# CURTAILING CEMENT'S CARBON FOOTPRINT

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## Introduction

The production of 1 t of cement generally leads to the emission of 0.82 t of $CO_2$. The $CO_2$ gas ordinarily comes from three sources:

1. $CO_2$ produced by the thermal decomposition of $CaCO_3$ according to the following equation: $CaCO_3 \rightarrow CaO + CO_2$.
2. $CO_2$ produced by the burning of fossil fuels required to reach the high temperatures necessary in the cement kiln.
3. $CO_2$ emitted during the production of electrical power, which is used extensively in the cement making process (~105 kWh/t cement).

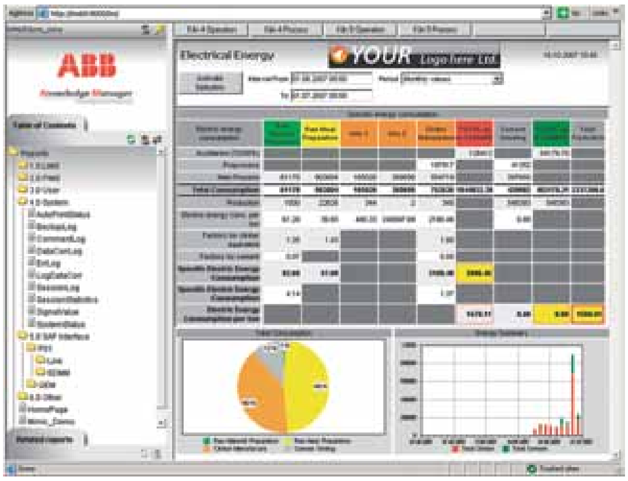


Figure 1. Total energy report – thermal and electrical – with energy indicators.

Given a cement production of approximately 2.6 billion tpa, this means that over 2 billion tpa of $CO_2$ is produced by the cement industry. Estimations show that cement production accounts for approximately 5% of manmade $CO_2$ emissions and it is thus key when it comes to reducing the impact of human activity on the environment.

Under these constraints, optimising the overall performance of a cement manufacturing unit requires a plant-wide automation strategy. Indeed, reducing energy demand and the carbon footprint in all areas must be combined with the search for the optimal operating point, consistent with productivity and quality targets, and in line with imposed environmental emission limits. The cement industry is meeting these challenges by implementing advanced technologies that aim to solve the three root causes of $CO_2$ emissions, namely:

1. Substituting limestone with alternative raw materials.
2. Burning alternative fuels during clinker production to reduce the dependence on fossil fuels.
3. Using alternative cementitous materials to reduce the clinker content per t of cement.

In addition to those measures, technology is used to improve the overall energy efficiency and process stability.

## Monitoring energy consumption

A common piece of wisdom is that what is not measured cannot be controlled. This is especially true in the complex operations of the modern cement plant. Indeed, the very same measures taken to reduce environmental impact have the side effect of increasing operational complexity. There is an immediate need for an information management system able to capture the raw data and generate reconciled information to the plant management.

ABB's Knowledge Manager provides the solutions and advanced tools needed to facilitate the collection, organisation and distribution of combined production, quality and energy information throughout a plant via web-based reports, trends, and graphs. On a single page all relevant key performance indicators (KPIs) for the process are calculated and displayed (Figure 1).

This software can be adapted and expanded to meet each company's specific requirements and is part of ABB's CPM Minerals application suite, which deals with production information monitoring and reporting. It drastically simplifies cement production management by covering manufacturing related functions, such as:

- Production tracking and reporting.
- Process operations monitoring and reporting.
- Material storage management.
- Energy and emission reporting.

The cost of production is directly influenced by the energy usage. Different areas of production consume different amounts of energy, and Knowledge Manager tracks the amounts linked to the material being consumed or produced (Figure 2).

With specific information available at the right time, at the right place, in the right format, decisions become goal oriented, resulting in optimised decision making.

