Chapter 4
Application of Design of Experiments in Biofuel Production: A Review

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ABSTRACT

Biofuels emerge as an alternative to mitigate climate change. In this sense, four biofuels generations have been proposed to produce clean and renewable fuels. To achieve this, the development of these fuels requires an extensive and rigorous experimental work that will bring optimal results in short time periods. Hence, to accelerate the development of clean fuels, the Design of Experiments (DoE) methodologies are a useful tool to improve the operational conditions such as temperature, time, pressure, and molar ratios. Several authors have studied and optimized the different biofuel production systems using Factorial Designs and Response Surface Design methods and statistical analysis with reliable results. This chapter reviews and classifies the results obtained by these investigations and demonstrates the scopes and limitations of the application of DoE.

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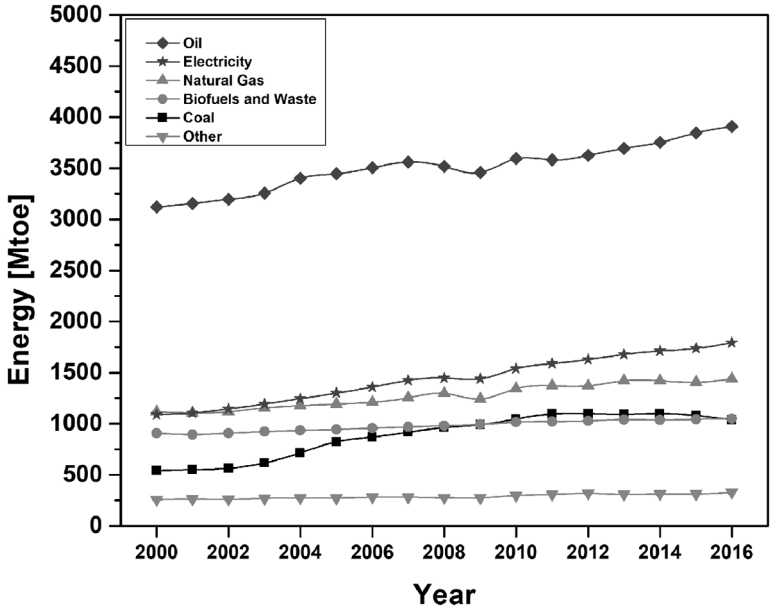
Figure 1. World TFC by fuel (♦) Oil, (∗) Electricity, (▲) Natural Gas, (●) Biofuels and Waste, (■) Coal, (▼) Other, from 2000 to 2016. Adapted from (IEA, 2019b)



INTRODUCTION

Biofuels

The constant growth of the world population has caused the increase on demand for energy. Industry and transportation sectors are the most end-use energy consumption in the world which require a large amount of liquid fuels. In this way, the combustion of fossil fuels has led to the emission and accumulation of greenhouse gases (GHG) causing negative effects to environment, such as global warming. Therefore, to mitigate the GHG emissions and eventual depletion of petroleum, new technologies and infrastructure have been developed to produce sustainable, efficient, economically viable and renewable sources of liquid fuels (H. Chen et al., 2017).On this basis, the use of renewable energy sources has presented a growth of 2.8% annually since 2008 and it is expected to increase according to the objectives of The Paris Agreement in 2016 (Paris Agreement, 2016). However, the global energy and economics are still based in fossil fuel utilization. Petro-oil represents the highest consumption of energy available for final use in industry transport and home (Total Final Consumption, TFC), compared with other energy sources, followed by electricity and natural gas as Figure 1 exhibits.

Within the alternative energy sources, biomass transformation into energy is an important option to consider. Biomass from crops and agroindustry residues can be converted into biofuels which are a suitable and ecological friendly option since they are inexpensive, clean, sustainable and they could improve the rural economy (Sunde, Brekke, & Solberg, 2011). Also, the emitted CO_2 can be reintegrated into the carbon cycle by photosynthesis and it can be mixed with fossil fuels as additives which would reduce SOx and NOx emissions. According to the International Energy Agency (IEA), it is expected that biofuels may provide the 27% of the world transportation fuel by 2050, which means that nearly 3 billion