PRE-FEASIBILITY STUDY OF WIND ENERGY RESOURCES IN MYANMAR

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Abstract

In this study, the wind power density of MERRA analysis data for weather and the ASTER DEM 30m enhanced with satellite data for terrain elevation are employed as input data to get wind resources distribution in Myanmar with the simulation of ArcMap 10, ArcGIS software. The simulated result shows that Yakhine State, Ayeyarwaddy, Yangon and Tanintharyi Regions are the best wind resource regions in Myanmar from the output color-coded wind power density map at 50m above ground level, of which the wind power density ranges from 80-126W/m^2 in some part of these regions; while the better wind resource regions are: Sagaing, Mandalay, Magway Regions and Mon State, the wind power density ranges from 20 to 80 W/m^2. The overall output of wind power density map shows the highest in the south and southwest coastal area in Myanmar.

Keywords: Myanmar, Wind energy, Wind power density map

Introduction

Since the power output of wind turbine is proportional to the cube of wind speed, the statistics data of wind speed is important for wind energy application. To identify the wind energy potential, high-quality wind measurement data is necessary. An accurate determination of wind climatology is taken into account of seasonal and year-to-year variations of the wind conditions; therefore, record data for several full years must be used in the analysis of wind resources such as Reference [1-7]. In power generation from wind, wind resource assessment is one of the most important requirements to be successful implementation of wind power projects and to understand how much wind resources available at a place for proper site selection. Most of countries have being predicted wind energy resource of the country to be useful for wind energy planning. However, in some parts of the world, including Myanmar, there are only available poor wind data. For example, Myanmar has not experienced widespread wind energy development yet due to the lack of sufficiently reliable surface wind measurements from tall tower. Hence, wind resource assessment study is crucial role to understand the overall wind resource and its characteristics for every country. If there is no measuring wind data in some country, statistical downscaling from large scale reanalysis produced by met office (ECMWF, NCEP/NCAR & MERRA) can be used for preliminarily. Therefore, in this study, preliminary wind atlas for Myanmar is provided by MERRA reanalysis data set for the first overview the statistic data across the whole country. An accurate wind resource assessment is highly dependent on the quantity and quality of the input data. For pre-feasibility on wind Atlas of Myanmar, the data inputs include terrain elevations (ASTER DEM 30m) and meteorological data (MERRA). The result of the simulation is presented in color-coded maps of wind power density using ArcGIS software tools. Refer to the result wind atlas, the regions with highest potential will be defined and given recommendations on the regions which should be developed and where measurement masts need to be installed. Therefore, this pre-feasibility study on wind energy is of high importance for Myanmar and will give a clear picture to the zones with the highest wind potential. This study also hope to provide preliminary wind resources assessment method not only Myanmar but also some other countries which has no real measuring wind data.

Status of Wind Resource Study in Myanmar

Myanmar has many hilly regions in rural areas and costal region of 2832 km strip, which are promising areas to harness wind energy sources. The promising areas to harness wind energy sources are the hilly regions of Chin and Shan State, Coastal region of 2832 km facing to the Bay of Bengal and the Andaman Sea and Central Myanmar region. Generally, wind pattern in Myanmar is not regular and low in capacity to produce sustainable energy at the current availability of technology. For this reason, it is important to find the proper and optimize site-selection.

Up to now, Myanmar has not been self-standing subject of extensive wind resource studies. Nevertheless, Department of Physics at Yangon University and the Department of Electric Power (DEP) and MEPE (Myanmar Electric Power Enterprise) at the MOEP (Ministry of Electric Power) were conducted research and development of wind energy in cooperation with the New Energy and Industrial Technology Development Organization (NEDO) of Japan, which had constructed meteorological observation stations in Central and Lower Myanmar since 1997. The results from investigative studies indicate that feasible areas to harness wind energy are in locations with an average wind speed of 5.6 to 7.4 meters per second, which would yield outputs ranging from 55 kW to 225 kW. According to Myanmar has a 2,832km coastal strip facing the Bay of Bengal and the Andaman Sea, potential available wind energy along this coastal strip, with its southwesterly wind for 9 months and northeasterly wind for 3 months, is around 365.1 Terra Watt-hours per year. However, available data on wind energy sources are not sufficient to select the suitable site for wind farm. Therefore, analysis of wind potential is urgently in need for Myanmar. The research data of yearly averaged wind velocity above 10m is described in accordance with States and Regions as shown in Figure 1.

