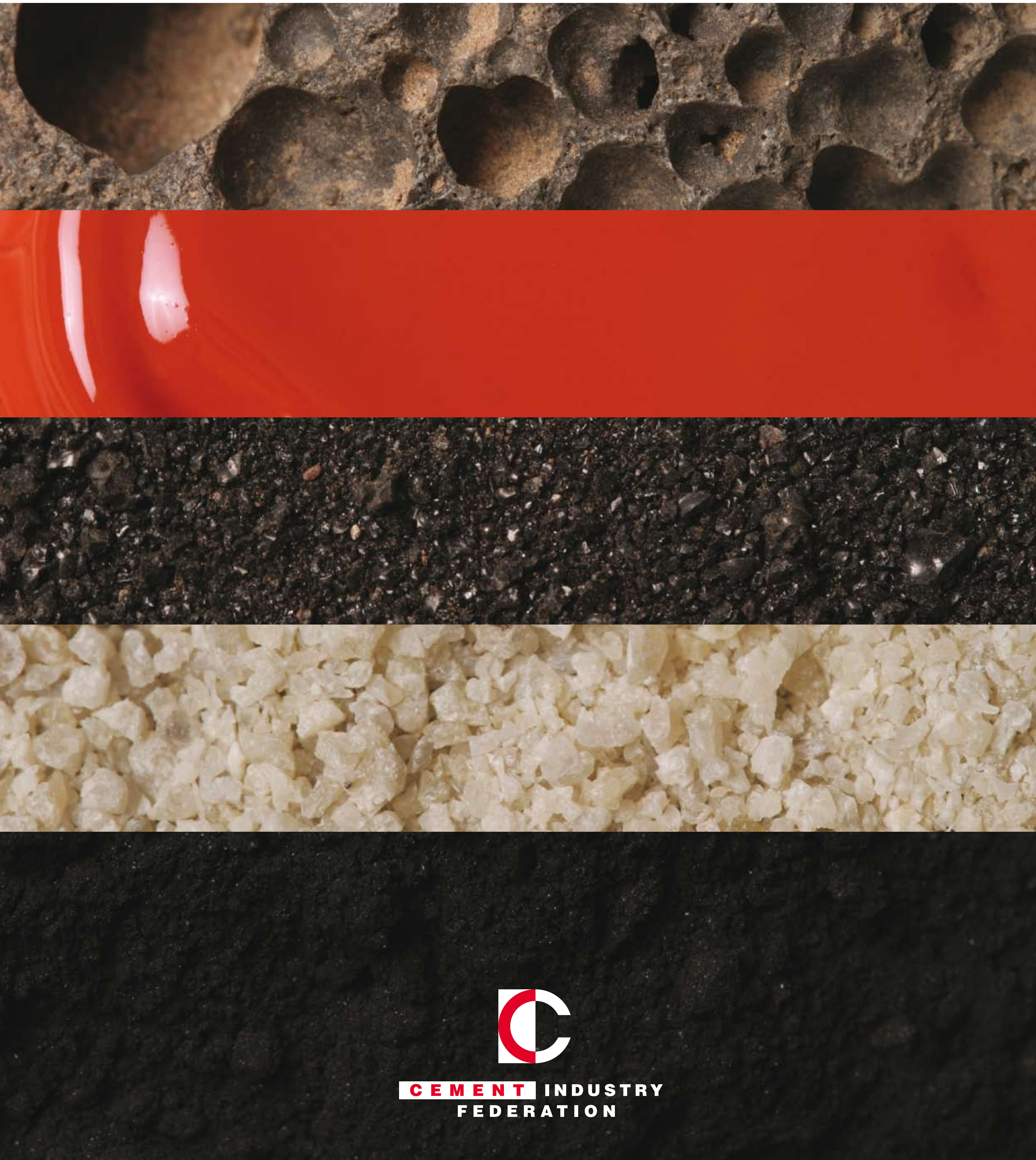
2007 REVIEW OF THE TECHNOLOGY PATHWAY

FOR THE AUSTRALIAN CEMENT INDUSTRY 2005–2030



CEMENT INDUSTRY FEDERATION

Preface

The Cement Industry Federation (CIF) is the national body representing the Australian cement industry. It aims to promote and sustain a competitive Australian cement industry that is committed to best practice in its activities. Since 1989, the CIF has been gathering extensive data from its members. Analysis of these data has allowed the cement industry to accurately articulate movements in the industry that have an impact on the Australian community.

