Optimization for Onshore Wind Farm Cable : Connection Layout using Ants Colony Optimization and Weiszfeld algorithm

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1 Introduction

The wind farm layout optimization problem is similar to the Steiner Minimal Tree Problem (SMTP) of a weighted undirected graph. Due to the cable current-carrying capacity limitation, the cable sectional area should be carefully selected to meet the system operational requirement and this constraint should be considered during the SMTP formulation process. Hence, the traditional SMTP algorithm cannot ensure a minimal cable investment layout. In this paper, a hybrid algorithm based on modified Ants Colony Optimization (ACO) and Weiszfeld Algorithm (WA) [1] for solving SMTP is introduced. Since the Steiner Tree Problem is NP-hard, we design an algorithm to construct high quality Steiner trees in a short time which is suitable for real time multicast routing in networks. After the breadth - first traversal of the minimal graph obtained by ACO, the terminal points are divided into different convex hull sets, and the full Steiner tree is structured from the convex hull sets partition. The Steiner points can be slotted by WA to get an optimal graph. The average optimization effect of WA is shorter than the minimal graph obtained using ACO, and the performance of the algorithm is shown. We give an example of application in optimization for onshore wind farm cable. The possibility of using different sectional area's cables is considered in this paper.

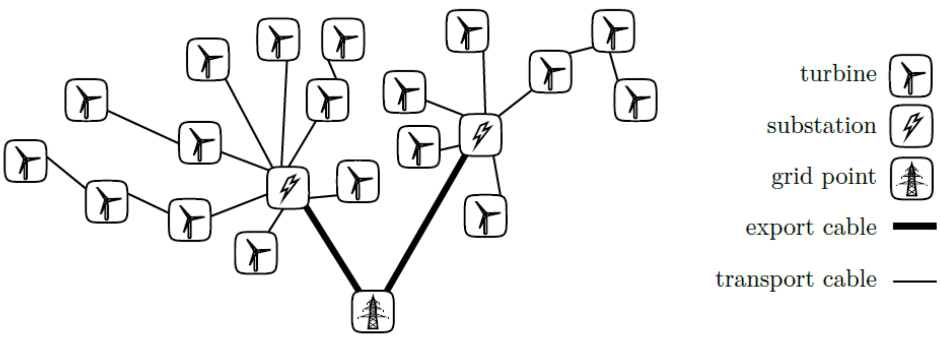

FIG. 1 – Structure of a Wind Farm

A typical wind farm contains a group of wind turbines, substations and grid points which are connected by a cabling system (see Figure 1). The turbines are driven by wind wheels and convert wind's kinetic energy into electrical power. This electrical energy is transferred by the cabling system to a substation collecting the electrical power of a group of turbines. The substation transforms the electrical energy to alternating current with a high voltage level to minimize transport energy loss. All substations are connected to a grid point, which is the entry of the general power grid.

1.1 Cost Model

The cost models are set up according to cables rated power. The mathematical equations can be written as follows [3] :

$$C_i = A_p + B_p \exp\left(\frac{C_p S_{\text{rated},i}}{10^8}\right)^2 \tag{1}$$

$$S_{\text{rated},i} = \sqrt{3} I_{i,\text{rated}} U_{i,\text{rated}} \tag{2}$$

where C_i [MMD/km] is unit cost of cable i, A_p , B_p and C_p are coefficients of cable cost model. $S_{rated,i}$, $I_{i,rated}$ and $U_{i,rated}$ are respectably, rated apparent power, rated current and rated voltage of a cable in line i.
After the voltage level is decided, the cables are selected according to their rated current which is correlated to the sectional area. The cable types are selected according to an existing cable list in [3]. In some cases, more cables are required between two Wind Turbines (WTs) if many are connected after a branch.

2 Conclusions et perspectives

This paper proposes a new approach for wind farm electrical system design. The introduced approach is capable of finding the optimal wind farm cable route in a short time and with less computational effort comparing to exact methods, such as Kruskal and Prim Algorithms [2]. The possibility of using different cables sectional area is also considered in this paper. Our results show that the proposed algorithms can be used to generate a design that has a lower cost in terms of investment and energy.

Références

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