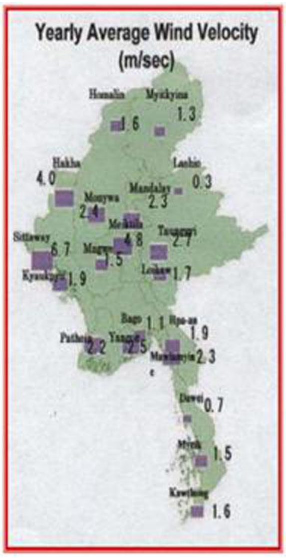


Figure 1. Yearly averaged wind velocity in Myanmar

Otherwise, two foreign companies, Gunkul Engineering Public Company Limited and China Three Gorges Company, signed MOU with Ministry of Electric Power in 2011for establishment of wind mills. The Gunkul Engineering Public Co of Thailand is to conduct the feasibility of building wind mills at seven places in Mon, Kayin, Tanitharyi Region and Shan State to produce 2,930 Mega Watts of electricity, while the Three Georges Co of China has also target area in Chin and Yakhine States, and Ayeyawaddy and Yangon Regions to produce 1,102 Mega Watts of electricity from wind mills. The feasibility study for developing commercial wind power could be taken more than one year, and the project will be pushed ahead if wind power is found economically feasible [8,9].

To do so, wind atlas and in-situ measurement are essential references. Therefore, this study can provide pre-feasibility of wind speed and wind power density arranged by MERRA as a supporting point in advance. Besides, to evaluate the site for its wind potential, instead of the average wind speed another parameter called wind power density is rather a very useful parameter. Therefore, this study focuses on wind power density map for wind resources assessment in Myanmar.

Study on Wind Resource Map of Myanmar

Wind resource assessment is the practice of collecting wind data to evaluate the wind resource at the candidate sites. As the accurate wind resource assessment is highly dependent on the quality and quantity of the input data, the two input models for the assessment are geographical and meteorological data. In this study, preliminary wind atlas of Myanmar is definitely evaluated using input files which are Digital Terrain Model (ASTER DEM 30m) for topography data and MERRA reanalysis data for meteorological data. The two inputs are added in ArcGIS map, and then, the spatial analysis tools, conversion tools and data management tools are extracted step by step to the output map as in the following mapping process.

Terrain Elevation Input

For reliable modeling of the wind flow over the terrain, an accurate description of the overall geometry of the terrain surface is prerequisite. The most important feature is the elevation of the terrain surface above mean sea level. Wind atlas model requires a digital height contours from a standard topographical map. Digital elevation models (DEMs) are increasingly used for visual analysis of topography, landforms, as well as modeling of surface processes. DEM of study area is generated form ASTER GDEM data of 30m resolution with the using software ArcGIS. The Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) global digital elevation model (GDEM) released by the National Aeronautics and Space Administration (NASA) and Japan’s Ministry of Economy, Trade and Industry features a higher spatial resolution (1″). The ASTER GDEM purports to be the highest resolution global digital elevation model, with 30 m spacing (actually 1 arc second) for geographical input of this study.

Wind- Climatological Input

As there is no measured wind data for the Myanmar, data from the Modern Era Retrospective-analysis for Research and Applications (MERRA) has been used for the preliminary wind potential assessment of the country. MERRA was published by NASA’s Global Modeling. The MERRA considers the orography and roughness of the site, and has a high availability. MERRA data is available for every 2/3° longitude by 1/2° latitude native grid (540×361 global grid points); with every one hour from 1979 onwards to till date. MERRA data have higher average correlation to the site. The use of MERRA datasets represents a relevant improvement in accuracy for long term results. Although a first rough judgment about the wind energy potential can able be made on the basis of the annual average wind speed, (i.e. the average of all measured data, including calm over a period of one year), the annual average should be calculated for as many years as possible. Therefore, a set of measured wind speed values u_i has been supposed, and then the mean of the set, u is defined as following Equation 1.

$$u = {}^{1}/_{n} \sum_{i=1}^{n} u_i \qquad (1)$$

The sample size or the number of measured value is *n*.