In 2005 the Australian cement industry established a technology taskforce to prepare a report *Cementing our future* which benchmarked the Australian cement industry's current technologies against the world's best, and ascertained what the industry is likely to do under current and forecast economic circumstances. It analysed what new technologies the industry could implement that would contribute to reduced energy consumption, reduced greenhouse-gas emission, and environmental enhancement of the community at large, at the same time as sustaining the industry as commercially viable.

In 2006 the Australian Government joined with the governments of China, India, Japan, South Korea and the United States of America to establish the Asia–Pacific Partnership on Clean Development and Climate (AP6). AP6 has established eight initial public-private task forces covering three energy supply sectors; cleaner fossil energy; renewable energy and distributed generation; power generation and transmission and five energy intensive sectors; aluminum; building and appliances; coal mining; steel and cement.

The Australian cement industry has been an active participant in the AP6 Cement Task Force and, in cooperation with China and India, has developed four projects within the Cement Taskforce Action Plan. One of the projects outlined in the action plan is to benchmark the industry against the world best technology so that the task force can track progress, especially with the inclusion of AP6 projects. This update of *Cementing our future* report serves as the Australian benchmarking exercise for the purposes of AP6.

The CIF wishes to thank and acknowledge the following people who assisted in the production of this report:

- Technology Taskforce, chaired by David Cusack of Cement Australia Pty Ltd and assisted by Balaji Chandrasekar of Cement Australia Pty Ltd, Girish Yadwad of Blue Circle Southern Cement Ltd, and Ros DeGaris of Adelaide Brighton Ltd, who were the authors, modellers and researchers.
- Company site personnel who provided the data to forecast technology plans.

Robyn Bain

Chief Executive
Cement Industry Federation
August 2007

Summary

In 2004 the Cement Industry Federation established a technology taskforce to examine the prospects for technological change during 2005–2012 under two different sets of conditions:

- Business as usual (BAU), where the drivers for investments are those that prevail under the present set of government fiscal, monetary and other policies.
- Best available technology (BAT), where there are additional mechanisms for permitting investments in new technology to be made where the financial returns would currently not be acceptable.

It was viewed that the main opportunities for technological improvements within the plants were:

- increased use of alternative fuels and raw materials in clinker-manufacturing plants, driven by the need to reduce the cost of production
- continuous incremental improvements in operating systems and equipment (e.g. more efficient motors, fan designs, maintenance practices) to provide small reductions in fuel and electrical energy consumption
- investment in cement grinding to address customers needs and to reduce electricity consumption and optimise production
- development of market opportunities to reduce the amount of cement kiln dust going to landfill
- further use of SCMs and mineral additions in cement and concrete.

The 2007 review by the Technology Taskforce revealed:

- The cement industry is still on track to achieve significant CO_2 emissions reduction over the next eight years with specific CO_2 emissions now forecast to reduce by approximately 12.6 per cent over 2003–2015. This is a reduction (from 16 per cent) than originally predicted in 2005 for the time period 2003–2015 due to the significantly higher demand for cementitious products.
- This significant increase in demand has inevitably led the companies to employing greater use of their older, smaller, less efficient cement manufacturing plants that have a much higher emissions profile. Spending effort to optimise existing plant than losing production time installing new plant.
- It is also worth noting that the standard emissions factor used in by the task group review have revised the CO_2 factor from 0.518 to 0.534 to more accurately reflect the World Business Council on Sustainable Development (WBCSD) emissions factor.
- The industry is likely to decrease its BAU spend on capital to $76 million and under BAT that spend increasing to approximately $560 million additional to the $76 million. (The decrease in BAU is due to the companies installing ball mills in preference for the vertical roller mills.)
- It is still the view of the task group that the main drivers of emission reduction continue to be increasing the use of alternative fuels; increasing production from modern, efficient cement plants and increasing the use of supplementary cementitious materials.

Review of significant changes
in new technology adoption forecast

Calcination: Use of precalcined raw materials in clinker such as steel slag, a by-product of the steel industry, has seen an increase in usage since 2006. The substitution rate is predicted to increase by nearly a factor of three from a 0.56 per cent substitution in clinker in 2005 to 1.48 per cent substitution in clinker in 2007 and going up steadily to around 2.6 per cent substitution for the years going forward. This class of material is pre-calcined, thereby reducing the emissions profile.

