Abstract. In recent decades, advances in low NO$_x$ coal combustion technology and increasingly strict CO$_2$ reduction mandates have changed power plant boiler operations quite significantly. As a result, the characteristics of combustion residuals, like fly ash, generated at many power plants have also changed. In particular, increases in unburned carbon content have been observed. Currently, close to 120 million metric tons of coal combustion residuals are produced in the U.S. annually, only 42% of which are productively reused. The elevated residual carbon content decreases the marketability of coal ash as a supplementary cementitious material in concrete – the primary productive reuse sector for coal ash. Additionally, combustion of biomass for energy generation has also received increased attention due to the potential benefits of reducing CO$_2$ emissions, and improved sustainability when compared to fossil fuel combustion. Biomass is directly burned, gasified, or co-fired with coal to achieve this goal. As with coal combustion, production of energy from biomass results in significant byproduct generation that must either be productively reused or geologically disposed. This talk presents results from a study characterizing and investigating productive reuse applications for high carbon content coal and biomass combustion products. These waste materials were investigated for productive reuse in fired bricks, low-cost sorptive agents, and alkali-activated geopolymers for solidification and stabilization applications in geotechnical and geoenvironmental fields.