Attachment 1: Description of Emissions Reduction Measure Form

Title: *Low Carbon Cement Standard*

Type of Measure (check all that apply):

☑ Direct regulation
☐ Monetary Incentive
☐ Voluntary
☐ Other Describe:
☐ Market-based compliance:
☐ Non-monetary incentive
☑ Alternative Compliance Mechanism

Responsible Agency: California Air Resources Board

Sector:

☐ Transportation
☐ Other Industrial
☐ Agriculture
☐ Sequestration
☐ Electricity Generation
☐ Refineries
☑ Cement
☐ Other Describe:

2020 Baseline Emissions Assumed (MMT CO2E): 14.8 MMT CO2e

Percent Reduction in 2020: 24% (3.5 MMT CO2e)

Cost-Effectiveness ($/metric ton CO2E) in 2020: $78/metric ton CO2E

Description:
A low-carbon cement production standard would set a cap on the carbon intensity of all cement produced in California at 0.69 metric tons of CO_2e emissions per metric ton cement produced in 2020. This could be achieved through improvements in energy efficiency, the production of limestone blended cement, and using lower carbon fuels, such as natural gas. The carbon intensity of cement would be verified using data on clinker production and GHG emissions from CARB's mandatory reporting program. CARB would enforce the standard using its AB 32 enforcement authority. Each of these modifications to the cement manufacturing process would provide significant reductions of emissions of GHGs, air toxics (such as mercury), and criteria pollutants.

Energy efficiency and blending have both been proposed for the cement industry in the September 2007 draft early action measure proposal document. These measures could be implemented together with low carbon fuels under this proposed low carbon cement standard, or alternatively, CARB could implement some energy efficiency and/or blending requirements first and later adopt a low carbon cement standard to ratchet down carbon intensity further.

Improve Energy Efficiency
Setting a carbon intensity standard for cement levels the playing field so that cement kilns that have already invested in energy efficiency would be that much closer to attaining the standard. California cement plants would select the mix of technologies and process changes that would be most cost-effective for them, taking advantage of resources such as technical assistance offered by the electric and natural gas utilities' efficiency programs, and publications by Lawrence Berkeley National Lab and the U.S. Environmental Protection Agency's Energy Star program guidance documents for the cement industry. Each of these contains an extensive list of existing, proven technologies and process changes.

Limestone Blended Cement
California's cement manufacturing facilities could modify the composition of the cement produced to replace a portion of the clinker with interground limestone. This would reduce the quantity of clinker produced, which would diminish the quantity of fuel combusted, the electricity used and the CO_2 liberated through pyro-processing of limestone. All relevant performance and safety specifications set by BT&H and ASTM would be met. We recommend the use of limestone for blending since other materials, such as fly ash, could have negative unknown impacts. Any other materials used for blending must receive a complete environmental review to ensure that they are safe and will not leach toxic substances or create other environmental hazards.

Lower Carbon Fuels
To achieve substantial GHG and other air pollutant emission reductions, California's cement manufacturing facilities would minimize or eliminate the use of high carbon fuels, such as coal and petroleum coke, in favor of low carbon fuels such as natural gas and biomass. For some plants, this would be a return to earlier fuel use patterns, such as in the 1970s when natural gas made up 44% of the fuel share at cement plants nationwide.[1] Care must be taken to assure no negative environmental impacts from fuel switching. For example, waste tires are not an acceptable fuel source, since many toxic byproducts are created upon combustion.

Although each of these individual measures could be implemented independently and provide significant GHG reductions, the implementation of a low carbon cement standard provides a mechanism by which California cement plants can cost-effectively combine the different measures to suit the individual needs of each facility.

Emission Reduction Calculations and Assumptions:
A low carbon cement production standard could achieve a 24% reduction in GHG emissions over 2020 levels. This is equivalent to 3.5 MMT CO_2e per year in 2020. Taken separately, individual measures to reduce GHGs also substantially decrease GHG emissions.

[1] Hanle, Lisa J., Jayaraman Kamala R. and Smith Joshua S. CO2 Emissions Profile of the U.S. Cement Industry. US EPA 2004.

