Evaluation of the Environmental Impacts from APCA/CW Partnership

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ABSTRACT

This paper examines the APCA/Climate Wise Partnership and its potential energy and environmental impacts. We discuss the issues surrounding greenhouse gas emissions from the production of cement, new and future technologies, and the primary drivers and barriers associated with reducing emissions. The APCA/CW Partner actions and the aggregated impacts of these actions that are undertaken through this partnership are examined. These impacts include cost and energy savings and emission reductions for the current year, and estimated for the year 2000. Comparing these impacts to industrial CO_2 benchmarks indicate the level of effort and what additionally needs to be accomplished. The current results from this partnership indicate that if the remainder of the industry adopts their level of effort, greenhouse gas emissions can be reduced well below the business-as-usual benchmarks.

The U.S. cement industry accounts for about 1.5 percent of U.S. industrial energy use and about 5 percent of U.S. industrial carbon dioxide (CO_2) emissions. In 1997 Climate Wise and the American Portland Cement Alliance (APCA) embarked upon a unique partnership to turn energy efficiency and pollution prevention into a corporate asset. This partnership consists of the 16 APCA member companies, representing nearly 60 percent of U.S. cement manufacturing capacity. Climate Wise, working with APCA and industry representatives, developed the cement industry Action Plan Software, reporting workbook, and sample Action Plan. Through these tools, continued technical support, and the hard work of the APCA companies, this partnership is showing positive results. Over half of the APCA Climate Wise partners have submitted Action Plans – detailing a comprehensive array of current and future actions to improve energy efficiency and reduce greenhouse gas emissions. These Action Plans have supplied valuable information about how this industry is reducing energy use and greenhouse gas emissions.

The Climate Wise Program

Climate Wise is a partnership initiative sponsored by the U.S. EPA designed to stimulate the voluntary reduction of greenhouse gas emissions among participating manufacturing companies. Climate Wise hopes to spur innovation in turning energy efficiency and environmental performance into a corporate asset, by encouraging broad goals, providing technical assistance, and allowing organizations to identify the most cost-effective ways to reduce greenhouse gas emissions. Climate Wise currently has over 500 partners across the country whose combined energy use represents about 13 percent of U.S. industrial energy use. As part of their Climate Wise commitment, partner companies develop comprehensive Action Plans that describe their energy efficiency and pollution prevention goals, the specific actions undertaken to achieve these goals, the time frame for

implementing commitments, and estimates of the impacts on energy, costs, and emissions from these actions.

Cement Industry Background Information

The U.S. cement industry (SIC 3241) accounts for about 1.5 percent of U.S. industrial (non-feedstock) energy use and about 5 percent of U.S. industrial carbon dioxide (CO_2) emissions. Half of the industry's CO_2 emissions result from energy use and half result from limestone calcination (the largest non-energy source of anthropogenic CO_2 emissions). The hydraulic cement industry consists of those firms producing Portland, masonry, prepared hydraulic, natural, lime, and oil well cements. Portland cement comprises 96 percent of the hydraulic cement production, with masonry cement comprising a significant proportion of the remainder.

The production of cement involves four main steps: quarrying and crushing, raw grinding, pyroprocessing, and finish grinding. During pyroprocessing, which accounts for about 82 percent of total cement production energy use, limestone (and other raw materials) are heated to 2,700°F in "wet" or "dry" kilns to produce clinker, the primary intermediate product of cement making. When the limestone is heated it undergoes a calcination reaction, resulting in CO_2 emissions.[1] Clinker is ground with about five percent gypsum (and other additives) to produce cement. The primary use of cement is in the production of concrete, where cement, in the presence of water, binds together coarse and fine aggregate materials, such as gravel and sand.

The American Portland Cement Alliance /Climate Wise Partnership

In the first Climate Wise industry partnership of its kind, the American Portland Cement Alliance (APCA) has embarked upon an exciting relationship with the Climate Wise Program. Through an innovative partnership with APCA the 16 member companies listed in Table 1 are turning energy efficiency and pollution prevention into a corporate asset with Climate Wise. These member companies represent almost 60 percent of U.S. cement manufacturing capacity. To date Climate Wise has received 17 facility and company Action Plans from nine APCA Climate Wise Partner companies, which were submitted using software that Climate Wise designed specifically for the cement industry. These Action Plans present almost 100 different measures that will reduce CO_2 emissions by almost 2,700,000 metric tons by the year 2000. This is equivalent to removing almost 600,000 cars from the roads or all the cars in Nevada. These actions are also cost- effective. These companies are expecting to save, on average, over $2.3 million in costs annually.