Fuel: The variety of materials being substituted and the number of plants involved in the usage of alternative fuels is increasing as more opportunities arise. Use of alternate fuels is predicted to step change from approximately 11 per cent weighted substitution in 2006 to 18 per cent in 2009 and then incrementally increase each year until 2015. This includes the usage of used tyres, spent pot or cell liner, solvent-based fuel, biomass and other AFR as and when they become available. Incremental improvements in fuel efficiency have also brought existing plant closer to best practice in energy efficiency.

Electricity: Low energy transport and adoption of more efficient technology such as high efficiency separators, automated control systems and better equipment to grind material have improved the usage of electricity across the industry (but this improvement has been offset by increased demand for product leading to the utilisation of older swing plants). Improved energy efficiency also includes improved control over all areas of the manufacturing process.

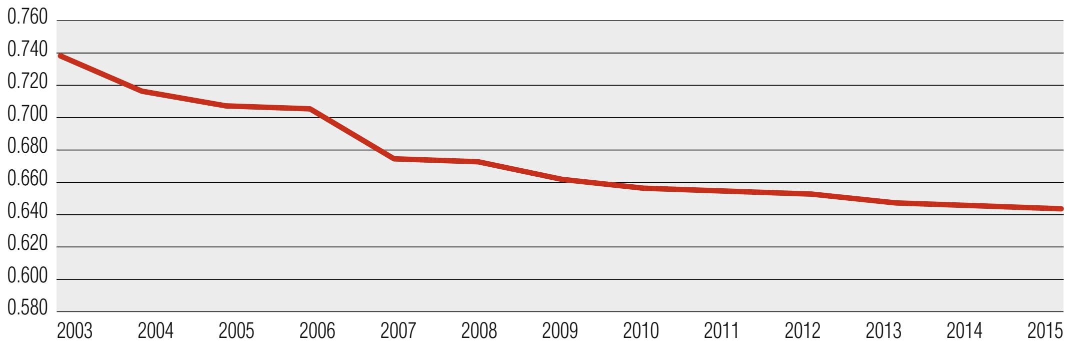
Supplementary cementitious materials: The industry as a whole predicts a marginal increase since the last forecast in the usage of SCMs such as granulated blast furnace slag and fly ash reducing the usage of natural raw materials and providing a sustainable alternative for waste from other industries and further reducing the emissions profile. The cement industry has also look to the formulation of cement in the Australian standard. With extensive trialing and consultation the standard is under review to increase the mineral content in cement, displacing clinker in the final product.

Extension of cementitious binder range has also progressed with tailoring of products with lower embedded GHG emission for specific applications in the mining industry. These products demonstrate a cooperation between supplier and customer to develop new opportunities for lower environmental impacts, maintain product service and utilise greater quantities of by-products.

Comparison of 2005 and 2007 report forecasts

The 2005 industry model predicts a decrease of approx 16 per cent in the total CO_2 per tonne of cementitious material by 2012 from 2003 however this predicted number is now revised to approximately 12.6 per cent.

Total CO_2/t cementitious material



The key reasons for this change are:

1. Much higher demand for product than predicted in the earlier model.
2. Greater change in fuel mix than was predicted.
3. Use of older swing plants having higher emission profile.

The standard emissions factor used in the current version of the model has also been revised from 0.518 to 0.534tCO_2/t clinker across the industry to more accurately reflect the WBCSD increasing calcination emission by 3 per cent and altering the trend of decrease in specific CO_2 emissions.

The table below shows the key indicators for sustainable industry performance namely electricity, fuel, AFR, SCMs and GHG emissions.

Indicator	2004	2006 A	2012 BAU	2015 BAU	2012 BAT	2015 BAT	Best practice
Electricity (kWh/t cement)	106	107	96	105.46	89	96.7	80
Fossil fuel (GJ/t cement)	3.6	3.6	3.3	3.5	3.3	3.5	3
Alternative fuels (% substitution)	6	11.1	23	21.2	26	27.2	60
Raw materials (% substitution)	2	2.3	4	4.3	8	8.9	–
SCMs (% substitution)	22	20.6	29	27.2	29	27.2	40
Greenhouse-gas emissions (tCO_2/t cementitous)	0.704	0.705	0.605	0.644	0.588	0.613	0.460–0.885

Note: kWh/t = kilowatt hours per tonne; GJ = gigjoules; SCMs = supplementary cementitious materials; tCO_2/t = tonnes of carbon dioxide per tonne

In 2005 the Technology Taskforce forecast 'no major requirement for increased clinker capacity before 2012'. Given the demand for cement has increased more than anticipated it could cause the Australian industry to increase local capacity before 2015. Should this occur there would be a significant impact on the CO_2 predictions as the older, more inefficient kilns would not be operating at full capacity as is the case today. Increased production capacity is also dependent on the regional demand for cement.

