Introduction to Advanced Combustion

Combustion continues to be the most widespread of human-managed energy conversions. Relatively inefficient combustion devices that harness some of the energy liberated during combustion are inexpensive to build and control. Humans have been using them for millennia. In the absence of carbon separation and capture, combustion of fossil fuels releases large quantities of CO_2 to the atmosphere.

Improving the efficiency of combustion processes has potential for widespread impact on emissions, perhaps with modest capital outlay. Some forms of combustion are already more efficient than others (diesel, for example), but often those efficiency gains come with unwanted side effects (soot, NO_x, etc.). And while combustion is a very mature field, there may still be unexplored combustion regimes which could enable breakthroughs in energy conversion efficiency.

Since its inception, GCEP has conducted advanced combustion research. In 2006, research into advanced combustion informatics and low-oxygen/high-pressure combustion was completed. More recently, investigations of low-irreversibility engines and low-cost combustion sensors were concluded.

Ongoing is a project led by Professor Tom Bowman on the design and optimization of synthetic oxygenated fuels. Such a fuel could enable the high efficiency of diesel engines with very low soot emissions. The team has delineated the relationships between fuel structure and sooting tendencies, and their future work, combined with advances in hybrid vehicle concepts, could make a dramatic impact on greenhouse gas emissions from transportation.

Professor Chris Edwards is pursuing low exergy loss chemical engines. He and his team are taking the reactants for combustion (fuel and air) to states of extreme energy density before combustion is initiated. Thermodynamic reasoning indicates that such a system could be twice as efficient as today's engines, and the apparatus now being constructed will test that theory.