Then, wind power density, a measure of the energy flux through an area perpendicular to the direction of the motion, varies not only with the cube of wind speed but also with air density. Due to air density correction has to be made for getting the actual wind power density, the standard density value used for wind energy assessments is ρ= 1.225 kg/m^3, which corresponds to dry air with a temperature of 15°C and a pressure of 1013.25Pa. Average wind power density is then proportional to the mean cube of wind speed is driven by Equation 2.

$$P_d = \tfrac{1}{2}\rho u^3 \text{Watt/m}^2 \qquad (2)$$

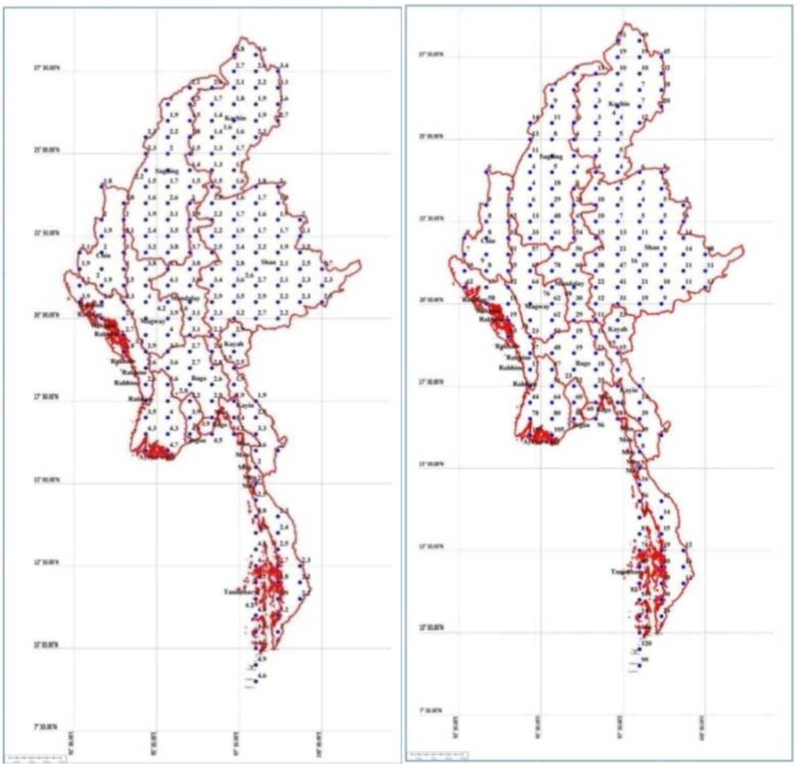
Where;

P_d = Wind Power Density in watt

ρ = Air Density in kg/m^3.

u = Mean Wind Speed in m/s.

With this result, the MERRA data (50m) for wind speed has been downloaded and wind power density has been derived by Equation (2). And then, both maps for every grid points are given in Figure 2. As reference data of MERRA, the numerical wind speed and wind power density of Myanmar could be prepared for input data file with .kmz format type.



