Utility industries use wooden poles for installation of cables, lights, telephone, and transmission lines. It is estimated that over 250,000 poles are utilized annually varying in height from 30 feet to 40 feet in the Midwest alone. In addition, over 1,000,000 smaller size utility poles (15-30 ft) are utilized. This project involves studies to develop and demonstrate Coal Combustion Byproducts (CCBs) based composite poles to replace wooden poles. The performance of wooden poles (designed using ANSI standards) was used as the benchmark to design the composite poles. Ashland Chemicals, Inc. and Trinity Marine Products Inc. are the industrial cooperators involved with development, manufacturing, and commercialization of the developed pole.

A polymer filled with CCBs forms the foundation material for the composite pole. The developed composite cylindrical pole may consist of a very stiff outer shell containing 5 to 30% CCBs alone (hollow cylinder) or with an inner-core material containing 40 to 60% CCBs (filled cylinder). Several composite pole designs were developed. Research was done to characterize the developed materials and to investigate the effect of fly ash loading percentage, particle size, curing temperature, and post-curing time on engineering properties of the developed materials. To further enhance the stiffness and strength of the pole, fiberglass was added as reinforcement for the outer shell. Model poles, approximately 5-in in diameter and 0.25 in. wall thickness and several flat panels (12 in. x 20 ft x 0.25 in.) were fabricated in Pennsylvania using the developed materials and the fabrication process. Engineering properties of the manufactured poles were systematically characterized through flexural bending test, off-axis tensile and compression tests, burnout test, Fiber Volume Fraction (FVF) analysis, micro/macro-mechanics analysis, finite element analysis, and full-size cantilever bending test. Depending on the elastic modulus of the wooden pole (600,000 to 1,200,000 psi), a cylindrical engineered pole with outer shell thickness of 0.25 to 0.5 in. and outer diameter of 9.5 to 12.5 in. will be comparable to a class-4 wooden pole. Such a pole will weigh 65 to 80% of the corresponding wooden pole. Laboratory testing and field demonstrations of the model poles reveal that CCBs-based composite utility poles have commercial potential to replace wooden poles.
EXECUTIVE SUMMARY

The goal of this cooperative research and development program is to establish technical feasibility of developing and fabricating CCBs-based composite utility poles to replace similar wooden poles. This summary presents an overview of all the work completed to date on the project.

This project involves small-volume, value-added beneficial use of CCBs. The composite cylindrical pole design consists of a very stiff outer shell with or without ultra-lightweight inner core. Each 35 ft pole may use about 40 to 50 lbs of CCBs. Successful development will increase use of CCBs with additional benefits such as: 1). Ground water contamination possibilities due to disposal of CCBs will be minimized. 2). The poles will be fireproof and termite proof. 3). Deforestation for wooden poles and destruction of wooden poles by wild animals will be minimized. 4). Labor cost to install utility cables will be reduced. 5). Water pollution potential due to chemical impregnation in wooden poles will be eliminated.

Over the last three (3) years, with financial support from Illinois Department of Commerce and Economic Opportunity, Illinois Clean Coal Institute, and Combustion Byproducts Recycling Consortium (CBRC), the project team (SIUC, Ashland Chemicals, Inc and Trinity Marine Products) has been engaged in research and development studies to develop CCBs-based composite materials, and design utility poles. More specifically, the project team has achieved the following:

- Developed CCBs-filled polymer composite materials that are suitable for engineered utility poles. These materials may contain about 18% high LOI, as-received FBC fly ash from SIU power plant. The strength and stiffness engineering properties and weathering properties of these filled materials are superior to polymer alone.

- Identified suitable designs for utility poles using these developed materials that will be equivalent to or better than wooden poles. A typical composite pole will weigh about 600 pounds; about 60-65 % of the weight of a wooden pole.

- Developed a commercial production process, and economics of utility pole production in the marketplace. About 30-35% rate of return on investment is indicated.

- Demonstrated the commercial production process in a facility in Pennsylvania to produce 200-feet of about 5-inch diameter and 3/16 inch wall thickness pipe containing 5% and 10% FBC fly ash for engineering performance studies. The CCBs content was limited for process demonstration only. Each 35-foot pole will utilize about 40-50 pounds of fly ash if 5% or 10% FBC fly ash is used.

- Performed engineering performance studies on the fabricated model pole, including ultra-violet degradation, water absorption, strength-deformation properties in tension, compression, and flexure, and full-size cantilever testing.
The results of these studies indicate that commercial production of CCBs-based utility poles is technically, environmentally and economically feasible and should be pursued to meet market needs in the Midwest.

- Installed two 10-foot poles 12-months ago at the Illinois Coal Development Park for weathering studies. To date, no effects of UV degradation have been observed by Ashland staff and the poles look like they are brand new.

- Performed studies to determine if larger amounts of appropriately graded fly ash may be added to develop composites for utility poles fabrication. The results indicate that if fly ash less than 75 microns is utilized instead of as-received fly ash, up to 30% ash may be added to yield composites suitable for utility pole fabrication. Gel time, beyond 20% fly ash addition, increases exponentially but Ashland Chemicals has ability to manage it through suitable chemicals addition. The results above are very important from volume of fly ash used and fabrication cost point of view. This should increase the amount of fly ash used per pole to about 70 pounds.

- Met with four (4) utility companies to seek their input on design, fabrication, and market viability of composite utility poles in the Midwest.

- Trinity Industries has performed an engineering economic evaluation of the project using their standard approaches for such projects. The estimated payback period should be less than 3 years.

- Developed a very strong collaborative project in cooperation with industrial partners. The partners are keen on commercializing the pole production in cooperation with State and Federal agencies.

- Submitted a development proposal to Illinois Clean Coal Institute for development of a facility for commercial production of poles and optimization of fly ash utilization. The proposed project would develop a commercial facility to produce and market full-size (11-12 inch diameter) utility poles. It was proposed that initially 500 -600 feet of full-size utility pole would be produced each day (one-shift operation). The process will utilize 600-700 Lbs of CCBs per shift initially (10% fly ash addition) which may double or triple as the composite materials and production processes are optimized to utilize higher percentages of fly ash. The State has indicated that they will not participate in a commercial venture located outside the State. Alternate approaches for commercialization are being considered. The PI strongly recommends that the state of Illinois participate in some fashion in commercial development of this project.

The remainder of this report contains proprietary information and is not available for distribution except to the sponsor(s) of this project.