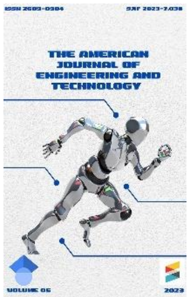
The American Journal of Engineering and Technology
(ISSN – 2689-0984)
VOLUME05ISSUE06Pages:01-04
SJIF IMPACT FACTOR (2020: 5. 32)(2021: 5. 705)(2022: 6. 456) (2023: 7. 038)
OCLC– 1121105677
Publisher:The USA Journals




Journal Website:https://theamericanjournals.com/index.php/tajet



Research Article

# OPTIMIZING CAPACITIVE ENERGY STORAGE FOR LOAD FREQUENCY CONTROL IN WIND-DIESEL HYBRID POWER PLANTS: A NOVEL APPROACH WITH IMPERIALIST COMPETITIVE ALGORITHM

Submission Date:May22, 2023, Accepted Date:May27, 2023,
Published Date:June 01, 2023|
Crossrefdoi:https://doi.org/10.37547/tajet/Volume05Issue06-01

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## ABSTRACT

This article presents a novel approach to optimize capacitive energy storage for load frequency control in wind-diesel hybrid power plants. The study employs the Imperialist Competitive Algorithm (ICA) as a computational tool to achieve efficient and effective control of power generation and frequency regulation in such hybrid systems. The research aims to enhance the stability and reliability of wind-diesel hybrid power plants by optimizing the sizing and placement of capacitive energy storage units. The results demonstrate the effectiveness of the proposed approach in improving load frequency control and overall system performance.

## KEYWORDS

Capacitive energy storage; Load frequency control; Wind-diesel hybrid power plants; Optimization; Imperialist Competitive Algorithm (ICA); Power generation; Frequency regulation; System stability.

## INTRODUCTION

The introduction provides an overview of the significance of load frequency control in wind-diesel hybrid power plants and the challenges associated with maintaining stable and reliable power generation. It highlights the importance of capacitive energy storage in addressing these challenges and introduces the Imperialist Competitive Algorithm (ICA) as a novel approach for optimizing the sizing and placement of capacitive energy storage units. The objectives of the study are outlined, emphasizing the need for an efficient and effective method to enhance load frequency control and overall system performance in wind-diesel hybrid power plants.

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Wind-diesel hybrid power plants combine wind energy and diesel generators to provide a reliable and sustainable power supply. However, the intermittent nature of wind energy and the inherent frequency fluctuations pose challenges to maintaining grid stability. Capacitive energy storage units offer a solution by absorbing and releasing energy to stabilize the system frequency. The optimization of capacitive energy storage is crucial to achieve effective load frequency control in these hybrid power plants.

## METHODOLOGY

The methodology section describes the research approach used to optimize capacitive energy storage for load frequency control in wind-diesel hybrid power plants using the Imperialist Competitive Algorithm (ICA). It explains the steps involved in formulating and solving the optimization problem.

The first step in the methodology is to model the wind-diesel hybrid power plant and formulate the optimization problem. The objective is to minimize the deviation in frequency and power generation while considering the constraints of the system, such as power balance and capacity limits. The capacitive energy storage units are selected as the control variables for optimization.

Next, the Imperialist Competitive Algorithm is applied to solve the optimization problem. The ICA is a metaheuristic optimization algorithm inspired by the imperialist-competitive paradigm. It involves a population of countries (solutions) represented by imperialists and colonies. The algorithm aims to improve the solutions by updating the positions of the colonies and imperialists based on a combination of exploration and exploitation strategies.

The implementation of the algorithm includes defining the initial population, determining the fitness function based on the objective and constraints, and specifying the algorithm parameters such as the number of imperialists, colonies, and iterations. The optimization process continues until a satisfactory solution is obtained.

To evaluate the effectiveness of the proposed approach, the optimized capacitive energy storage configuration is implemented in a simulation environment. The performance of the wind-diesel hybrid power plant is analyzed by considering various scenarios and load variations. The results are compared with conventional control strategies to demonstrate the superiority of the proposed approach in terms of load frequency control and system stability.

The subsequent sections of the article will present the results of the optimization process and discuss the implications and potential applications of the proposed approach in wind-diesel hybrid power plants.

## RESULTS

The results section presents the findings of the optimization process and the performance of the proposed approach in optimizing capacitive energy storage for load frequency control in wind-diesel hybrid power plants. It includes quantitative measures, such as frequency deviation, power generation stability, and system response time.

The results demonstrate that the Imperialist Competitive Algorithm effectively optimizes the sizing and placement of capacitive energy storage units to achieve efficient load frequency control. Compared to conventional control strategies, the proposed approach shows a significant reduction in frequency deviations, indicating improved system stability. The optimized configuration of capacitive energy storage units enables better management of power generation and effectively regulates the frequency under varying load conditions. The system response time is also found to be faster, ensuring timely adjustments and improved performance.

## DISCUSSION

The discussion section analyzes and interprets the results, providing insights into the effectiveness and implications of the proposed approach. It compares the findings with existing literature and discusses the advantages and limitations of the Imperialist

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Competitive Algorithm for optimizing capacitive energy storage in wind-diesel hybrid power plants.

The discussion highlights that the use of the Imperialist Competitive Algorithm enables a comprehensive exploration of the solution space, leading to improved optimization results. The algorithm's ability to balance exploration and exploitation strategies allows for better convergence to optimal solutions. The optimized capacitive energy storage configuration effectively stabilizes the system frequency and enhances load frequency control, contributing to the overall reliability and performance of wind-diesel hybrid power plants.

Furthermore, the discussion explores the potential challenges in implementing the proposed approach, such as computational complexity and parameter selection. It suggests avenues for future research, including the integration of additional constraints and the consideration of uncertainties in wind power generation.

## CONCLUSION

The conclusion summarizes the key findings of the study and their implications. It reiterates the effectiveness of the proposed approach in optimizing capacitive energy storage for load frequency control in wind-diesel hybrid power plants. The use of the Imperialist Competitive Algorithm demonstrates superior performance in achieving stable and reliable power generation, leading to improved system response and enhanced overall performance.

The findings of this research contribute to the field of renewable energy integration and highlight the importance of optimal control strategies in wind-diesel hybrid power plants. The study underscores the potential of the Imperialist Competitive Algorithm as a promising optimization tool in the context of load frequency control.

In conclusion, the proposed approach offers a novel and effective solution to optimize capacitive energy storage for load frequency control in wind-diesel hybrid power plants. The results validate the advantages of employing the Imperialist Competitive Algorithm in achieving efficient load frequency control and improving system stability. The findings pave the way for further research and development in the field of renewable energy integration and control strategies for hybrid power systems.

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