Table 1: GHG emission reductions

Reduction Strategies	Percent Reduction in 2020	CO_2e reductions in 2020 (MMT/yr)
Low carbon cement production	24%	3.5
Individual reduction measures		
Improving energy efficiency	9%	1.3
Production of 5% limestone blended cement	5%	0.7
Using low carbon fuels	15%	2.2

Note: The emission reductions from each separate measure are not additive because each measure has the capacity to affect the parameters of the others (i.e. the first two measures both reduce fuel demand).

See attached spreadsheet for more information.

Cost-Effectiveness Calculation and Assumptions:
The low carbon standard would likely entail an array of measures as outlined above. There is a great deal of uncertainty in the estimates of cost effectiveness, particularly for individual cement manufacturing facilities. However, using general estimates of the cost of technical modifications to improve energy efficiency in clinker production ($90 million)[2] and increased cost of natural gas[3] as compared to coal and petroleum coke, we estimate a cost effectiveness of $78 per metric ton of CO_2e reduction. Additional infrastructure costs may be applicable for those cement manufacturing facilities not currently serviced by natural gas lines. A cost savings was assumed for blending, based on a 5 percent reduction in energy use. Individual plants would likely experience other cost savings through reduced fuel requirements, and avoided criteria and air toxics emissions, however, we were unable to quantify these.

See attached spreadsheet for more information.

Implementation Barriers and Ways to Overcome Them:
A low carbon standard for all cement produced in California could potentially lead to some leakage, that is, greater imports of cement than would otherwise occur. Therefore, if necessary, CARB could explore the application of a low carbon cement standard on all cement consumed in California as opposed to only that produced in California. This would likely present some enforcement challenges, as well as potentially delaying implementation. For example, while CARB could easily enforce a carbon standard for California kilns based on mandatory reporting data, as discussed above, an independent third party verification approach may be necessary for any imported cement.

Further, cement imports may grow in the future as a result of limited production capacity in California. The extent to which California relies on imports may impact the speed at which a low carbon standard could be implemented. A step-wise approach, ratcheting down the standard

[2] CARB draft "Expanded List of Early Action Measures to Reduce Greenhouse Gas Emissions in California Recommended for Board Consideration," September 2007. Note that this estimate excludes the emission reductions achieved through reduction in electricity demand, which is 3% of total emission reductions, to avoid double counting with the electric utility efficiency programs.
[3] 2020 fuel costs estimated in 2006 dollars in the draft Updated Macroeconomic Analysis of Climate Strategies Presented In the March 2006 Climate Action Team Report.

over time from .90 MT CO_2e/MT cement today to .69 MT CO_2e/MT cement in 2020 could alleviate this issue. We expect the large market of California could spur improvements from out of state cement kilns and encourage CARB to explore this further.

Additionally, we encourage CARB to explore the advanced energy efficiency measures and increased blending techniques employed by cement kilns outside California and outside the US.

Potential Impact on Criteria and Toxic Pollutants:
Cement production in California accounts for almost 90% of statewide mercury (Hg) emissions according to US EPA's TRI data and is also a significant source of criteria pollutants such as Particulate Matter (PM_{10}) and Nitrogen Oxides (NO_x).[4] Implementation of a low-carbon cement production standard would reduce significant sources of these pollutants and make substantial gains towards improvements in air quality.

Mercury
As a result of meeting the low-carbon cement production standard, California's cement manufacturing facilities would reduce mercury emitted due to the combustion of coal and the pyro-processing of mercury containing limestone. We estimate this would amount to almost 200 pounds less mercury released into the environment or a 35-55% reduction in total mercury emitted.[5] Factors such as the source of the limestone and coal could result in higher or lower reductions at individual plants.

Particulate Matter (PM_{10})
California's cement manufacturing facilities would reduce particulate matter emissions due to reduced fuel combustion and limestone pyro-processing.

Nitrogen Oxides (NO_x)
Improvements in energy efficiency and the production of limestone blended cement would reduce NOx emissions from California cement manufacturing facilities due to reductions in fuel combustion. Combustion of natural gas in cement kilns requires the utilization of additional stack emission controls for NOx emissions.

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[4] U.S. EPA, 2004 data release for Toxic Release Inventory, available at http://www.epa.gov/triexplorer.
[5] Percent mercury reduction is calculated based on USEPA estimate that 30-45% of mercury emissions are due to coal combustion.