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Social and Environmental Study on Wind Power Development in Ayeyarwaddy, Myanmar

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Abstract—*To integrate the power grid and more efficient power serving to the local residents of Ayeyarwaddy Region,wind power is better resource from this study of social and environmental findings. The main objective is to provide a better understanding of the socio-economic requirements that contribute to the integration of wind energy in sustainable power supply systems. The demonstration wind farm area was performedby excluding the social land use. The wind farm siting was observed withsufficient distance from the residences to effect environmental impact appropriately in noise emission and in shadow flickering by employingNoise calculation model: Danish 2007 and shadow flickering model in WindPro software. These acquired results are not high impact to the local resident's atKyonkadun village, Ayeyarwaddy Region. Hence, this paper will initiate new discussions about the future of wind power project and to safeguard the long-term societal acceptance in Ayeyarwaddy Region, Myanmar.*

Keywords— ***Ayeyarwaddy, Greenhouse gas, Noise, Shadow, Wind energy.***

I. INTRODUCTION

From a technical and economic standpoint, the most technologically and operationally matured form of renewable and "clean" energy is wind energy. Since wind energy is a clean and environmentally friendly technology to produce electricity instead of using fossil fuel, it is a mature and rapidly growing renewable energy technology both in developing and developed countries. When compared to nuclear power plants taking over 10 years of construction time, wind power is the most economic new power plant technology. Although improved project economy is a vital challenge for wind power, wind power is closer to commercial profitability than any of the other renewable sources except hydro power. Due to reduced installations costs, no fuel costs, reduction of greenhouse gas emission and shorter construction time, the global capacity had grown to 486.7GW by the end of 2016.

With increasing wind power installed capacity, it can effectively contribute to combating climate change while at the same time providing various environmental, social and economic benefits. Simultaneously, the major challenges for further development are connected to economy, land usage, grid accessibility and environmental impact. Environmental impacts of wind-energy facilities include the killing of wildlife, especially birds and bats, visual, noise, shadow and other impacts on humans. However, compared to other forms of human and industrial activity, environmental impact on wind power is very low and can make effort to further mitigate these affects in the planning phase.

Through technological development and by properly siting wind turbines in the wind power plants, most of these problems would be resolved and greatly reduced. Landscape and visual sensitivities can be addressed through good design in wind farm layout. Noise predictions can be calculated and the noise levels in the area surrounding each wind farm as a result of its operation can be experimentally measured as well. Shadow flicker can also be assessed where it could occur based on the distance to the turbines. Therefore, by learning from guidelines and good practices on managing the impacts of wind farms [1]-[11], this paper analyses the potential for impacts on local residents to inform the future siting and design of wind farms in Ayeyarwaddy Region, Myanmar.

Ayeyarwaddy Region is a region of Myanmar and occupying the delta region of the Ayeyarwaddyriver. It is bordered by Bago Region to the north, Yangon Region to the east, and the Bay of Bengal to the south and west. It is contiguous with the Rakhine State in the northwest. The region lies between north latitude 15° 40' and 18° 30' approximately and between east longitude 94° 15' and 96° 15'. It has an area of 35,140 square kilometres (13,566 sq miles). According to the National Census 2014 of Myanmar, there are 6175123 populations in Ayeyarwaddy Region. Ayeyarwaddy Region is flanked by the RakhineYoma (Arakan Mountains) range in the west and large areas were cleared for paddy cultivation, leading to its preeminent position as the main rice producer in the country. Of the rivers branching out from the mighty Ayeyarwaddy, Ngawun, Pathein and Toe are famous. There are 6 districts, 26 townships, 252 wards, 1913 village tracts, 12,194 villages and the capital city of AyeyarwaddyRegion is Pathein. The area was the site of heavy devastation when Cyclone Nargis made landfall in 2008, affecting 2.4 million people that included 140 thousand dead and missing persons. The cyclone damaged about 770,000 ha of paddy fields through salt water ingress and flooding and also seriously affecting the living conditions in the polders [12]. The urban area can only access the national grid (10% of electrification ration of household) and the power demand was 89.45MW in 2016[13]. While the rest of some city and rural areas were not connected yet to the national grid (8602 non-electrified villages), the total electricity generation is using rice-huskgasifier, diesel power and solar home system. Leading rice farming area of the country, traditional biomass resources (rice-husk) are abundance for generation of electricity. However, this generation source effects on the level of environmental impact to the local residents which needs to be improved through technology for the energy access to the local residents and as of now most of rice mills are not able to use grid power [14]. According to demand forecasting based on fiscal year 2012 with low and high case, the maximum power demand may be 329MW and 406 MW by 2030[13, 15].

To solve these issues both to mitigate the environmental impact of rusk-husk gasifier and to meet electricity demand forecast by 2030, wind energy can be part of alternative energy resources in the region. For this reason, this paper will highlight the siting guidelines for wind power development in Ayeyarwaddy Region by mitigating the social and environmental impact with good practices of wind farm/sitting plan.

II. WIND POTENTIAL OF AYEYARWADDY

The previous studies [16, 17] determined that this region has high potential and identified for wind farm exploitationdue to the situation of a long coastline in Myanmar. In this study again, based on MERRA_2 reanalysis data set [18], the wind potential at 100 m hub height inAyeyarwaddy is estimated at 4.5-6.2 m/s wind speed (WS), 104-259 W/m^2 of wind power density (WPD) and 13-24% of capacity utilization factor (CUF). The highest potential (blue colour) is found in the southern part of Ayeyarwaddy as shown in Fig.1. Therefore, this region can be considered for future wind power development in Myanmar.