## Saving energy and working closer to constraints

Conventional cement plant control requires the services of an experienced operator who must constantly interpret process conditions and make frequent adjustments to set points, such as the amount of fuel and air for a kiln or precalciner, or feed and separator speed in grinding. This task is onerous enough, but it is made even more difficult when measures such as those

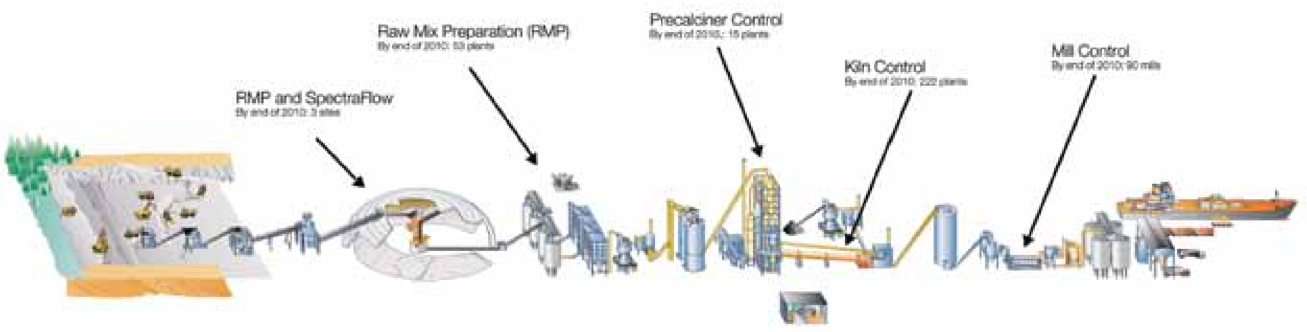


Figure 2. Expert Optimizer applications for the cement industry.

depicted in the introduction are introduced to reduce $CO_2$ emissions.

For instance, if alternative raw materials are used, then there is a strong need for closed loop control of the raw mix quality. The reason for this is that alternative materials tend to be less homogenous than traditional ones, creating the need for feedback control, possibly with the use of online analysers.

When alternative fuels such as tyres, plastics, or dry sludge are deployed, there is an even more acute problem. Indeed, these fuels are not only inhomogeneous, but also hard to dose. Their handling is so difficult that maintaining a constant energy input to the kiln and calciner becomes a challenge that can only be solved with the help of advanced process control.

Expert Optimizer, part of ABB's CPM Minerals application suite, is based upon a history of proven successes from the LINKman optimisation system. It combines rule based control with modern tools such as Neural Networks, Fuzzy Control and Model Predictive Control (MPC). Expert Optimizer improves on conventional control by constantly interpreting plant conditions and initiating appropriate actions. This software has been extensively used in all parts of the cement plant operation, including:

- Blending of raw material.
- Raw materials grinding.
- Calciners, kiln and cooler.
- Cement finish grinding.

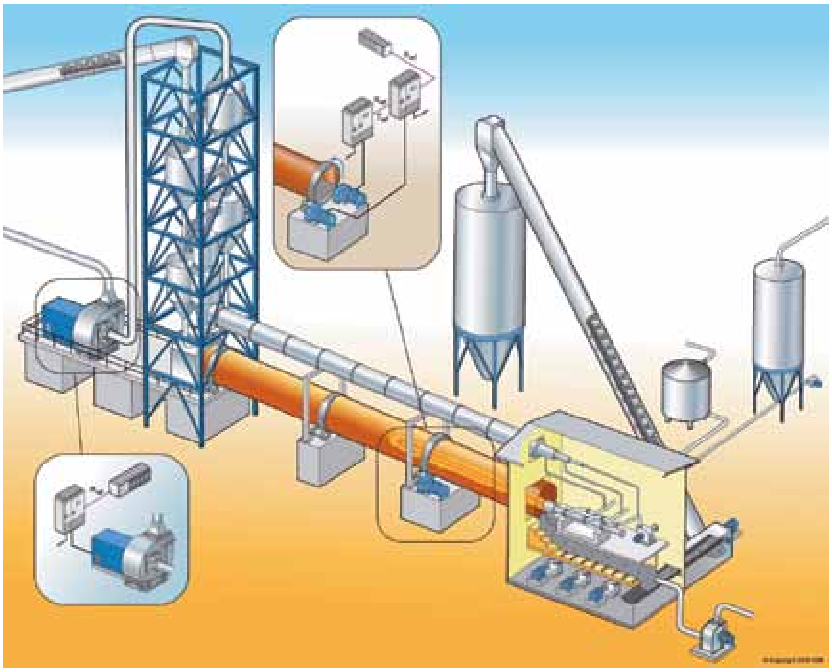

Figure 3. Fans suitable for deployment of variable speed drives.

## Fans with variable speed drives

Fans of different sizes and operational modes are central for the operation of a cement plant. Large fans draw air through the kiln, precalciner, mills and filters to an exhaust stack. Further, smaller fans push air into the grate cooler to recover the energy contained in the hot clinker leaving the kiln.

