

Introduction to Advanced Combustion

Combustion is, by far, the most common first step in converting the energy stored in chemical bonds to energy services for humankind. Sometimes, it is the only controlled step, but more often, it is part of a longer series of transformations that turn fuels into useful work or other forms of desired energy. Because of its ubiquitous nature and its intimate coupling with carbon-based fuels, even small improvements to combustion technology, if applied across all applications, can have significant impact on total greenhouse gas emissions.

Combustion has become, and will continue to become less detrimental to the environment through the minimization of emissions. Emissions reductions arise from two inter-related phenomena: efficiency improvement and reaction pathway engineering. Improved combustion efficiency (the quantity of fuel required per unit of energy service derived) simply reduces the total amount of material processed by combustion systems, thereby limiting the quantity of potentially harmful effluent. Tailoring the pathway along which reactants are converted into products can minimize the number of environmentally harmful species which might otherwise be generated in the chaotic combustion reaction zone.

The efficiency of combustion is often dependent upon the pathway the reactants take as they are converted to products. This process is rich in complexity, and the body of knowledge surrounding its details is growing rapidly. New sensing technologies allow unprecedented ability to monitor the progress of reaction, while increased computational resources enable prediction of the emissions from new strategies even before they are tested.

GCEP has five active research programs in the area of advanced combustion science (in addition to two programs that have been completed). While Professor Edwards finishes his initial work on the theory of low-irreversibility engines, he and his team have begun work on the design and fabrication of such a device. Professor Bowman, Golden, Hanson and Pitsch are investigating oxygenated fuels for compression-ignition engines which would react along a pathway that minimizes soot formation. Professor Mitchell is researching the means by which coal and biomass particles are converted to gaseous species, and Professor Hanson is developing laser-based diagnostic techniques which could be applied to all of these investigations (and more) as we seek to minimize the impact that combustion has on the environment.