We discuss how process systems engineering (PSE) studies can facilitate the development of novel strategies for the production of renewable fuels. First, we present process synthesis and technoeconomic evaluation studies for catalytic biomass-to-fuels (liquid hydrocarbons) processes, and illustrate how systems-level analyses can be coupled with experimental heterogeneous catalysis studies to identify promising research directions. Second, we develop a process synthesis framework where complex unit models are replaced with surrogate models built using data generated from process simulators, and discuss the application of the proposed framework to a number of areas. Finally, we present an optimization-based framework for the assessment of biomass-to-fuel production strategies. Specifically, we generate a technology superstructure that consists of a wide range of conversion technologies, and formulate optimization models that allow us to: (i) identify and evaluate alternative promising strategies; (ii) identify the major technological barriers and cost drivers of a given strategy; and (iii) perform sensitivity analysis studies.