Environmentally Safe, Large Volume Utilization Applications for Coal Gasification Byproducts

STATEMENT OF PROJECT OBJECTIVES

A. OBJECTIVES

The objective of the proposed work is to evaluate large volume utilization options for gasifier slag produced by the Eastman gasifier, Kingsport, Tennessee and TECO's Polk Station in Mulberry, Florida. Each substrate will be characterized and beneficiated into 3 distinct products: frit, coarse carbon and fines. The beneficiated products will then be evaluated for large volume and higher-value utilization options to enable total utilization and potentially eliminate the need for by-product storage. Products will be tested for leaching potential to ensure the environmental safety of the uses.

B. SCOPE OF WORK

Representative samples will be collected from both Eastman's and TECO's commercial gasifiers. Laboratory scale studies will identify the suitability of beneficiated products to specific markets. Once the utilization options are assessed, larger quantities of beneficiated products (i.e. 50 to 100 tons) will be generated for larger scale product testing at the gasifier sites using a mobile processing plant or existing processing capabilities.

C. TASKS TO BE PERFORMED

Task 1.0 Sample Collection and Characterization. Representative composite samples of gasification by-products will be obtained from gasifiers operated by Eastman and TECO and characterized as a function of particle size to determine partitioning of carbon and ash. Previous evaluations of these substrates revealed that frit, carbon and ash particles partition into distinct particle size ranges. Each size fraction will be thoroughly analyzed for proximate and ultimate analyses, BTU, and major oxides.

Task 2.0 Composite Sample Preparation and Characterization. The composite samples will be processed by screening at the appropriate screen opening size in order to separate the bulk sample into the desired products: slag, coarse carbon and fines. This will provide a sufficient quantity of each product to conduct utilization testing. Each product will be thoroughly characterized for size distribution, proximate and ultimate analyses, BTU and major oxides.

Task 3.0 Lab-Scale Product Utilization Evaluation. Product utilization evaluation will entail appropriate testing for the products obtained in Task 2. These evaluations will be conducted at laboratory-scale using appropriate testing protocol for the various end-use products.

Subtask 3.1 Slag or Frit Product Utilization. The slag or frit product will be evaluated for potential use as kiln feed, pozzolan, roofing granules and abrasive media. Utilization potential as kiln feed will be evaluated by Cemex and will be based on the chemical, physical and thermal properties of the frit product and the specific requirements of the CEMEX kilns in eastern Tennessee and central Florida.

Slag utilization potential as pozzolan will be conducted by the CAER in collaboration with CEMEX. The slag will be ground using wet grinding techniques, monitoring energy consumption as a function of size reduction. The fine-ground slag product will then be evaluated in mortar and concrete mix designs using standard cylinders and cubes at the CAER. Properties to be evaluated include flow, mortar air and compressive strength at several substitution levels.

Roofing granule and abrasive media evaluations will be conducted by the CAER in collaboration with Charah Environmental, Inc. Batches (10 kg) of slag will be generated to meet vendor specifications. They will be characterized and submitted to the appropriate vendors within the market areas of both gasifier sites. Relevant test parameters include friability, hardness and staining. Appropriate ASTM tests will be conducted on the materials.

Subtask 3.2 Coarse Carbon Product Evaluation. The coarse carbon product evaluation will focus on the potential for large volume utilization as kiln fuel, gasification feedstock and combustion fuel. The use of the carbon as an absorbent material will be examined at the CAER.

Eastman will conduct laboratory-scale gasification feedstock evaluation using feedstock requirements for their gasifier. Feed blends will assess the technical feasibility of recycling the coarse carbon product to the gasifier as feedstock comprising 6% by weight of the coarse carbon product with 94% by weight of the feed coal to maintain slurry properties (i.e. solids loading, viscosity, etc.) and gasifier efficiency. Kiln fuel utilization will be conducted by CEMEX and will be based on the fuel requirements of their kilns in eastern Tennessee and central Florida. Fuel evaluation will also consider the impact of the inorganic portion of the carbon (i.e. ash) in the cement manufacturing process.

