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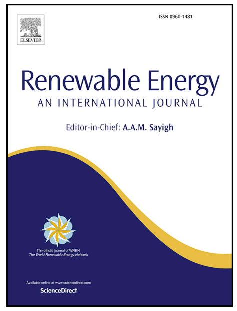

Decomposition based multi-objective evolutionary algorithm for windfarm layout optimization

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Multi-objective evolutionary algorithm based on decomposition (MOEA/D) for windfarm layout optimization

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Abstract: An efficient windfarm layout to harness maximum power out of the wind is highly desirable from technical and commercial perspectives. A bit of flexibility on layout gives leeway to the designer of windfarm in planning facilities for erection, installation and future maintenance. This paper proposes an approach where several options of optimized usable windfarm layouts can be obtained in a single run of decomposition based multi-objective evolutionary algorithm (MOEA/D). A set of *Pareto* optimal vectors is obtained with objective as maximum output power at minimum wake loss i.e. at maximum efficiency. Maximization of both output power and windfarm efficiency are set as two objectives for optimization. The objectives thus formulated ensure that in any single *Pareto* optimal solution the number of turbines used are placed at most optimum locations in the windfarm to extract maximum power available in the wind. Case studies with actual manufacturer data for wind turbines of same as well as different hub heights and realistic wind data are performed under the scope of this research study.

Keywords: Wind turbine data · Windfarm turbine placement · Power output · Efficiency · Multi-objective evolutionary algorithm · Hub heights.

1. Introduction

Enormous growth in renewable energy is anticipated in electric sector for a sustainable future and for stricter norms imposed on carbon emission. A popular, fast growing form of naturally replenished renewable energy is the wind energy where the power in the wind is extracted by the turbine through rotation of its blades. Wind turbines, in general, are installed in a cluster at a potentially windy site. However, careful study and judgement are pre-requisites to place the wind turbines in a windfarm as wake loss induced by upstream turbines affect the output of downstream turbines, thereby reducing total power output from the windfarm. Mosetti *et al.* [1] proposed binary coded genetic algorithm (GA) to optimize windfarm layout with objective of minimizing cost per unit power output (e.g. cost per kW) from the windfarm. Grady *et al.* [2] improved the results employing same method but with higher number of generations. Mittal [3] in his research showed fine grid spacing in windfarm could further increase the power output. Emami *et al.* [4] took weighted sum approach of the objective function consisting of both cost and power. Marmidis *et al.* [5] adopted Monte Carlo simulation method to study single objective of cost per unit power output for simplest wind condition. Binary particle swarm optimization with time varying acceleration coefficient (BPSO-TVAC) in ref. [6] showed competitive results on windfarm layout optimization with objective of cost per kW. Literature [7] performed the same layout optimization using linear population size reduction technique of success history based adaptive differential evolution (L-SHADE) algorithm and claimed to have obtained best results among comparable studies on single objective optimization. Ant colony optimization (ACO) algorithm, a co-operative agent approach was proposed in [8]. Greedy algorithm with consideration of levelized cost of energy (LCOE) was studied in [9]. Literature [10] performed windfarm layout optimization using same greedy algorithm for multiple hub heights of wind turbines. Global windfarm cost model incorporating initial investment and yearly income on net generated energy was established in [11]. Analytical modelling of windfarm with multi-level extended pattern search was presented in [12]. All these literatures considered optimization of single objective of either maximizing power output or minimizing cost per kW. Furthermore, literatures [1-8] adopted simplified cost model proposed in [1] where cost was considered to be a function of only number of turbines in the windfarm. Ref. [13] performed case studies to maximize windfarm efficiency with different rotor diameters and hub heights. In summary, literatures on windfarm layout optimization mostly consider varying single objective, sometimes alongwith simplified cost model.

Multi-objective genetic algorithm (MOGA) based optimization of windfarm is proposed by Chen *et al.* [14]. However, the authors in [14] have focused only on a specific value of installed capacity. In other words, mainly

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