[1] $CaCO_3 + Heat \rightarrow CaO + CO_2$

Table 1. APCA/Climate Wise Cement Industry Partners

• Arizona Portland Cement Company	• Lafarge Corporation
• Ash Grove Cement Company	• Lehigh Portland Cement Company
• Calaveras Cement Company	• National Cement Company of California
• California Portland Cement Company	• Phoenix Cement
• Capitol Aggregates Ltd.	• RC Cement Co. Inc.
• Dragon Products Company	• RMC Lonestar
• ESSROC Corp.	• Southdown, Inc.
• Holnam Inc.	• TXI Corporation

Climate Wise Customized Technical Assistance

Because the cement industry has joined as a group, Climate Wise has customized technical support to meet its needs. As a key part of this effort, Climate Wise has developed the Cement Industry Action Plan Software and Reporting Workbook. The Action Plan Software helps cement companies prepare their Action Plans and report on the results of their efforts. The software incorporates cement industry-specific issues such as CO_2 emissions resulting from calcination, a principal part of the cement manufacturing process. Climate Wise has continued to support and improve this software through workshops for APCA members and technical support through the Climate Wise *Wise Line* (a toll-free number supplying Climate Wise Partners with technical support and clearinghouse resources).

Climate Wise Sample Cement Industry Action Plan

Climate Wise, working with APCA and industry representatives, developed a sample cement industry Action Plan that gives examples of energy efficiency opportunities. Through these actions, Climate Wise determined that a mid-to-large size cement company could reduce its annual CO_2 emissions by more than 80,600 metric tons in the year 2000 with gross annual fuel cost savings of about $1 million. The measures from the sample Action Plan include:

- Optimizing heat transfer in the clinker (24,200 Savings in metric tons of CO_2)
- Intergrinding clinker with 2.5% limestone (22,733 Savings in metric tons of CO_2)
- Installing expert systems for kiln secondary control (11,367 Savings in metric tons of CO_2)
- Optimizing raw mix components (9,167 Savings in metric tons of CO_2)
- Compressed air leak repair, and motor efficiency measures (2,420 Savings in metric tons of CO_2)

Key Economic Drivers Shaping the Industry

- *Energy and capital costs.* On average, energy accounts for 30 to 40 percent of cement manufacturing costs. Purchased fuel and power costs were about 16 percent of the value of shipments in 1995, and energy-related capital expenditures were about 5.3 percent of the value of 1995 shipments. Cement companies typically look for a return on discretionary capital of about one to three years.

- *International competition.* Imports accounted for about 14 percent of U.S. cement consumption in 1996. Any energy conservation efforts that increase U.S. production costs could shift cement sales toward cheaper imports, which could increase global CO_2 emissions if the foreign cement kilns are less efficient than average U.S. kilns.
- *Environmental Concerns.* CKD, HAPs, SO_x, NO_x, CO_2. Raw material mining: dust, stream sediment loads, chemical changes to local water supplies.
- *Material substitution.* What potential exists for engineered wood products or other materials to displace concrete in building construction? Would this reduce GHGs?

A Summary of Technologies and Measures That Can Reduce GHG Emissions

Near term and/or cost effective practices: Examples of cost-effective measures for cement plants include heat transfer optimization in the clinker cooler, optimization of raw mix components, increased use of blended cements produced from industrial wastes (such as fly ash and blast furnace slag), housekeeping improvements, heat recovery — waste heat drying using preheater exit gas, kiln shell heat loss reduction, roller mills, wet process slurry dewatering with filter presses, improved grinding media, high-efficiency particle size classifiers, mechanical conveying systems, and specifying low alkali cement only when necessary. The potential application of cogeneration, by using waste heat from the cooler or by using gas turbines as tertiary air supply or to dry blast furnace slags, is also an option in some plants. Whether or not a given measure makes sense for any specific facility will depend upon individual site-specific characteristics such as kiln configuration, energy prices, availability of capital, and payback requirements.

A number of cement plants are implementing new clinker cooler technology that can reduce kiln energy use by up to six percent, and facility CO_2 emissions by up to 2.5 percent, with a payback on the order of two years at some plants. Optimizing raw mix components to achieve a better burn could save up to five percent of kiln energy use and up to two percent of facility CO_2 emissions, where technically feasible.

