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# Wind Energy Projection for the Philippines Based on Climate Change Modeling

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**Abstract**

To complement the existing method of wind energy assessment, this study presents wind energy projection by downscaling a regional climate model, RegCM3, which is also used in predicting rainfall and temperature changes, and using a conversion method using the Weibull distribution. A couple of papers which used long-term predicting models focused on two regions, China and the US High Plains, show a decrease of about 14% and 7%-17% respectively in wind power density due to global warming over the next century. This paper focuses on a smaller grid size of 10 km x 10 km to concentrate on a specific wind farm in Pililla, Rizal, Philippines which is considered as a commercially feasible site by wind developers. Wind energy projection that considers the effects of climate change for the expected period of operation of 25 years is used because this gives wind developers an outlook on the power production during the wind farm's lifetime and would contribute in determining the wind farm's potential for financial returns. Percentage difference of wind power density between the baseline period of 2008-2012 and five-year projection periods from 2013-2037 are presented. Contrary to the results of studies in China and western US, the results of this research show that there is an average five-year period increase of 6% in wind power density in Pililla, Rizal over the next 25 years.


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*Keywords:* wind energy assessment, climate change, wind projection

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## 1. Introduction

The step to move toward cleaner sources of energy has been driven by the noticeable changes in climate due to global warming. "Going green" by preferring wind energy is one of society's approaches to combat climate change. However, wind energy is very much dependent on the wind and monsoons, which are also affected by climate change. With this cycle where wind energy is a solution for climate change but climate change could affect wind energy resource, this paper attempts to answer the following question: How would climate change affect the future of the wind industry?

In China and the United States, wind energy projection studies using climate models were conducted. Ren [1] used eight regional climate models and concludes that there is a decrease in wind power density by approximately 14% from 2071 to 2100 in China. For US Western High Plains, Greene et al. [2] presents in his paper that there will be a decrease of 7% to 17% for the years 2040-2070 when using the North American Climate Change Assessment Program (NARCCAP) model.

A study by National Renewable Energy Laboratory (NREL) [3] shows that the Philippines has a wind potential installed capacity of 76.6 GW. Because of this high potential of wind energy in the country, wind energy developers are interested in commercial wind energy in the Philippines. Most of the projects of these wind energy developers are in the northern portion of the Philippines, where the Northeast Monsoon is expected to provide good wind energy yield. There are also other areas in the Philippines that also show favorable wind potential such as Guimaras and Rizal.

Different from studies in China and US Western High Plains, this paper uses a smaller resolution of 10 km x 10 km grid to focus on a location with a potential for a commercial wind farm operation in Pililla, Rizal, Philippines.

## 2. Projected wind results

The work uses the International Centre for Theoretical Physics (ICTP) Regional Climate Model version 3 (RegCM3) [4] to make projections for the wind fields at Pililla, Rizal. This model is a hydrostatic model that uses finite differencing method. The wind fields are determined by calculating the following momentum equations:

$$\frac{\partial p^* u}{\partial t} = -m^2\left(\frac{\partial p^* uu/m}{\partial x} + \frac{\partial p^* vu/m}{\partial y}\right) - \frac{\partial p^* u\dot{\sigma}}{\partial \sigma} - mp^*\left(\frac{RT_v}{p^* + p_t/\sigma}\frac{\partial p^*}{\partial x} + \frac{\partial \phi}{\partial x}\right) + fp^* v + F_H u + F_V u \quad (1)$$

where $u$ and $v$ are the eastward and northward component of wind velocity, $T_v$ is virtual temperature, $\phi$ represents geopotential height, $f$ is the coriolis parameter, $R$ is the gas constant for dry air, $m$ is the map scale factor. $F_H$ and $F_V$ are the horizontal and vertical diffusion, respectively. In Eq. (1), $\sigma$, $\dot{\sigma}$ and $p^*$ are defined by these relations: $\sigma = (p - p_t)/(p_s - p_t)$, $\dot{\sigma} = d\sigma/dt$ and $p^* = p_s - p_t$ where $p$ is the pressure, $p_s$ is the surface pressure and $p_t$ is a specified constant top pressure.

Similar to Eq. (1), the north-south wind vectors are governed by the following equation:

$$\frac{\partial p^* v}{\partial t} = -m^2\left(\frac{\partial p^* uv/m}{\partial x} + \frac{\partial p^* vv/m}{\partial y}\right) - \frac{\partial p^* u\dot{\sigma}}{\partial \sigma} - mp^*\left(\frac{RT_v}{p^* + p_t/\sigma}\frac{\partial p^*}{\partial y} + \frac{\partial \phi}{\partial y}\right) + fp^* u + F_H v + F_V v$$