EXECUTIVE SUMMARY

Section 6017(a) of the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users, P.L. 109-59, Aug. 10, 2005 (SAFETEA-LU), directs the U.S. Environmental Protection Agency (EPA or the Agency) to, "…conduct a study to determine the extent to which procurement requirements, when fully implemented…may realize energy savings and environmental benefits attainable with substitution of recovered mineral components in cement used in cement or concrete projects."

SAFETEA-LU directs EPA to submit a report to Congress within 30 months of the enactment of SAFETEA-LU that addresses the following requirements:

> (A) Quantify (i) the extent to which recovered mineral components are being substituted for portland cement, particularly as a result of current procurement requirements; and (ii) the energy savings and environmental benefits associated with that substitution;
>
> (B) Identify all barriers in procurement requirements to greater realization of energy savings and environmental benefits, including barriers resulting from exceptions from current law; and
>
> (C) (i) Identify potential mechanisms to achieve greater substitution of recovered mineral components in types of cement and concrete projects for which recovered material components historically have not been used or have been used only minimally; (ii) evaluate the feasibility of establishing guidelines or standards for optimized substitution rates of recovered material component in those cement and concrete projects; and (iii) identify any potential environmental or economic effects that may result from greater substitution of recovered mineral components in these cement and concrete projects.

Energy savings and environmental benefits associated with substitution. Recovered mineral component (RMC) use yields positive environmental benefits through lower resource consumption. To overcome procurement data limitations, for ground granulated blast-furnace slag (GGBFS), coal combustion fly ash (coal fly ash) , and silica fume, the report derives estimates of their use in Federal projects by roughly apportioning total volumes to Federal and non-Federal projects (based upon the estimated proportion of total cement demand related to federally-funded projects). For the years 2004 and 2005, our life cycle analysis indicates that the use of GGBFS, coal fly ash, and silica fume in Federal concrete projects alone resulted in significant reductions in greenhouse gas (GHG) emissions, criteria air pollutants, and energy and water use. For these two years combined, the analysis indicates reduced energy use of 31.5 billion megajoules, avoided CO_2 equivalent air emissions of 3.8 million metric tons, and water savings of 2.1 billion liters. The report further illustrates how these benefits may accrue over a longer time period (through 2015) given alternative use scenarios. This aspect of the analysis also links to issue C noted above.

With respect to the issues identified under parts (B) and (C), research suggests that while a number of barriers impede the beneficial use of RMCs through procurement requirements, a variety of potential mechanisms exist for addressing these barriers. Specifically:

- **Procurement policies and material standards** initiatives, including ongoing assessment and refinement of EPA's Comprehensive Procurement Guidelines (CPGs), refinement of engineering standards governing substitution of RMCs, and development and application of green building standards.

- **Education, technical assistance, and recognition programs,** such as EPA's foundry sand outreach efforts and public/private partnerships, such as the Coal Combustion Products Partnership (C^2P^2) to encourage the beneficial use of coal combustion products (CCPs).

    - As part of education, technical assistance, and recognition, ongoing research and pilot projects are critical to advancing the use of RMCs.

- **Economic incentives,** such as using transportation funding mechanisms to increase RMC use and providing incentives related to various components of the RMC generation and use chain.[1]

The CPG program is part of EPA's continuing effort to promote the use of materials recovered from solid waste and by-products.[2] Under this program, EPA designates products that are made with recovered materials, and recommends practices for buying these products by procuring agencies.[3] Once a product is designated, procuring agencies are required to purchase it with the highest recovered material content level practicable (e.g., the highest material content level that can be economically obtained and can provide the needed product specifications). EPA has issued guidelines for procurement of cement and concrete containing coal fly ash, and has further designated cenospheres[4] and silica fume as RMCs for cement and concrete.

This report presents EPA's analysis and discussion of the requirements contained in SAFETEA - LU. Consistent with SAFETEA-LU, this Report reflects the input of multiple Federal partners in addition to EPA, including the U.S. Department of Transportation (DOT), the U.S. Department of Energy (DOE), the General Accountability Office (GAO), the United States Geological Survey (USGS) and the Office of the Federal Environmental Executive (OFFE). In addition, the Report also reflects comments and information from state entities and certain industry sources, such as the American Coal Ash Association (ACAA), the Slag Cement Association (SCA), the Silica Fume Association (SFA), the National Slag Association (NSA) - Edw. C. Levy Co., Headwaters, Inc., Venable LLP, and Holcim, Inc. We summarize the salient features of the report below.