(a) Wind Speed (b) Wind Power Density

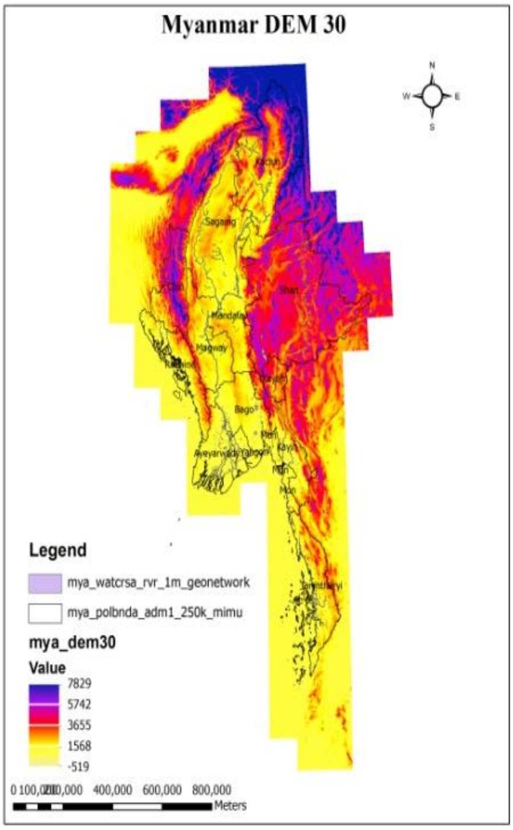
Figure 2. Wind data input

Wind Resource Mapping Procedure

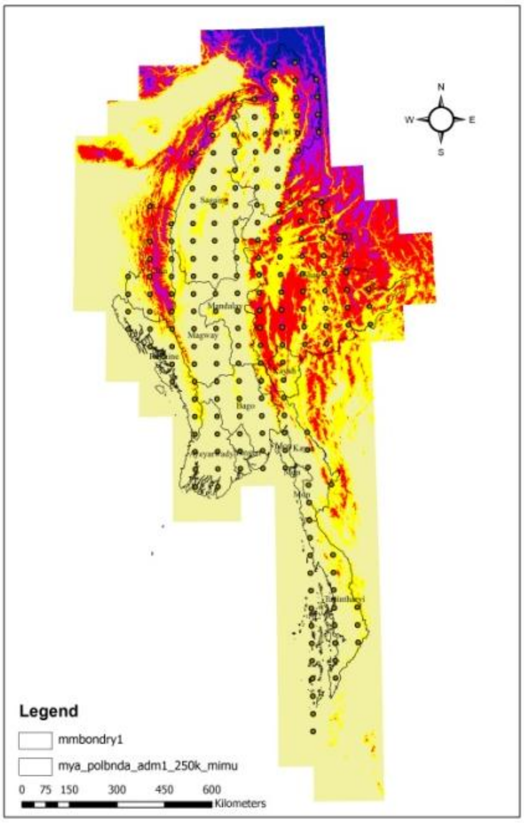
Wind mapping system is divided into two main components: input data, simulations file preparation for input data, and output section that produces the final wind map. Using ArcGIS Map software, the most favorable locations can be determined for wind atlas. The ESRI software ArcGIS 10 with Spatial Analysis, Conversion tools and Data management tool are used in the wind mapping. In the mapping system, geographical constructing of the digital elevation model (DEM) of Myanmar and meteorological transferring of wind data (MERRA reanalysis data) added into the ArcGIS software package as two primary inputs.

Firstly, the main geographical input DEM is generated at contours interval of 10 m, which is conducted by using ‘Surface’ of ‘Spatial Analysis Tool’ from ArcGIS software as shown in Figure 3(a). Secondly, the wind data (wind power density) input file built by kmz.file is added again. Using with ‘From kml’ of ‘Conversion tool’, the file is converted to kml to layer. Wind power density unit is overlapped for each grid points in Figure 3(b). For evaluation of export project, project merge output is interpolated after transferring Coordinate System (UTM reference from World Geodetic System 1984, WGS84) seen in Figure 3(c). The project output is extracted along with the Myanmar boundary layer. Finally, in Figure 3(d), output of the map is established with a color-coded wind power density map in units of W/m^2 height of 50 m above ground level for Myanmar with a resolution of 1:10,000,000. And output portion of the wind power classification describes in label, Legend. The output portion of the map produces the proper wind power density for each region of Myanmar.