Industrial wastes such as coal fly ash, blast furnace slag and silica fume have cementitious properties and can be interground with cement or added at the concrete mixing stage. For each percent of cement displaced by these materials, CO_2 emissions are reduced proportionally. (It takes approximately 1.2 tonnes of coal fly ash to displace a tonne of Portland cement in concrete.) The consistency and quality of blended cements will determine their market demand and price. At present, blended cements account for about one percent of domestic cement shipments. Limitations on further penetration of fly ash into the concrete market such as ash quality availability, construction standards, transportation costs, and user preferences warrant further examination. Specifying low alkali cement only when necessary could reduce CKD and CO_2 emissions.

The quality of blended cements is comparable to Portland cement; the main differences are lower early strength but higher final strength, and improved resistance to sulphates and seawater. Portland Cement Association has estimated a potential market of 30 Mtonnes blended cement production capacity in 2001 – about a third of existing 1994 capacity – which could result in significant CO_2 emissions (greater than 20-30 percent) if implemented (PCA 1997). The market barriers to the adoption of this measure will need to be addressed in greater detail.

Advanced efficiency practices: Examples of advanced opportunities for reducing cement industry GHG emissions include wet to dry process conversion, fuel switching, advanced kiln systems such as fluidized bed or trough kilns, expert systems for kiln secondary control, other monitoring and dynamic process controls, low pressure drop cyclones, high pressure finish grinding, unconventional clinkers, and new cementitious materials (such as geopolymers).

- If all existing wet kilns and long dry kilns were replaced with high efficiency, preheater, precalciner dry kilns, and all new kilns were also precalciner dry kilns, total carbon savings in 2010 would be about 20 percent above the AEO98 business-as-usual scenario. (reference?)
- Coal and coke account for about 70 percent of cement industry energy use, natural gas 11 percent, electricity 10 percent and waste fuels eight percent (PCA 1996). Switching from coal to natural gas could significantly reduce fuel-related CO_2 emissions, but at current fuel prices is cost-prohibitive for the industry. Switching to natural gas may also face some technical limitations and could potentially increase NO_x emissions.
- Expert systems for kiln secondary control could reduce kiln energy use by up to three percent, and facility CO_2 emissions by up to one percent, with a payback time of less than two years, this does not include maintenance costs which can be significant.
- New cyclone designs that allow for lower system pressure may be able to reduce electricity use by up to 4 percent (and CO_2 emissions by less than one half percent), but are usually only cost-effective with a production increase.

Climate Wise Action Plans Submitted by Cement Companies

The actions reported by the Climate Wise partners are shown in Table 2. This represents almost 60 percent of the Climate Wise cement companies. The information includes energy use and savings, CO_2 emissions savings, and cost savings for 1997 and 2000. Reported electricity and fuel use increase slightly over those three years. Electricity savings as the result of Climate Wise projects amount to approximately 10 percent of annual electricity use, while fuel savings are roughly 20 percent of the total fuel consumption. These fuel efficiency improvements lead to CO_2 savings of between 1.5 million tonnes and 2 million tonnes per year. Another 0.5 million tonnes of CO_2 are avoided by blending pozzolans with the clinker in production.

Table 2. Aggregated Values for the Cement Companies' Climate Wise Action Plans

	1997	2000
Annual Energy Use		
Electricity (MWh)	3,593,904	3,670,020
Fuel (MMBtu)	102,307,330	102,381,722
Annual Energy Savings		
Total Electricity Savings (MWh)	353,232	434,279
Total Fuel Savings (MMBtu)	16,619,348	24,074,816
Annual CO_2 Savings (tonnes)		
From Electricity Savings	203,438	256,197
From Fuel Savings	1,348,302	1,863,724
From Calcination	491,618	576,131
Total	2,043,358	2,696,052
Annual Cost Savings		
Gross	$803,309	$4,095,987
Net	$18,414,435	$19,305,209

Company Action Plans have incorporated the energy-efficiency measures included in the sample Action Plan as well as: modernizing kilns and mills; changing from wet kilns to pre-heater pre-calciner systems; burning tires in place of coal; and installing variable frequency drives (VFDs). In all, 98 measures from these Action Plans have been or will be implemented by the year 2000. The APCA/CW Partners are very conscious of their process energy use. Over 90 percent of their actions will reduce emissions and energy use from major parts of their processes. Figure 1 is an analysis of actions by the type of process they improve. For example, 32% of the process related actions are modifications to the kiln. Figure 2 is an analysis of non-process specific actions. Examples are motor improvements that are not specific to a part of the process or compressed air system improvements that may affect multiple steps in the process.