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[1] These incentives are presented for Congressional consideration only. We recognize that the Department of Transportation does not currently have the legal authority to use transportation funding mechanisms to help increase RMC use.

[2] EPA also issues guidance on buying recycled-content products in Recovered Materials Advisory Notices (RMANs). The RMANs recommend recycled-content ranges for CPG products based on current information on commercially available recycled-content products.

[3] Procuring agencies include: (1) any federal agency, (2) any state or local agency using appropriated federal funds for procurement, or (3) any contractors to these agencies who are procuring these items for work they perform under the contract.

[4] Cenospheres are a very specialized product used in a number of different industries. Cenospheres are also sometimes called microspheres.

Industry Overview, Materials Evaluated, and Current Recovered Mineral Component Substitution Levels

Provisions of SAFETEA- LU identified certain RMCs for further study, and directed EPA to identify and consider other waste and byproduct materials diverted from solid waste that should be considered as "recovered mineral components."[5] The four congressionally-identified mineral components include: GGBFS; coal fly ash; blast furnace slag aggregate (BFSA)[6]; and silica fume. Congress specifically excluded lead slag from this Report. The other by-product materials identified by EPA for evaluation include: foundry sand, cenospheres, flue gas desulfurization (FGD) gypsum, flue gas desulfurization (FGD) dry scrubber material, power plant bottom ash, power plant boiler slag, steel furnace slag, and cement kiln dust (CKD). Table ES-1 provides a description of each of the RMCs and their general uses. Table ES-2 identifies the estimated annual quantities available for each RMC (including both domestic production and imports), and summarizes the positive environmental impacts and product enhancements associated with use of these materials.

[5] Section 6017 (a) of SAFETEA-LU defines recovered mineral components as "(A) ground granulated blast furnace slag other than lead slag; (B) coal combustion fly ash; (C) blast furnace slag aggregate other than lead slag aggregate; (D) silica fume; and (E) any other waste material or byproduct recovered or diverted from solid waste that the Administrator, in consultation with an agency head, determines should be treated as recovered mineral component under this section."

[6] Also known as Air Cooled Blast-Furnace Slag (ACBF Slag)

Table ES-1: Summary of RMCs

RMC	Description	Uses/Applications
RMCs Named by Congress		
Ground granulated blast-furnace slag (GGBFS)	A ferrous slag produced during the production of iron as a result of removing impurities from iron ore. Quick quenching (chilling) of molten slag yields glassy, granular product which can be ground to a fine, powdered hydraulic cement.	GGBFS can be used as partial replacement for portland cement, or, if not finely ground, as concrete aggregate.
Coal combustion fly ash	A finely-divided mineral residue from the combustion of ground or powdered coal in coal-fired power plants.	Partial replacement for portland cement in concrete applications. Can be used as a raw material in the production of portland cement clinker or as an inter-ground or blended supplementary cementitious material (SCM) in the production of blended cements.
Blast furnace slag aggregate (BFSA)	Produced by allowing molten slag to cool and solidify slowly. Also commonly referred to as: air cooled blast-furnace slag (ACBF slag).	After crushing and screening, used as aggregate in applications, such as concrete, asphalt, rail ballast, and roofing. It is also used in shingle coating, and glass making.
Silica fume	A very fine, dust-like material generated during alloyed metal production.	Concrete additive used to increase strength and durability.
Other RMCs Identified by EPA		
Foundry sand	Silica sand that is a byproduct of both ferrous and nonferrous metal castings.	Can be used in the manufacture of cement clinker and as an ingredient in concrete.
Cenospheres	Small, inert, lightweight, hollow, "glass" spheres composed of silica and alumina and filled with air or other gases. They occur naturally in coal fly ash.	Used in concrete production to increase concrete's strength and decreasing shrinkage and weight. [Cenospheres may also be used in a wide variety of materials, from paints and finishes to plastics and caulking.]
Flue gas desulfurization (FGD) gypsum	FGD by-products are generated by air pollution control devices used at some coal-fired electric power plants. Forced oxidation wet FGD systems create gypsum as a by-product.	Replacement for natural gypsum in wallboard production and grinding with clinker to produce finished cement.
Flue gas desulfurization (FGD) dry scrubber material	Dry FGD systems remove sulfur dioxide (SO_2) from coal-fired power plant flue gas. Main constituents of resulting byproduct include calcium sulfite, fly ash, portlandite, calcite, calcium sulfate.	Dry FGD material is used in concrete mixes and products as a substitute aggregate material. Dry FGD material may also be used for embankments and roadbase compositions.
Power plant bottom ash	A coarse, solid mineral residue that results from the burning of coal in utility boilers.	Used as aggregate in concrete, or for other aggregate uses such as compacted base course. Also used as raw material in cement clinker manufacture as alternative source of silica, alumina, iron, and calcium.
Power Plant Boiler slag	A coarse, hard, black, angular, glassy material, produced from slag in wet-bottom boilers.	Owing to its abrasive properties, boiler slag is used almost exclusively in the manufacture of blasting grit; can also be used as raw feed component to make cement clinker.
Steel furnace slag	A by-product from the conversion of iron to steel in a basic oxygen furnace or the melting of scrap to make steel in an electric arc furnace.	Used as raw material substitute in cement clinker manufacturing. Also used in aggregate base, fill and asphalt.
Cement kiln dust (CKD)	The fine-grained, solid, highly alkaline material removed from cement kiln exhaust gas by air pollution control devices.	Material is primarily recycled through closed loop processes in the cement kiln. Small amounts used as supplementary cementitious material (SCM) for blended and/or masonry cements. Material can be used as a soil liming agent.
Note: Congress specifically excluded lead slag from this Report.		