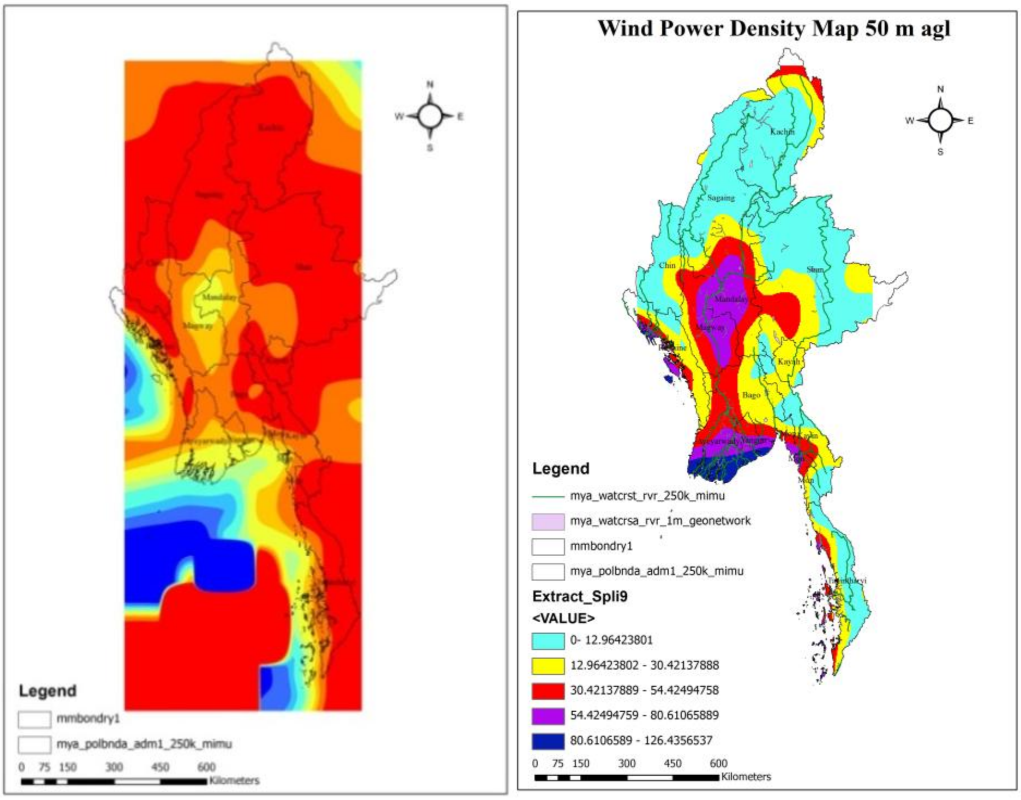
In the map, there are five wind power density values in seven States and seven Regions respectively. It labels the map with useful information, such as a legend, location of States and Regions and a distance scale. The mapping processing is shown in Figure 3; the projection is run step by step.



(a) Input DEM



(b) Input kmz file



(c) Interpolation (d) Output Color0oded Map

Figure 3. Wind atlas of Myanmar

Analyzing and Interpreting Output Result

The DEM data can be used to create a color-coded elevation map, a hill-shaded relief map, and a map of elevation contours. After combining with wind power density data (MERRA), wind atlas is created by running ArcGIS map. When the runs are finished, simulated wind atlas results show wind power density within 50m above the ground (50m agl) which is poor widely spread in the entire country (< 80 W/m^2) except coastal area. The strongest wind power density areas are south and southwest part of Myanmar (up to 120W/m^2). Overall Wind power density classification is figured out in accordance with seven States and seven Regions in Myanmar respectively shown in Table 1.

Table 1. Estimation of Wind Power Density in Myanmar

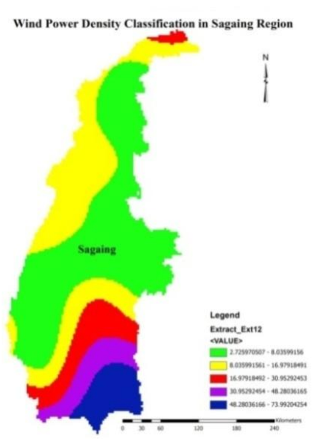
State/ Region	WPD (W/m^2)	Class/Description
Kachin, Kaya, Kayin, Chin, Shan, Bago	10-50	1/ Poor (0-200)
Sagaing, Mandalay, Magway, Mon	20-80	1/ Poor (0-200)
Yakhine, Ayeyarwaddy, Yangon, Tanintharyi	20-126	1/ Poor (0-200)

From reviewing the outcome results of the map seen in Table 1, the lowest wind power density of below than 50 W/m^2 is found in Kachin State, Kaya State, Kayin State, Chin State, Shan State and Bago Region. Sagaing Region, Mandalay Region, Magway Region and Mon State can be defined as moderate rate, wind power density arranges from 20

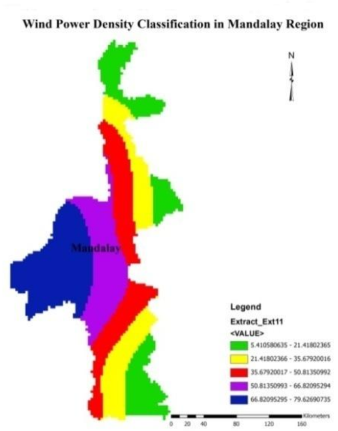
W/m^2 to 80 W/m^2. The highest wind power density (80- 126W/m^2) found in Yakhine State, Ayeyarwaddy Region, Yangon Region and Tanintharyi Region.

