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Wind atlas of Chanthaburi and Trat provinces, Thailand

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Abstract

The Ministry of Energy of Thailand has established a target of wind energy production of 1,800MW in 2021; currently, there are only 222.71MW (12.4%) generated. Therefore, determining the optimal regions for wind farm construct to increase the capacity of wind energy production is required. An economical solution method is to apply numerical simulations of computational fluid and dynamic (CFD) techniques on specific regions. This paper presents wind simulations for a high-resolution wind atlas of Chanthaburi and Trat as a case study. The resolution of the simulations can resolve mesoscale and microscale characteristics using computational fluid dynamic (CFD) techniques. The wind data were derived from MERRA for a period of 5 years. The highest resolution is 200 meters (m) in the represented area, where the potential for wind power generation is determined by using nest techniques. The results are compared with the actual observed average wind speeds from local wind stations. The simulation results demonstrate that areas located between 40-100m above the ground have the potential to generate electricity. Three potential areas with average wind speeds of over 6 m/s are proposed; (1) Kao-Soy Dao; (2) The area between Muang Chanthaburi and Muang Khlung; (3) Chang Island.

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Keywords: wind mapping; wind assessment; wind simulation; CFD; wind energy potential;

1. Introduction

Wind power is a natural clean energy to generate electricity. Currently, wind power is widely used to generate electricity with low pollution. The limitations of wind to generate electricity are wind speed and direction. To determine appropriate locations, wind measuring equipment has been installed at sites to record wind data. The investment of a wind station is a risk and costly.

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The Ministry of Energy Department of Alternative Energy Development and Efficiency [1] has announced the target of 1,800 Mega Watt (MW) of electricity produced by wind power within 2021. Currently, wind power only generates 222.71 MW, which is only 12.4% of the target. Therefore, wind power infrastructure must be continuously developed to achieve this target. Wind farms in Thailand have been installed in multiple regions, including Central, Northeastern, and Southern Thailand, but not yet in Eastern Thailand. This research considers two potential provinces located in eastern Thailand: Chanthaburi and Trat. The geography of both provinces includes a coastline along the gulf of Thailand.

In Thailand, a local wind atlas has been simulated since 2001 at a low resolution of 1 km [2]. However, the detail in certain areas is not sufficient to indicate whether wind farm construction is appropriate. The purpose of this research is to determine potential areas of establishing wind farms in the The Chanthaburi and Trat provinces. The computer simulations were performed using a finer resolution of 200 m and the computational fluid dynamic (CFD) technique. The wind data were obtained from MERRA [3] for a period of 5 years (2008-2012).

2. Methodology

In this paper, WindSim software is employed. WindSim is based on CFD, which involves heat transfer and fluid transfer phenomena [4]. WindSim has the same solution as ordinary CFD which consists of three main parts: 1) the pre-processor; 2) the solver; 3) the post-processor. WindSim is a finite volume method based on the PHOENICS code. The model is based on the Reynolds Averaged Navier-Stokes equations for an incompressible flow. They do not establish an explicit relationship between the variables of interest [5], but rather they establish associations of rates of change that link the variables. A solution of the Navier-Stokes equations is called a velocity field and describes the velocity of the fluid at a point in time.

In WindSim, the stability is generally dependent on the vertical wind speed profile at the inlet, and also on the vertical wind profile and explicit calculation of temperature to include buoyancy effects inside the simulation area by adding the Boussinesq approximation and an additional term using MERRA data, which consist of temperature data from sea level. The boundary conditions in WindSim at the top layer, which is the geostrophic domain where the wind speed profile is constant, are set to match with the height of the geography model. Another parameter to set is the boundary condition at the top; this could be set to a fixed pressure condition for complex terrain or a frictionless wall, which is suitable for flat terrain; the fixed pressure condition is selected in this simulation considering the topography of the study area.

Modeling of both ,mesoscale and microscale processes was performed, using a large provincial map and actual wind data collected over a long period to ensure that the microscale simulation was as accurate as possible. The preliminary mesoscale simulation used topography data, roughness data, and 5 years wind data.

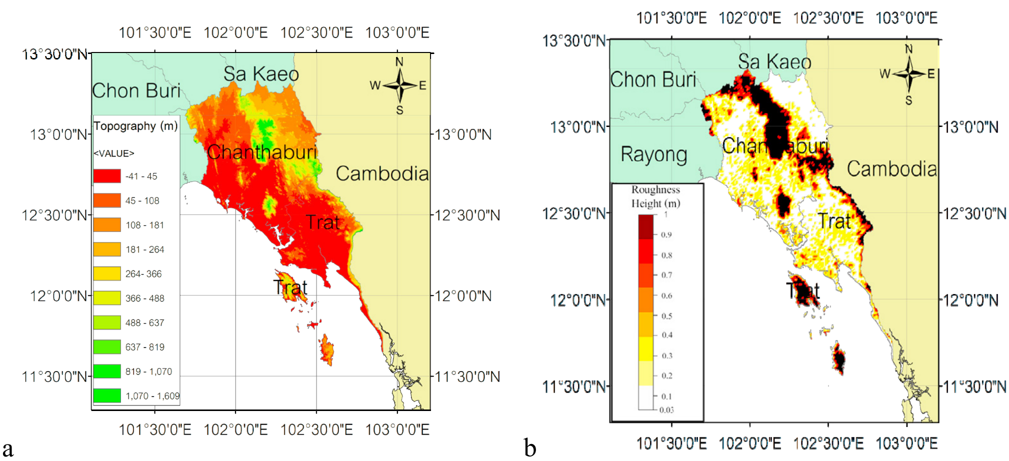

Fig. 1. (a) Topography; (b) roughness height of the Chanthaburi and Trat provinces.