# Dynamic Modelling and Analysis for Global Biofuels Production Considering Market Pricing and Political Uncertainties

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Remaining sources of non-renewable resources, such as fossil fuels, must be used wisely and efficiently. While vast swaths of natural are now accessible due to advances in hydraulic fracturing and technological advances for extracting petroleum out of marginal resources such as tar sands temporarily increase the rate we can extract these resources, they will ultimately deplete. Producing fuels from biomass could pose a renewable alternative to fossil resources, but these technologies are not as mature as their fossil-based counterparts. Furthermore, biofuels production presents additional, different sources of greenhouse gas (GHG) emissions than petroleum fuels production, such as cultivation, feedstock production and pre-processing, and GHG emissions from global land use change (LUC). LUC GHG emissions occur when forests, pastures, etc. are converted to cropland. All or most of the original biomass and some of the soil organic carbon (SOC) and nitrogen are released to the atmosphere as CO2 or N2O. Furthermore, there will be foregone CO2 sequestration that the original biomass would have provided that must also be accounted for. Current models that calculate LUC GHG emissions of biofuels use computable general equilibrium (CGE) models from economics to model global land use change. However, these models are always static and can only provide one snapshot of LUC at a time. Global biofuels production in reality changes from year to year. These changes can have important, dynamic impacts on the LUC GHG emissions of biofuels and should be accounted for in a dynamic CGE-LUC life cycle optimization (LCO) model.

This project will take advantage of previously published work in Process-Energy-Environmental Systems Engineering (PEESE) research group; we have developed a CGE-LUC-LCO modelling framework for biofuels that merges a CGE with a LUC-LCO model for biofuels. Our life-cycle optimization modeling framework identifies a bioconversion pathway with minimum greenhouse gas emissions (GHG) in order to satisfy some biofuel demand (e.g. gasification and upgrading of corn stover to gasoline and diesel). We will consider emissions from LUC, cultivation, feedstock pre-processing, biofuels production, and biomass transportation. However, biofuels production is often impacted by the ever-changing price of crude oil, policies and regulations, and political climates around the world. In order to properly understand the year-to-year anticipated life cycle GHG emissions of biofuels production, such dynamics must be modeled.

The student will develop the currently existing CGE-LUC-LCO modelling framework into a dynamic CGE-LUC-LCO modelling framework. In addition to adding a temporal dimension to the model, specific, dynamic constraints and external market or political uncertainties must also be integrated into the model. The dynamic between crude oil prices and biofuel production will need to be modelled appropriately, possibly with stochastic programming or surrogate modelling. Changes in global biofuel policies, subsidies, and regulations will also need to be modelled either explicitly or probabilistically, again with stochastic programming. The final model will be at least a large-scale nonlinear programming problem or a mixed-integer nonlinear programming problem, which could be very difficult to solve. Novel, tailored solution algorithms may be required.