Refer to the standard classes of wind power density for standard measurement height of 50m, the entire role of Myanmar wind power class is class one, poor (0-200 W/m^2). The significance wind resource potential of Myanmar can be identified for rural applications such as water pumping, battery charging, etc., where particularly in remote areas. However, the clarification wind power density map of Myanmar can point out two specified sectors such as better and best windy site upon wind power density range.

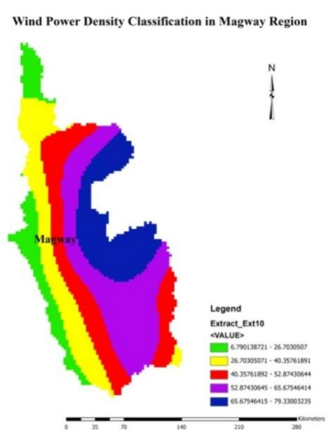
The better wind resources are observed in four specified regions. There are Sagaing, Mandalay and Magway Region (central part of Myanmar) and Mon State (south eastern part of Myanmar). Significantly, wind power density of southern tip of Sagaing Region (48.28-73.65W/m^2), western part of Mandalay Region (66.82W/m^2 -79.63W/m^2), eastern part of Magway Region(65.68W/m^2-79.33W/m^2), western part of Mon State situated in coastal area (58.75W/m^2-77.38W/m^2) are estimated as shown in the following Figure 4. Those sites are likely to be attractive for small wind turbine in village power application if wind masts would be installed on certain sites in the future.



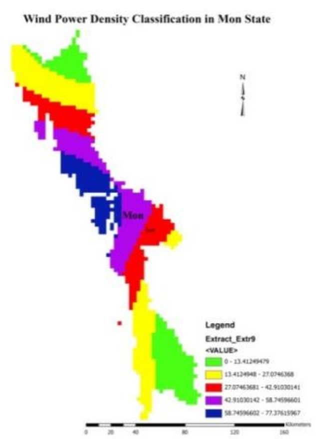
(a) Sagaing



(b) Mandalay



(c) Magway

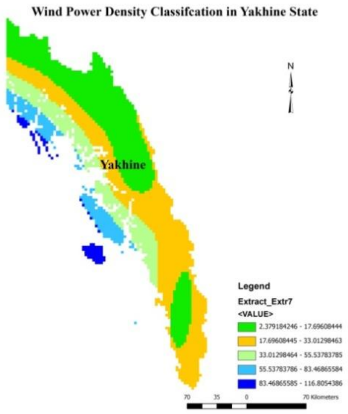


(d) Mon

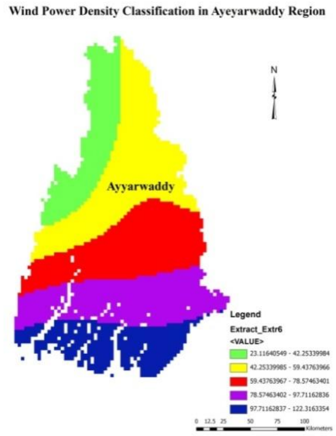
Figure 4. Wind power density maps of Sagaing, Mandalay, Magway, and Mon

The latter wind resources represent the near coastal area, west, south and southern west of Myanmar which areas are known as Yakhine State, Ayeyarwaddy Region, Yangon

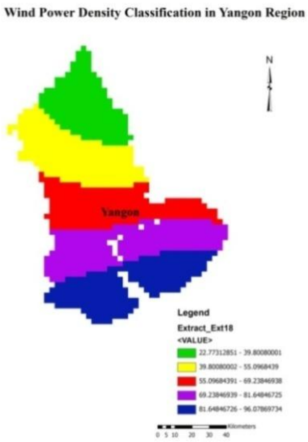
Region and Tharnitharyi Region. Cheduba Island, Taik Kyun, Ye Kyun and other Kyuns in western part of Yakhine State, costal area (83.47W/m^2 -116.81W/m^2), southern edge of Ayeyarwaddy Region (97.72W/m^2 - 122.32 W/m^2), southern tip of Yangon Region (81.65W/m^2 W/m2-96.08W/m^2) and archipelagos in Tanitharyi Region (89.34W/m^2 - 126.44W/m^2) are described in Figure 5.