Table ES-2: RMC Generation and Benefits of Use

RMC	**Annual Quantity Generated, 2004.** *(excludes stockpiles)* (million metric tons)	**Benefits of Use**
RMCs Named by Congress		
Ground Granulated Blast Furnace Slag (GGBFS)	3.6[a]	Use of GGBFS in concrete results in environmental benefits from avoided virgin materials extraction and manufacturing of portland cement. These benefits include reduced energy use and associated greenhouse gas (GHG) emissions, reduced water use and reduced air pollution. In addition, the beneficial properties of concrete mixes containing GGBFS include increased strength, improved workability, lower heat of hydration, lower permeability, improved resistance to alkali-silica reactivity, and resistance to sulfate attack. Use of GGBFS creates more concrete from the same amount of portland cement.
Coal Combustion Fly Ash	64.2 [b]	Use of coal combustion fly ash in concrete results in environmental benefits from avoided virgin materials extraction and manufacturing of portland cement. These benefits include reduced energy use and associated GHG emissions, reduced water use and reduced air pollution. In addition, certain performance benefits can be attained through the use of fly ash in cement, including greater workability in the mixed concrete and higher strength and increased longevity in the finished product. Also, creates more concrete from the same amount of portland cement. Can also be used as a raw material in the production of portland cement clinker or as an inter-ground or blended supplementary cementitious material (SCM) in the production of blended cements.
Blast Furnace Slag Aggregate (BFSA) (ACBF slag)	8.1[a]	As an aggregate in concrete mixes, BFSA reduces the need to quarry, crush, sort, and transport virgin aggregate materials, resulting in reduced energy use and associated GHG emissions, reduced water use and reduced air pollution.
Silica Fume	0.10 – 0.12[c]	The beneficial properties of concrete mixes containing silica fume include decreased water bleeding, increased strength, and reduced permeability to corrosive chemicals. Use of silica fume in concrete also reduces the required amount of portland cement for a specific quantity of concrete. Silica fume concrete is used in high-performance applications where special durability and strength performance is required.
Other RMCs Identified by EPA		
Foundry Sand	8.5[d]	Use of foundry sand in concrete results in environmental benefits from avoided virgin sand extraction. These benefits include reduced energy use and associated GHG emissions, reduced water use and reduced air pollution.
Cenospheres	0.0052[e] (sold only) (Total not available)	When incorporated into special light weight concrete or other cementitious materials mixes as fillers or extenders, cenospheres and can decrease shrinkage and weight. Use of cenospheres can also offset the production of other filler materials, such as manufactured glass, calcium carbonate, clays, talc, and other silicas.
Flue Gas Desulfurization (FGD) Gypsum	10.8[c]	Use of FGD gypsum in wallboard production and as an additive in cement production results in environmental benefits from avoided extraction of virgin gypsum. These benefits are likely to include reduced energy use and associated GHG emissions, reduced water use and reduced air pollution.
Flue Gas Desulfurization (FGD) Dry Scrubber Material	1.7[b]	Use of dry FGD material as a substitute for virgin aggregate results in environmental benefits from avoided virgin material extraction and aggregate production. These benefits include reduced energy use and associated GHG emissions, reduced water use and reduced air pollution. Use of dry FGD as a substitute (partial or total) for natural gypsum used as an additive in the finish mill (to control the setting time of the portland cement).
Power Plant Bottom Ash	15.6[b]	Use of bottom ash in concrete results in environmental benefits from avoided aggregate production. These benefits include reduced energy use and associated GHG emissions, reduced water use and reduced air pollution. The porous surface structure