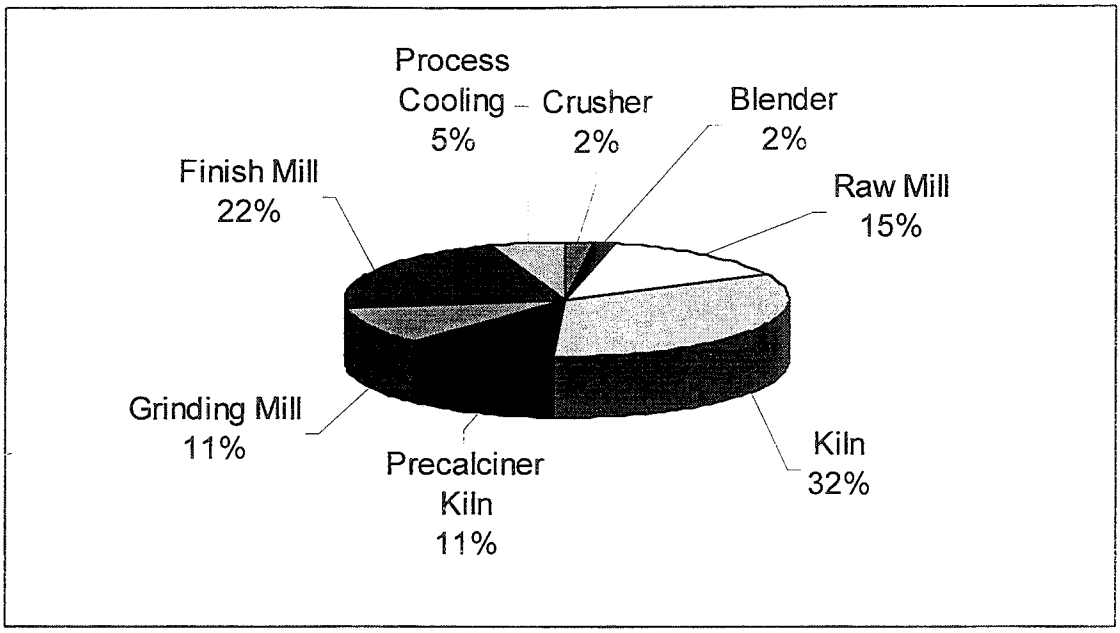

Figure 1. Cement Company, Production-Specific Actions

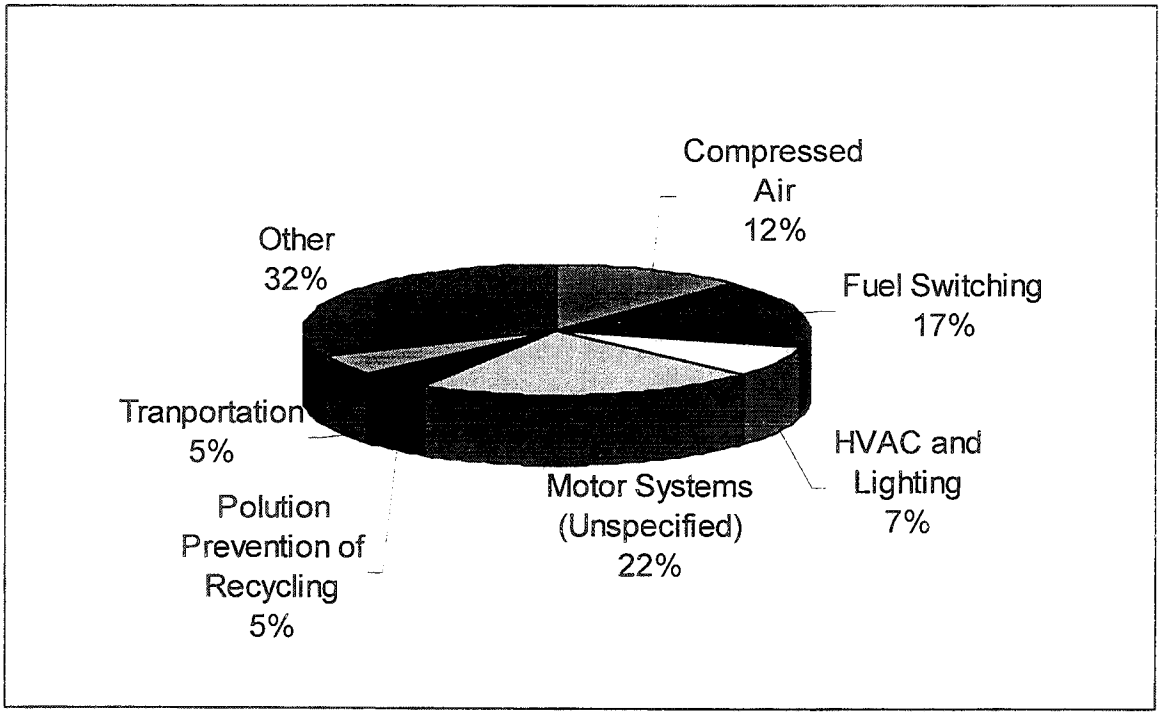

Figure 2. Cement Company, Non-Production-Specific Actions

Analysis of APCA/CW Impacts

Estimation of CO_2 Emission Reductions Baseline from AEO Data

Establishing a baseline level of CO_2 emissions is critical in evaluating the effects of the Climate Wise program. According to the Energy Information Agency (EIA), energy efficiency has been improving at a rate of around one-half of one percent per year over the last twenty five years in the cement industry. This implies that there are a large number of efficiency improvements that are projected to take place in the absence of any additional programs or technical assistance measures. In order to determine the effects of the Climate Wise program, it is necessary to isolate the actions that were expected to occur in the absence of the program from the actions taken in response to the Climate Wise program. EIA's "Annual Energy Outlook" (AEO) report, describes the "baseline" of the expected CO_2 emission reductions in the cement industry in the absence of the Climate Wise program. They are used as a starting point against which to analyze the effects of Climate Wise.

The method for establishing a baseline level of CO_2 emission reductions begins by converting the historical and forecast energy consumption data in the AEO into an amount of CO_2 emissions associated with that energy consumption. This is done by using the carbon content coefficients for the different fuel types (DOE 1998) to convert fuel consumption into CO_2 emissions.[2] The expected reductions in CO_2 emissions, shown in Figure 1, are then the difference between the total CO_2 emissions in 1996 and CO_2 emissions in a future year. The AEO forecast shows a significant drop between 1997 and 1999 in the amount of energy derived from coal by the cement industry (equal to six percent of total coal consumption). This results in a large initial reduction in CO_2 emissions that remains essentially unchanged afterwards.