All these airflows have to be adjusted and controlled as the atmospheric conditions, process conditions and ventilation changes. The control method employed has a major effect on the running costs. For example, a damper with a fixed speed motor is the least energy efficient solution, while the application of variable speed drives (VSD) is proven to be the most energy efficient. Power savings of up to 70% are possible in this context.

Fans are predestined for saving energy due to a quadratic load characteristic. Normal operation of large fans consumes about 90% of nominal airflow, which still represents a potential saving of 20% power. Nowadays, VSD for large fans are usually installed in all new plants. However the potential for large energy savings still exists in fan replacements, especially in the cooler area. As seen in Figure 3, a cement plant offers a significant quantity of opportunities for selecting a variable speed drive.

## Optimised solution for grate coolers

Large amounts of energy are used to move the fans needed for clinker cooling, with this being one of the largest areas in terms of electrical energy consumption. Therefore, choosing a drive system designed to meet the needs of this application is paramount for operational excellence. One such choice is ABB's Multidrive. This technology brings together the advantages of VSD while eliminating the drawbacks of single drives.

Indeed, single drives have their own rectifier, DC link and inverter generating excessive cost and undesirable harmonics in the power grid. On the other hand, the Multidrive system generates the required DC voltage in a central unit and feeds it onto a common DC bus to which the single, independently operated inverters are connected (Figure 4). This architecture ensures that the desirable features of a single drive are retained. Moreover, the individual inverters do not have to have the same power rating, adding flexibility to the plant configuration.

Some of the benefits of this system include:

- Reduced cabling.
- Energy saving motor-to-motor braking.
- Reduced space requirement.
- Elimination of the low voltage distribution.
- Cost-effective reduction of harmonics.

## Heat recovery technologies in cement plants

The most commonly used technology employs the waste heat from the preheater and the cooler to generate steam in a heat exchanger. The steam is then used to generate electricity in a turbine. Over the last 20 years the technology has been refined, enabling lower temperature waste heat to be used for generating electricity. However, waste heat generation plants based on the steam turbine technology are still sensitive to the inlet temperature and require significant space for the installation of boilers, steam turbines, etc.

The ABB Heat Recovery System operates with the Organic Rankine Cycle (ORC) to use low temperature waste

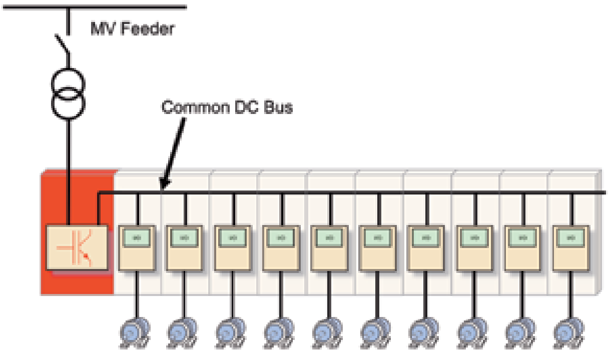


Figure 4. A Multidrive system layout.

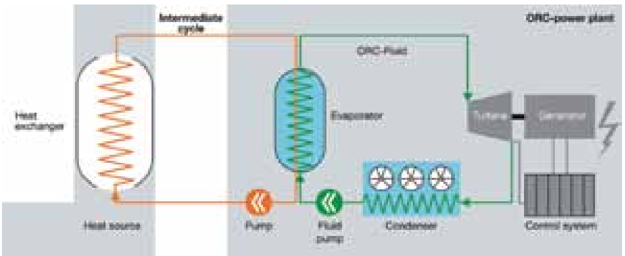


Figure 5. Functional principles of the ABB Heat Recovery System.

heat sources for power generation (Figure 5). The waste heat plant consists of:

- Heat exchanger and intermediate hot water cycle.
- Power container with standard components of the power generation (turbine, generator) and evaporator.
- E-container (control system and electrical equipment).
- Cooling unit (condenser).

Some of the major benefits of the ABB Heat Recovery System include:

- Compact modular concept.
- Simply designed heat exchangers.
- Low temperatures in the ORC allowing cooling of waste heat source to low temperature, leading to wide exploitation of waste heat energy.
- Automatic operation without personnel.
- Low operation and maintenance cost.

Naturally, each potential application needs to be assessed on its merits, but a reduction of at least 15% in electricity consumption and the associated $CO_2$ should be expected.

## Summary

This article shows how advanced technologies provide reduced thermal and electrical energy consumption, and/or reduced costs. Reliable equipment and proven technical solutions ensure the efficient use of energy without jeopardising the quality and productivity of a plant, while minimising the environmental impact.