RMC	**Annual Quantity Generated, 2004.** *(excludes stockpiles)* (million metric tons)	**Benefits of Use**
		of bottom ash also makes it useful in lightweight concrete and concrete block applications. As a raw material in cement manufacture, the bottom ash can supply some of the necessary oxides (thus saving on virgin raw materials), and can do so at a lower energy cost and with reduced emissions than for some virgin materials.
Boiler Slag	2.0[b]	Boiler slag can reduce the need for virgin materials used as a raw feed for clinker production. Boiler slag is also used in the manufacture of blasting grit.
Steel Furnace Slag	9.0[a]	Use of steel slag in clinker manufacturing helps to reduce energy use, decrease CO_2 and NO_X ,emissions, increase production capacity, and reduce virgin limestone extraction. As an aggregate, steel slag reduces virgin aggregate extraction. The benefits of avoided limestone or other types of aggregate extraction include reduced energy use and associated GHG emissions, reduced water use and reduced air pollution.
Cement Kiln Dust (CKD)	12.0 – 15.0[f]	Use of CKD as a filler or cementitious extender for finished cement can offset virgin materials extraction and reduce waste sent to landfills. Other beneficial uses of off-site CKD include stabilization of sludges, wastes, and contaminated soils. CKD may also be used for land reclamation, livestock feed ingredient, and as daily landfill cover.

Notes:

[a] Hendrik G. van Oss, 2004b, values given are amount sold, as the industry does not report on actual production. Sales include imports of ground blast furnace slag (GBFS) that are ground domestically into GGBFS. Van Oss (2006) estimates total blast furnace slag production in 2004 to be 12-14 million metric tons (vs. total reported sales of 12.2 million metric tons), but this figure does not distinguish between GBFS, GGBFS, and BFSA.

[b] American Coal Ash Association (ACAA). 2004 Coal Combustion Product (CCP) Production and Use Survey.

[c] Kojundic, 8/30/2006

[d] Oman, Alicia, American Foundry Society (AFS), September 18, 2007. Personal Communication. Foundry Sand data are annual average for 2005/06.

[e] American Coal Ash Association (ACAA). 2004 Coal Combustion Product (CCP) Production and Use Survey. Reported as sold only.

[f] van Oss, 2005. The industry does not report total CKD production. A majority of this material is known to be recycled back into the kiln. According to PCA, in 2006 approximately 1.2 million metric tons was beneficially reused (other than in kilns) and 1.4 million metric tons was landfilled (PCA, 2006. Summary of 2006 Cement Kiln Dust and Clinker Production)

Congress specifically excluded lead slag from this Report.

Energy and Environmental Benefits of RMC Use in Federal Cement and Concrete Projects

As indicated in Table ES-2, the use of RMCs can decrease the demand for certain virgin materials and decrease the demand for the use of portland cement. This leads to decreased resource consumption, namely energy and water. Lower resource consumption can yield, in turn, reductions in various pollutants and other positive environmental impacts, such as a reduction in GHG emissions. To assess these potential benefits further, this analysis provides quantified estimates of the environmental impacts and benefits for three RMCs: coal fly ash, GGBFS, and silica fume.[7] Consistent with the Congressional mandate to examine "recovered mineral components in cement used in cement or concrete projects," these estimates focus specifically on the impacts resulting from the use of these three mineral components as a partial replacement for, or supplement to, portland cement in Federal construction projects involving concrete. The assessed metrics include resource savings (e.g., reduced energy and water consumption), various avoided priority air pollutants (e.g., NO_2, PM_{10}, SOx, Hg, Pb), and various measures of avoided GHG emissions (e.g., CO_2, CF_4, CH_4, N_2O), which we further translate into equivalent metrics of avoided gasoline and oil consumption, and vehicles removed from the road.[8]