CO_2 Emission Reduction Results

In Figure 3, it is assumed that the Climate Wise Partners maintain the energy efficiency improvements shown in Table 2 for the years following the reported data in 2000.[3] This feature involves three assumptions: first, the projects undertaken by the firms do not decrease in efficiency over time; that there are no continued improvements over time; and finally, that the efficiency improvements have reached their full potential by the year 2000. Taken in conjunction, these assumptions are likely to underestimate the CO_2 savings associated with the Climate Wise program.

Figure 3 shows the CO_2 emission reductions from the Climate Wise Partners as compared with the AEO baseline. The first few years show a dramatic change in the AEO figures, resulting in them quickly catching up with the Climate Wise Partners' reductions. However, the emission reductions achieved by the Climate Wise Partners are greater initially than those forecast by the AEO and remain above the industry reductions expected by the AEO until 2010. This indicates that the Climate Wise actions have a greater impact on lowering CO_2 emissions than would be expected in the normal course of business in the cement industry. In addition, if the remaining 60 percent of the industry were to adopt

[2] Note that changes in the level of production in this method only enter into the baseline to the extent that they are reflected in changes in the level of energy consumption.

[3] The trend between 1997 and 2000 is interpolated.

techniques similar to those pursued by the Climate Wise members ("Industry Adoption of Climate Wise"), the industry's CO_2 savings would be significantly higher than the AEO expectations. Note that the AEO emission reductions trend remains essentially unchanged after 1999. Consequently, any improvement in energy efficiency by the Climate Wise Partners will quickly outpace the improvements predicted by the AEO data.

