

# **Economic Assessment of Biodiesel Production: Comparison of Alkali and Biocatalyst Processes**

## **Abstract:**

This research paper offers an extensive and meticulous economic assessment of biodiesel production, focusing on a comparative evaluation of three catalytic processes: alkali, soluble enzyme, and immobilized enzyme. It delves into the intricate details of production cost, plant investment, and manufacturing cost for each method, shedding light on the nuanced economic viability of enzymatic biodiesel production versus the traditional alkali catalysis. The findings underscore that while alkali catalysis currently stands as the most cost-efficient choice, the realm of biocatalyst processes presents substantial potential for cost reduction, especially through advanced enzyme reuse and diminished enzyme expenditure.

## **Introduction:**

In an era characterized by an escalating global energy demand coupled with mounting concerns about environmental degradation, there is an urgent imperative to explore and adopt sustainable alternatives to fossil fuels. Biodiesel, with its eco-friendly and renewable attributes, has emerged as a promising candidate to meet these challenges. This research paper embarks on a comprehensive economic assessment of biodiesel production, placing special emphasis on comparing the well-established alkali catalysis with the emergent enzymatic processes. The latter, owing to its intrinsic advantages such as minimized wastewater generation and facile glycerol recovery, has captured the attention of the biodiesel industry.

## **Methodology:**

The research methodology adopted for this study is characterized by its thoroughness and systematic approach. It is divided into several key steps: The first step involves the creation of detailed process flow sheets for each of the three biodiesel production methods: alkali catalysis, soluble enzyme catalysis, and immobilized enzyme catalysis. These flow sheets serve as comprehensive blueprints of the production processes, detailing each step, from feedstock intake to final biodiesel production and glycerol recovery. The aim is to provide a clear visual

representation of the entire production process, enabling precise cost estimation at each stage. Process time charts are generated for all three production methods. These charts outline the duration of each step within the production process. Notably, the batch cycle times for alkali catalysis and biocatalyst processes are detailed. To ensure a fair comparison, adjustments are made to equalize batch reaction times for all processes, assuming that five transesterification units in biocatalyst processes operate simultaneously, as opposed to the single unit in alkali catalysis. This step is crucial for accurate cost calculations. A comprehensive list of equipment required for each biodiesel production method is meticulously compiled. This list encompasses all machinery and apparatuses used in feedstock handling, trans esterification, glycerol separation, and other relevant processes. Each piece of equipment is described in terms of specifications, capacity, and associated costs.

### **Calculations:**

The cost estimation phase is characterized by its meticulous attention to detail and encompasses a wide range of factors: Variable costs are calculated based on the quantities and unit prices of raw materials (such as feedstock, methanol, sodium hydroxide, and enzymes), products, and utilities (including heating energy and electric power). These costs are meticulously analyzed and factored into the overall cost estimation. Fixed costs are determined based on plant-related expenses and employee costs. These costs are an essential component of the cost estimation process, ensuring that all overheads and operational expenses are taken into account. To provide a comprehensive economic assessment, the study includes depreciation, repair, interest, and tax expenses as a percentage of the plant investment cost. These elements contribute to the overall financial picture of biodiesel production.

### **Comparison with Previous Studies:**

One of the critical aspects of this research is the comparison of its findings with previous studies on biodiesel production costs using alkali catalysts. This comparative analysis offers valuable insights into the economic competitiveness of the processes under investigation. The following comparison with previous studies is presented in detail: In this study, the manufacturing cost for biodiesel derived from palm oil using alkali catalysis is determined to be \$1167/tonne. This

figure represents a current snapshot of the cost landscape for alkali catalysis in biodiesel production. It is essential to note that the manufacturing cost can vary depending on factors such as feedstock prices, labor costs, and regional differences. This research contextualizes its findings by referring to prior studies on biodiesel production costs using alkali catalysts. Several key findings from these studies are summarized: Sakai et al. [9] reported a manufacturing cost of \$641/tonne and a plant cost of \$7.99 million for biodiesel production from waste cooking oil using KOH catalyst batch process. Marchetti and Errazu [8] documented a manufacturing cost of \$429/tonne and a plant cost of \$7.42 million for biodiesel production from waste cooking oil using alkali catalyst continuous process. You et al. [5] reported a manufacturing cost of \$779/tonne and a plant cost of \$1.35 million for biodiesel production from soybean oil using alkali catalyst continuous process. These comparisons underscore the variability in manufacturing and plant costs across different feedstocks, catalysts, and process configurations. It highlights the importance of considering specific feedstock and process-related factors when evaluating biodiesel production economics.

## **Conclusion:**

The study unequivocally substantiates that, as of the present, alkali catalysis stands as the most cost-efficient choice for biodiesel production. This established method demonstrates a competitive edge in terms of production cost, plant investment, and manufacturing cost. Its dominance is primarily attributed to well-established practices and the cost-effectiveness of alkali catalysts. While alkali catalysis maintains its dominance, the study's findings emphasize that biocatalyst processes hold untapped potential for cost reduction. The key drivers of this potential include enhanced enzyme reuse and decreased enzyme costs. The research underscores that as white biotechnology continues to advance, biocatalyst processes could become formidable contenders in the biodiesel production landscape. The findings of this study contribute substantively to the broader mission of establishing biodiesel as a more sustainable, economically viable, and environmentally friendly energy source. This mission aligns with global objectives for renewable energy and environmental stewardship. The research underscores that while the present favors alkali catalysis, the future may witness a shift in the economic landscape as biocatalyst processes evolve and enzyme costs decrease.