The analysis employs three primary steps in modeling the environmental benefits of using RMCs in Federal concrete applications: (1) development of RMC substitution scenarios; (2) use of life-cycle analysis to estimate quantified environmental impacts associated with the substitution of one unit (metric ton) of RMC; and, (3) calculation of the environmental impact profile for the total quantities of substituted RMC.

Concerning RMC substitution scenarios, the report first focuses on past years for which actual use data can be estimated (2004 and 2005). The report then develops multiple projected use scenarios for the years 2006 through 2015 based upon existing trends (i.e., baseline) and expanded use based upon attainment of certain program goals (e.g., attainment of the C^2P^2 goal of 16.9 million metric tons of coal fly ash use in concrete by 2011). Because data concerning the volume of these RMCs procured by the Federal government are unavailable, the report derives an estimate based on a rough measure of the proportion of the total volume of cement demand attributable to Federal concrete projects (equal to approximately 20% of the annual totals). Chapter 3 and Appendix D provide detailed background on the derivation of RMC use scenarios for Federal concrete projects.

For purposes of illustrating the general magnitude of potential impacts, Table ES-3 shows projected quantities of coal fly ash, GGBFS and silica fume used in Federal concrete projects for one scenario -- "baseline" usage. Chapter 3 and Appendix D provide detailed results for all

[7] The report focuses on these three RMCs due to the fact that more robust data sources and modeling resources exist with respect to material volumes and their use in federally-funded concrete projects. While it is likely that other materials used to supplement or substitute for portland cement would have similar benefits, it is difficult to extrapolate results from the RMCs addressed here because quantities in use are uncertain and different processing requirements for different materials can have a significant impact on the magnitude of environmental benefits.

[8] Additionally, unquantified benefits may be associated with improved performance of concrete and resulting decreases in the materials and energy needed to repair, replace, and upgrade road beds. Evaluation of these benefits, however, would require more robust estimates of average changes in management required for different concrete uses. To date, this type of information has been too limited to support a national estimate.

scenarios. The shaded area, covering years 2004 and 2005, represents the historical period. As the table shows, under this scenario, the forecast estimates that coal fly ash use in Federal concrete projects will grow from approximately 2.6 million metric tons in 2004, to 3.3 million metric tons in 2015. The GGBFS forecast contemplates lower growth, from approximately 0.7 million metric tons in 2004 to 0.9 million metric tons in 2015. Coal fly ash shows higher utilization growth potential as this RMC is currently used at lower rates compared to the highly-utilized GGBFS. Overall volumes of silica fume use are lower relative to coal fly ash and GGBFS.

Table ES-3: Use Projections for Fly Ash, GGBFS, and Silica Fume in Federal Concrete Projects (baseline scenario)

Year	Federal Demand for Portland Cement	Coal Fly Ash used in Federal Projects - Baseline Scenario	GGBFS used in Federal Projects - Baseline Scenario	Silica Fume used in Federal Projects - Baseline Scenario
	million metric tons			
2004	24.4	2.6	0.7	0.01
2005	25.1	2.7	0.7	0.01
2006	25.7	2.8	0.7	0.01
2007	26.2	2.8	0.7	0.01
2008	26.8	2.9	0.8	0.01
2009	27.4	3.0	0.8	0.01
2010	27.9	3.0	0.8	0.01
2011	28.5	3.1	0.8	0.01
2012	29.0	3.1	0.8	0.01
2013	29.6	3.2	0.8	0.01
2014	30.1	3.3	0.8	0.01
2015	30.7	3.3	0.9	0.01

Notes:
(1) These figures reflect use of materials as a supplement to or partial replacement for portland cement in Federal projects only.
(2) Shaded area represents "historical" period for which actual use data are estimated. Unshaded area represents the "forecast" period.

