efficiency optimisation of the plant, the recourse to experts and external auditors to deal with such complexity may be required. The collection of precise process data plays a fundamental role in energy assessment. VDZ, as have other companies, has developed its own assessment methodology and has conducted technical energy audits worldwide for years. Depending on the objectives of the plant, technical energy audits at three different levels can be provided:

- A-level-audit (assessment based on information available in the plant).
- B-level-audit (assessment based on available plant information and on-site visit).
- C-level-audit (assessment based on complex measurements on-site, such as mass and airflows, heat and energy balances, emissions, etc. and on available plant information).

Supported by VDZ’s strong scientific background in cement production, the comparison of assessment results is done against internationally accepted standards and VDZ’s data base. The scientifically based results of energy audits enable managers to prioritise investment strategies and release capital for other investments with higher profitability or urgency.

A highly motivated and trained workforce with the awareness of the impact of their daily tasks on the energy performance of the plant also promotes the reduction of energy consumption. For this reason training plays a pivotal role. A deeper knowledge of the cement production process can not only potentially reduce the energy consumption of the plant through more technically supported decisions, but can also make the implementation of strategies to enhance energy efficiency easier and more efficient. CCR operators and plant supervisors are two target groups of VDZ’s trainings due to the impact of their daily decisions and actions on the performance of the plant. Multi-disciplinary teams which incorporate process engineers and maintenance engineers, among others, can also be trained to lead internal energy audits and become the spearhead of the cement plant in the detection of energy saving potentials. Moreover, they not only play a central role in the company’s communication with external auditors, but also become the critical mass needed to comprehend, discuss and implement suggested improvement measures.

Every year VDZ audits several cement plants which have already implemented an energy management system in accordance with ISO 50001. This management system is considered a keystone of a structured, technically supported and well documented strategy towards energy efficiency optimisation. The auditing and certification of the energy management system is not only imperative for public recognition of the efforts conducted by companies towards sustainability, but also for the detection of failures and the improvement of the system itself.

**Conclusion**

The German cement industry is facing important challenges with regard to new regulatory constraints, as well as the energy efficiency of its manufacturing processes. The rise of the thermal substitution rate, as well as the compliance with new environmental protection measures, which will be imposed by new regulations in a very near future, will increase the energy demand of cement plants. Lowering the cement to clinker ratio presents the greatest energy reduction potential but depends on external factors, such as market demand and the availability of clinker substitute materials. Depending on the circumstances, the optimisation of the process without major changes to the production technology has an overall low impact as compared to lowering the cement to clinker ratio, but can still improve energy efficiency. The gain in energy efficiency again depends on the existing circumstances. While energy efficiency is already very high in the cement industry for cost reasons, the potential for improvement can be realised by the implementation of certified energy management systems, workforce training and the performance of energy audits.

**References**

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