Technology opportunities 2007 to 2030 and beyond

As outlined in the 2005 technology report, beyond 2012 new technology currently being developed will become commercially viable and introduced through production-cost efficiencies, changes to standards in quality and environmental performance and, to a lesser extent, the replacement of old equipment.

With the global focus on climate change and GHG reduction and changes to national and international policies, many emerging technologies will be more fully tested over the next twenty years. The industry is monitoring developments in carbon capture and storage, geosequestration, hot rock technology, hot disks, oxy-fuel technology, bio-sequestration and alternative cements.

BAT/BET emerging from Asia–Pacific Partnership on Clean Development and Climate (AP6)

The AP6 Cement Taskforce has identified nine projects ranging from status surveys, benchmarking through to the deployment of some new and emerging technologies. Australia, in partnership with China and India has agreed to proceed with three projects that combine existing and new technology that will decrease CO_2 emissions from cement manufacture.

Low grade waste heat used as cogeneration

This project will document the economic and energy efficiency gains obtained by utilising cement plant waste heat to generate electricity. The potential reductions in GHG emissions will also be documented as the cogeneration reduces the cement plant's use of grid electricity.

The project will also explore mechanisms to address the technical and engineering challenges involved in retrofitting cogeneration facilities to an existing cement manufacturing plant.

The project combines two conventional technologies, dry cement kiln operation and cogeneration technology, in a novel manner to reduce the greenhouse gas emissions from cement production, to increase cement kiln energy use efficiency, reduce kiln energy consumption and to generate electricity. The cogeneration technology represents a relatively new approach when compared with cogeneration units installed in other Australian industries in that the Chinese systems utilise relatively low heat transfer conditions (boiler temperatures and pressures) in the steam raising plant.

This project has the potential to reduce greenhouse gas emissions by up to 40,000 tonnes of $CO_{2\text{-}e}$ per year from a plant of a capacity of approximately 1.5 MTPA.

Biosolids as a fuel for cement kilns

This project involves the processing of biosolids from Melbourne Water's Western Treatment Plant (Werribee, Victoria) for use at the Blue Circle Southern Cement Plant (Waurn Ponds, Victoria). Specifically the project will examine the economic and technical issues relevant to utilising biosolids as an alternative energy source in to the Waurn Ponds Cement plant. Biosolids are a

potential partial replacement fuel for traditional fossil fuels (coal, oils, natural gas) utilised in cement kilns with the non-combustible portions of the biosolids replacing need for quarried sand as a raw material input to the cement production process.

A key component of the project is to demonstrate and utilise a cost effective mercury capture and removal technology in a commercial setting at the cement plant.

- A net greenhouse gas benefit of approximately 24,500 tonne CO_2-equivalent per annum.
- Substitution of 10,000 tonnes of quarried sand with ash produced when biosolids are combusted as a fuel in the cement kiln.
- A process that effectively deals with heavy metals, in particular mercury, so that environmental impacts are minimised and environmental standards met or exceeded.

Solvent-based fuels in cement kilns

The project will develop new techniques to process hazardous liquid, semi-liquid and solid by-products from other industrial processes into alternative fuels for co-processing in Australian (and international) cement kilns, by bringing together existing technologies from several other industries in a unique combination and coupling them with several new developments. Specifically the project involves a fully integrated: high viscosity fuel production and utilisation process; a waste dewatering/water purification system; a steel drum recovery/recycling system; and the production of high quality distillate fuel.

The application of this technology, once proven, may be applied to any industrial process reliant on fossil fuels.