Table ES-4 presents the results of a life cycle inventory analysis of the use coal of fly ash, GGBFS and silica fume in Federal concrete projects under the baseline usage scenarios described above. These results are aggregated estimated benefits covering the historical period (2004 and 2005) and projected over the full time frame, 2004 through 2015. For a detailed description of the modeling approach, please refer to Appendix D.

Table ES-4: Estimated Environmental Benefits of Using Coal Fly Ash, GGBFS, and Silica Fume as a Substitute for, or Supplement to Portland Cement in Federal Concrete Projects, Baseline Scenario[9]

Metric (units)	Historical Environmental Benefits: 2004-2005	Projected Environmental Benefits: Baseline Scenario 2004-2015[a]
Energy Savings *(billion megajoules)*	31.5	212.1
Water Savings *(billion liters)*	2.1	14.1
Avoided $C0_2$ equivalent (GHG) *(million metric tons)*	3.8[b]	25.7[b]
Passenger cars not driven for one year[c] *(million)*	0.8[b]	5.7[b]
Passenger cars and light trucks not driven for one year[c] *(million)*	0.7[b]	4.7[b]
Avoided criteria pollutants (air) *(thousand metric tons)*	31.3	209.7
Avoided Hg (air) *(metric tons)*	0.3	1.9
Avoided soil emissions *(metric tons)*	0.0*	0.0*
Avoided end of life waste *(metric tons)*	0.0	0.0

Notes:
a. Calculated as the sum of impacts for coal fly ash current use baseline, and GGBFS and silica fume current use scenarios.
b. Results reflect only coal fly ash impacts.
c. These metrics are equivalent expressions of the avoided greenhouse gas metrics and do not represent additional benefits.
* Negligible.

We also developed representative benefits estimates for use of BFSA as an aggregate. See Appendix D.

As shown in Table ES-4, the use of coal fly ash, GGBFS and silica fume as a partial substitute for, or supplement to, portland cement in Federal concrete projects yield energy and water savings, as well as avoided criteria pollutant emissions. In addition, use of coal fly ash alone may result in 3.8 million metric tons of avoided carbon dioxide equivalent in the years 2004 to 2005. This savings is equivalent to removing 0.8 million passenger cars from the road for one year. Through the year 2015 under this scenario, we estimate that the use of such RMCs in Federal concrete projects may result in reduced CO_2 emissions of over 25.7 million metric tons, which is equivalent to removing 5.7 million passenger cars from the road for one year. Impacts on the reuse on soil and end of life waste are not significant because the use and disposal of portland cement and concrete are not affected by RMC use.

It is difficult to quantify the incremental contribution to RMC use that may be attributable to any particular relevant procurement requirements. A number of economic, operational, and regulatory factors combine to influence procurement behavior, and data limitations prevent the

[9] Blast furnace slag aggregate (BFSA) is primarily used as a source of aggregate in concrete and does not act as a supplementary cementitious material, or substitute for portland cement. Our assessment focuses on the benefits of substitution for portland cement. However, an illustration of the types and magnitude of benefits that can be achieved by using BFSA as a substitute for virgin aggregate in concrete mixtures, in asphalt mixtures, or as roadbase, can be found in Appendix D.

type of detailed analysis that would support attribution of specific behavior changes to specific programs. In general terms, however, the analysis identifies the combined impact of the CPG, state, Federal government, industry, and market-driven influences on the use of RMCs in Federal concrete projects.

Barriers to Increased RMC Substitution

Consistent with Part (B) of the Congressional mandate, this report describes barriers to increased RMC use, focusing specifically on the RMCs identified in the report for which current supply significantly exceeds current use. (i.e., coal fly ash, foundry sand, FGD gypsum, FGD dry scrubber material, power plant bottom ash, and CKD). Barriers to the increased use of RMCs in cement and concrete projects fall into four main categories:

- Technical barriers;
- Legal, regulatory, and contractual barriers;
- Economic barriers; and
- Perceived safety and health risk barriers.

These categories can include a range of specific issues that have the potential to limit the use of an RMC. For example, regulatory barriers may include certain state and local-level regulations and procedures governing the use of RMCs in various applications. Technical issues that limit the use of RMCs include the variability of standards for use of RMCs in portland cement and concrete and operational constraints with materials not typically used as RMCs; variation in RMC properties; and the availability of consistent, high-quality materials. Potential economic factors limiting RMC substitution include the RMC value to the supplier, transportation costs, the market price of RMCs, and disposal costs. Safety and health risk perception barriers include a lack of understanding of the potential and proper use, features, and risks associated with RMCs.

