

<https://doi.org/10.7250/CONNECT.2024.051>

# NATURE-INSPIRED WIND FARM LAYOUT OPTIMIZATION: HARNESSING SMART PATTERNS FOR SUSTAINABLE ENERGY

Jaydeep Patel<sup>1\*</sup>, Vivek Patel<sup>2</sup>, Garlapati Nagababu<sup>3</sup>

<sup>1-3</sup> Pandit Deendayal Energy University, Gandhinagar, Gujarat, India

\* **Corresponding author.** Email address: jaydeppatel028@gmail.com

**Abstract** – This research investigates the transformative realm of wind farm layout optimization, with a specific focus on harnessing the efficiency of bio-inspired patterns. The positioning of wind turbine plays a vital role in maximizing the energy output of a wind farm. If a wind turbine is placed in the wake region of the upstream turbine, the energy produced by the downstream turbine is reduced. Hence, it is imperative to place turbines in such a way that effect of the wake is minimum on a performance of turbines. The conventional grid-based approaches, commonly employed in wind farm layouts, face limitations in capturing the inherent complexity of wind flow dynamics, especially in varied terrains. In contrast, bio-inspired layouts, inspired by patterns observed in natural ecosystem, offer the promising results over the conventional Grid based approach. Our investigation involves the development and implementation of a novel bio-inspired wind farm layout positioning pattern. In the proposed approach, various nature inspired patterns, such as honeycomb and sunflower seeds pattern, is explored for the turbine positioning. Further, the approach includes the modelling of wind behaviour in terms of both uniform wind speeds and variable wind speeds originating from all directions. The modified passing vehicle search (mPVS) optimization algorithm is used for optimizing the wind turbine placement. The results are obtained for the different wind scenarios and compared with the available results in the literature. The anticipated outcomes of this research include a deeper understanding of the potential benefits and challenges associated with bio-inspired wind farm layouts. The findings aim to contribute valuable insights into optimizing wind turbine placements, maximizing energy capture, and fostering sustainable practices in the wind energy sector. Results show that the turbine positioning in the proposed bio inspired pattern produces higher power output (6 %) compared to the conventional grid-based approach. Hence, it can be concluded that the approach present in this study can assist wind farm designers and developers in optimally placing turbines for better performance.

**Keywords** – *Energy system optimization; nature inspired pattern; wake deficit; wind farm layout; wind farm layout optimization*