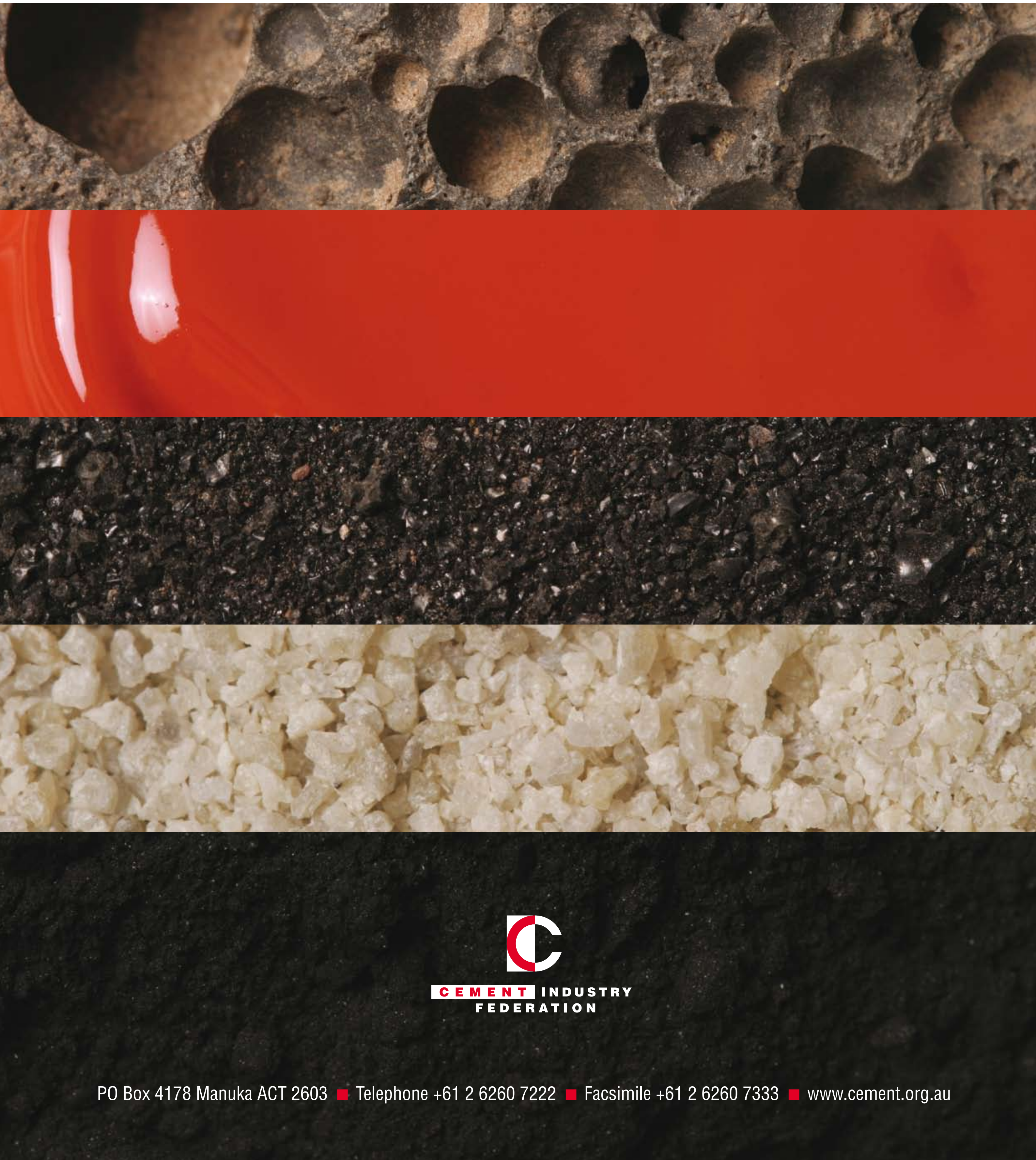
- Providing a solution for industry in the disposal of hazardous by-products creating an environmental beneficial use for by-products that are otherwise stockpiled or disposed of in landfill.
- Reducing costs and promoting resource efficiency, conserving scarce resources by displacing the use of non-renewable fuels such as coal, oil and gas.
- Reducing kiln emissions by 18 per cent on black coal driven kilns.

Drivers to adopting new technology

The drivers to adopt new technology in the period 2007 to 2015 are expected to change slightly from those in 2005–2007. The change in the Australian Government's policy to implement a national emissions trading scheme, (while at the same time protecting trade exposed, emission intensive industries, such as cement) will have some impact on the rate of uptake of R&D in emerging technologies. Other drivers will remain the same, technical, commercial, risk and community.

The Australian cement companies have demonstrated their readiness to not only implement commercially viable new technology, but also with the assistance of the Australian Government, to trail best available and emerging technologies that have all the potential to reduce greenhouse emissions even further.

Predicting the use of alternative materials beyond five years is difficult with an unstable, developing resource recovery industry. Government policy in this area will affect the rate at which innovative opportunities are able to be taken up, as will community attitude towards change. Customer acceptance of new products and demand for greater use of sustainable materials will also be important.



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