In addition to external barriers, the CPG provides that a procuring agency need not procure RMCs if certain criteria are met. If these criteria are over-interpreted by project managers, it could result in lower usage rates of RMCs than are technically and economically feasible. That is, while the CPG requires Federal agencies to procure products containing certain RMCs, the guidelines allow that such RMCs do not have to be procured if they: (1) are not available within a reasonable period of time; (2) fail to meet the performance standards set forth in the applicable specifications or fail to meet the reasonable performance standards of the procuring agencies; or (3) are only available at an unreasonable price. Additional limitations of the CPG include a lack of awareness of CPG requirements and products, the perception that CPG is not mandatory, and the cost and availability of CPG materials.

Mechanisms to Increase RMC Substitution

EPA, in collaboration with a variety of stakeholders, has identified a number of mechanisms that may serve to address the barriers noted above. These mechanisms are particularly focused on

RMCs with high reuse potential, but which appear to be under-utilized. For example, coal fly ash exists in large quantities, but is currently (2006) used in portland cement and concrete at a rate of roughly 13.6 million metric tons per year out of a generation of roughly 65.7 million metric tons. The report focuses on current and potential mechanisms to increase substitution rates relevant to these materials, specifically in Federal cement and concrete projects.[10]

Central to this report, and RMC use in Federal concrete projects, is the role of the CPG. As noted, the extent to which major Federal procuring agencies have purchased products containing RMCs is difficult to measure because few data systems identify purchases of specific recycled-content designated products. However, the multi-faceted approach to green purchasing implemented under the CPG has led to many successes, including influencing the amount of RMCs procured for use in concrete products. As one example, for FY 2003, more than 80% of the concrete purchases made by NASA, DOE, and GSA contained coal fly ash or slag. The CPG program, therefore, represents a critical mechanism to achieve higher RMC reuse levels.

To continue and expand upon this progress, the procurement guidelines and their implementation are the focus of ongoing improvement efforts (e.g, updating of CPG Supplier database). Further, a number of other potential mechanisms exist for addressing barriers. Chapter 5 provides a detailed listing of these potential mechanisms. In summary, the current and potential mechanisms for increasing RMC use include:

- **Procurement policy initiatives**, including improved procurement data systems, allowing for the identification and tracking of cement and concrete purchases using RMCs; enhanced CPG compliance and implementation procedures; and, delivery of effective information resources, training, and outreach to Federal agency contracting, purchase card, and program personnel.

- **Material standards optimization**, including refinement of engineering standards governing substitution of RMCs, development and application of green building standards, and incorporation of these considerations into contract bidding specifications and procedures.

- **Education and recognition programs,** such as EPA's CCPs outreach efforts and public/private partnerships, such as the FHWA, ACAA, DOE, the Electric Power Research Institute (EPRI), the United States Department of Agriculture (USDA), and the Utility Solid Waste Activities Group (USWAG) collaboration on C^2P^2 to promote the beneficial use of CCPs.

- **Technical assistance and research**, such as FHWA's ongoing research on the beneficial use of RMCs in highway construction projects, which includes primary research concerning material specifications and guidance on their use.

[10] We also note that the amount of certain RMCs produced annually in the U.S. surpasses the amount that can be incorporated into Federal cement and concrete projects alone. Although Federal projects currently comprise a moderate percentage of U.S. cement and concrete projects, increasing reuse rates to higher levels will require greater reuse among both Federal and non-Federal cement and concrete projects. To that end, many of the mechanisms contemplated here can apply to non-federal, as well as Federal projects.

- **Economic incentives,** such as using transportation funding mechanisms to increase RMC use and enhancing the economic viability of various components of the RMC generation and use chain.

The linkages between these mechanisms and barriers are complex and varied. For example, some barriers related to inaccurate perceptions concerning RMC use may be overcome relatively easily through education or outreach efforts. These mechanisms, however, would be less effective in instances where strong economic disincentives to RMC use are present. In addition, implementation of many of these mechanisms is subject to resource availability and active participation by a broad range of entities. These factors all indicate that increasing RMC use in concrete products requires an ongoing, multi-faceted approach.