Combustion utilization will be evaluated at the CAER by proximate and ultimate analyses along with calorimetry and ash fusion. The potential of this product for higher-value applications will also be addressed by the CAER, using a variety of characterization techniques such as surface analyses (BET area and functionality) and porosimetry.

Subtask 3.3 Fine Product Evaluation. The fine product generated from each composite sample will be evaluated for potential use as kiln fuel, kiln feed and gasification feed. Eastman will conduct laboratory gasification feed evaluations while CEMEX will evaluate kiln fuel and kiln feed potential. The CAER and Charah

Environmental will study the dewatering and pelletization/briquetting properties of the materials.

Task 4.0 Environmental Evaluation and Leaching Tests. Products generated in Task 3 will be subjected to leaching analyses using TCLP, batch and column leaching techniques to ensure that utilization will be environmentally safe. Leaching will be conducted in borosilicate bottles with Teflon-lined lids at several liquid/soild ratios and pH values. Leaching times will depend on the particle sizes and will be calculated from an equation in Kosson et al. (2002, p. 167). The measured leachate parameters will include: Al, alkalinity (carbonate species), ammonia, trace elements, cond., nitrate, pH, sulfate and sulfide.

Task 5.0 Process Plant Design. Based on the results of Tasks 1, 2 and 3, a process plant design will be completed to address the specific process needs of the two gasifier sites. The slag processing flowsheet for Tennessee Eastman will be specific to the capacity and product utilization requirements for their by-product generation. For the TECO site, the flowsheet will incorporate any modifications to the existing processing plant that will further enhance utilization. The plant designs will be complete and allow operating cost estimates.

Task 6.0 Proof of Concept (POC) Field Processing Plant. While this proposal addresses utilization of all of the products generated, efforts in this task will be focused on large volume utilization of the product streams prioritized by Eastman and TECO as part of their utilization strategies over the next 5 years. Eastman is primarily concerned with utilizing a high carbon content stream as supplemental recycle feed to the gasifier. TECO is primarily concerned with utilization of the slag product. as their carbonaceous rich char is currently being utilized.

For the Eastman site, a POC plant will be constructed on a flatbed trailer at the CAER and hauled to Kingsport for installation and operation. The POC plant will be operated using a portion of the gasifier by-product as feed for a period of time sufficient to produce ~100 tons of coarse carbon product. During operation of the POC plant, it is estimated that as much as 60 ton of slag product will be generated. The slag product will be stockpiled, characterized and shipped to prospective end-users for testing identified in Task 3. The POC plant will be constructed and operated by the CAER in collaboration with Charah while full-scale recycling of the coarse carbon product will be conducted by Eastman. Testing of the slag product resulting from POC operation will be the responsibility of Charah and prospective end-users.

At the Polk Station, ~ 60 tons of frit along with representative samples, will be retrieved from operation of the existing processing plant. Large-scale utilization options will then be carried out on the bulk frit sample based upon the results achieved in Task 3.

Task 7.0 Large Volume Testing of the Char Material as Gasification Recycle Fuel. The coarse carbon product generated from the field POC plant will be used to conduct full-scale recycling tests using ~100 tons of char, at Eastman. Fuel to recycle char ratios

will be tested over a 3 to 4 day period as determined from the laboratory evaluations. If successful a recycle strategy and a benefication plant that will reduce the amount of disposed solids will result.

Task 8.0 Large Volume Uses of Vitreous Frit in Cement Manufacture. Based on laboratory tests, CEMEX will complete a mix design for its kilns in Tennessee and Florida for the use of the vitreous frit as a feedstock for the manufacture of portland cement. Several hundred tons of frit will then be used in actual kiln operations to produce cement. The thermal properties of the frit in actual kiln operations will be studied as well as the properties of the ground cement clinker.

Task 9.0 Reporting. Reporting will be the responsibility of the CAER with input from all participating organizations. Information deemed proprietary to the gasifier plant owner will be excluded from reports.

D. DELIVERABLES

Periodic reports will be submitted in accordance with the requirements of DOE. A conceptual flowsheet for producing beneficiated products from the gasifier slag at each site also will be generated along with an economic analysis for utilization options at both sites including capital construction and operating costs, as well as revenue streams. A final report will address technical and financial feasibility of implementing all of the utilization strategies investigated.