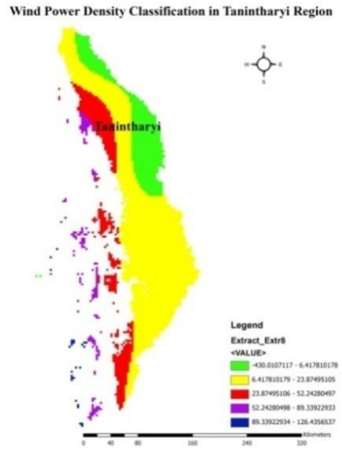
(a) Yakhine



(b) Ayeyarwaddy



(c) Yangon



(d) Tanintharyi

Figure 5. Wind power density maps of Yakhine, Ayeyarwaddy, Yangon, and Tanintharyi

Above these areas are the best wind resources in Myanmar and would be considered for small-scale wind power generation as a future plan. These specified areas are likely to be facilitating the development of wind energy both for village power and other off grid application in Myanmar near future.

However, these result outcomes need to be checking with promising areas. In the previous research study by NEDO, the promising areas are the hilly regions of Chin and Shan State, Coastal region of 2832 km facing the Bay of Bengal and the Andaman Sea and Central Myanmar region. The coastal region and central region of Myanmar is relevant with the previous research study similarly. However, when these results compare with those resource works, the hilly regions, Chin and Shan state are not included in promising area. In fact, the input data of both geographical and meteorological may contain errors that affect the wind resource estimation in each study. In this respect, this study is intended to validate of the previous studies and to confirm the resource estimation in areas for planning wind energy development and focusing on areas of immediate promise.

While the wind atlas represented to Myanmar is compared to other advanced wind energy resource assessment study, it is needed to be modification by using measuring data. The range of wind power density of this study is estimated from 55km×66km approximately within a grid cell. In geographical data, topographical map has to identify with the zone layer in mapping procedure considering the roughness class. Regarding to these matter, wind resource assessment for Myanmar is highly recommended that wind measurement program must be conducted to validate the wind resource estimation by setting up met mast and to refine the wind map supporting by government sectors, private developers, and others cooperation combined each other as an energy strategy. For preliminarily, this study can cover the appropriate result data based on both input reliable data.

Recommendation for Future Resource Assessment

This study introduces the first stage of wind resource assessment in Myanmar in terms of general wind speed information (MERRA) and wind mapping. Wind power density map can be used for identifying wind farm development areas. However, lack of surface wind data to validate the wind resource maps generated through MERRA data is a major constraint in Myanmar. The present analysis is a pre-feasibility study and is limited in scope. No attempt was made to analyze the wind turbine and energy production. This analysis focuses solely on preliminary wind resources assessment and site-specific identification for future. Therefore, it is recommended a measurement programme so that verification will be done which is very crucial for finalizing the wind farm area. Using WAsP and WindSim software tools, a detailed analysis will also be done for predicting wind climates, wind resources and energy productions from wind turbines and wind farms. With all these information, it will be possible to identify the most potential regions which should be further looked into detail for site-specific feasibility analyses. A combination of this information with setting up met (meteorological) masts will give the basis to prepare wind resource maps for Myanmar. One year measurement will give a preliminary idea of the wind conditions and possible energy yield and this would be sufficient for planning purpose. MERRA data will help to study the long term variation of wind speed at the studied area. Thus, for future extension, setting up wind mast in the proposed areas described above States and Regions and collecting the real data by meteorological center are the best way to create Myanmar Wind Atlas for finding out micrositing in evaluation of very good wind penetration source in Myanmar, a next option.

Conclusions

Based on MERRA data, a wind power density map of Myanmar was prepared and the preliminary wind resources assessment of the country has been assessed. The wind power density map was computed because it could provide a truer indication of the wind resource potential than wind speed. For this factor, the resulting map could provide a good starting point in understanding of the wind resources in Myanmar. This study is intended to facilitate and accelerate the use of wind energy technology for wind energy applications in the Myanmar by providing the pre-estimation of wind power density map over the entire national territory. This study also hopes that will also provide an incentive to authorities, private investors or banks for further steps to be taken and to ensure the implementation of wind energy in Myanmar.

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