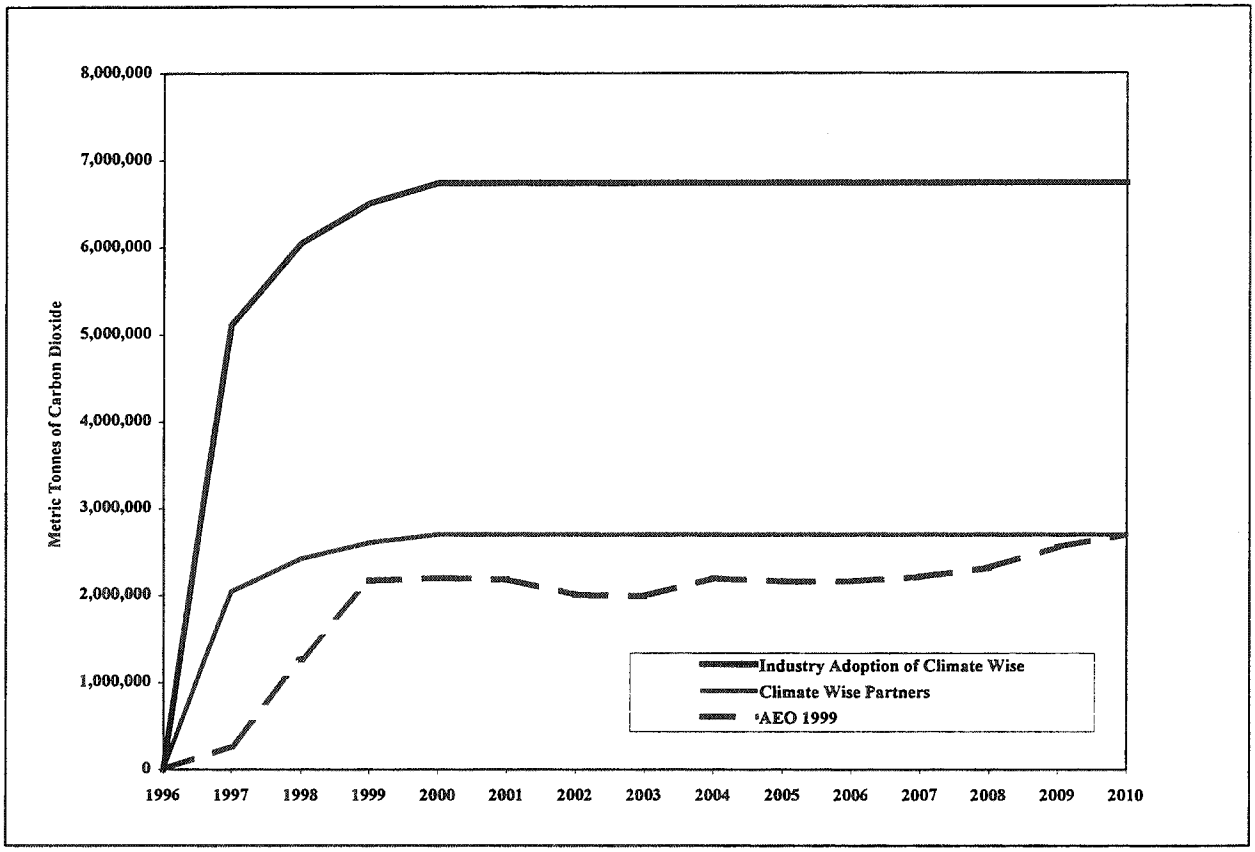

Figure 3. APCA/CW Annual CO_2 Reductions, Industrial Potential and AEO Baseline

Conclusions

The APCA cement companies have demonstrated that working together with the help of Climate Wise, positive environmental impacts can be accomplished while reducing costs. The APCA/Climate Wise Partners have achieved reductions of greenhouse gas emissions greater than what is estimated by established benchmarks. Their example is one that will help guide the rest of the cement industry and all other manufactures. Through measures similar to those on the Action Plans, such as the implementation of new clinker cooler technology, increased use of blended cements produced from industrial wastes, housekeeping improvements, and use of waste heat the industry will further reduce their greenhouse gas emissions.

Climate Wise is continuing work with the cement industry to reduce energy use and emissions, through the promotion and distribution of information regarding present and new technologies. Climate Wise is working with the cement industry to make it easier to identify and select environmentally preferable cement products, meeting with State and Local government leaders to identify opportunities and obstacles to the enhanced use of blended cement products, and developing informational material and pilot projects to demonstrate the use of blended cement and other energy savings measures.

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