Fig.1 Wind potential at 100 m in Ayeyarwaddy Region

III.MITIGATION OF SOCIAL AND ENVIRONMENTAL IMPACT ON STUDY REGION

Among the renewable energy technologies, wind energy has great potential to meet the electricity needs because it could provide electricity in a cost effective way, environmental effects and usability. The success of wind power project mainly depends on the proper selection of its site. The proposed site should be identified followed by the national environmental legislative and regulatory framework including the social, cultural and environmental effects. To overcome this issue, the related social and cultural places are not considered (excluded) for wind power application such as archaeological, paleontological, historical, architectural, religious, aesthetic, or other cultural significance.

For feasible sites selection of the study area, land use pattern (vegetation, crop land, forest area, heritage/ historic places, etc.) and resident infrastructural constraints (electricity network coverage, airport, railway, river, road, etc.) are identified as an exclusion area according to the Environmental and Social Management Framework of Myanmar National Electrification Project [19]. The required data and Geo spatial maps of Ayeyarwaddy are gathered for exclusion area of wind project study. Administrative area map [20], land use map [21], airport map, road network map, river network map [22], protected area map [23], settlement map [22,24] and existing electricity grid network map are exploited by using ArcGIS software as shown in Fig.2.

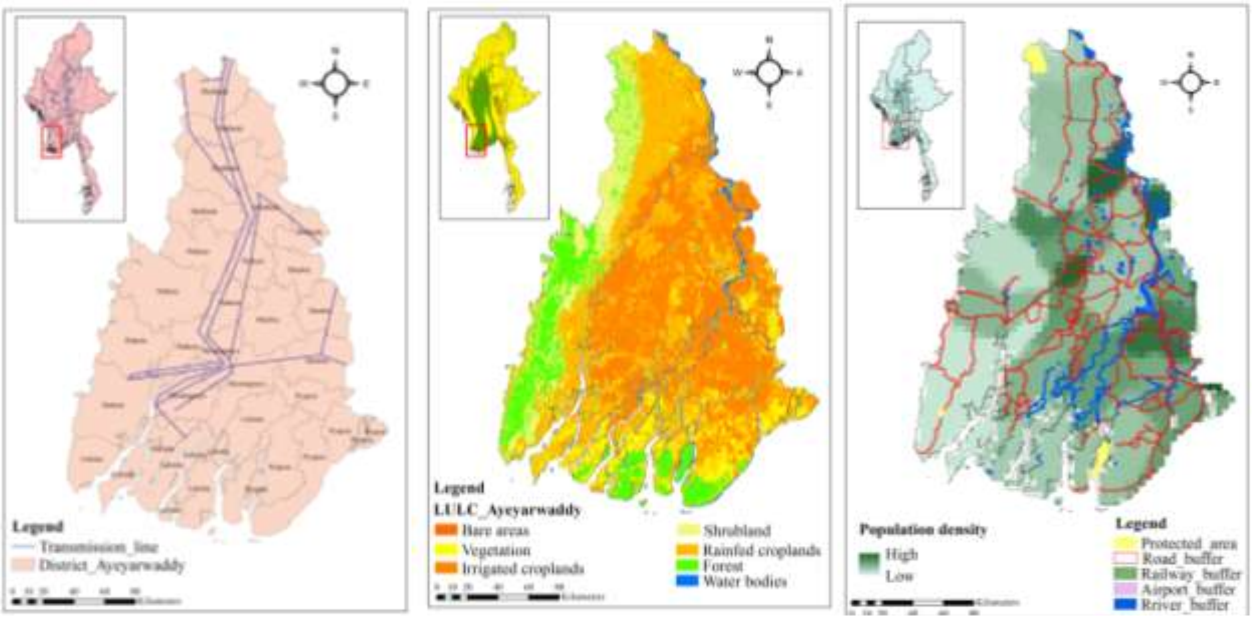


Fig.2 Social land use in Ayeyarwaddy

To mitigate the social and environmental impact on the region, the restriction areas are extracted after setting up appropriate buffer layer (5 km buffer for airport, 1 km for railway, road & river, 5 km for settlement) and also excluded are greater than 20 degree slope area [25], which are not suitable for wind farm development. The available sites were determined by deducting the areas required for road, river, forest, infrastructures, agricultural land etc. from the total area of the region. The acceptable area of the region is 14924.54 km^2 approximately and then installable area is about 7425.10km^2in the region. The installable capacity is about 47 GW with greater than 20% CUF.Therefore, these areas can be identified as the suitable area for wind farm developmentcorrespondence with national strategies for future plan and decisions as per National Electricity Master Plan, renewable energy(only solar and wind) share 9% (2,000MW) of installed capacity by 2030.

IV. RESULT

A. Social and Environmental Assessment on Wind Farm Layout

The utilization of wind turbines has not only ecological effects but also impacts on humans, and climate-related issues such as wildlife safety, bio system disturbance, noise, shadow, visual pollution, electromagnetic interference, and local climate change. The significant positive ecological effect is the reduction of the amount of harmful greenhouse gas emissions when electricity is generated from wind power instead of using conventional sources. This contributes in a positive way to improving the health, diversity, and productivity of the environment for the benefit of future generations [10]. Compared to the environmental impact of traditional energy sources, wind power plant has only minor impact on environment, if the project siting is selected with the best practices. For the environmental impacts on humans and climate-related issues, it will be possible to mitigate future impacts through careful siting decisions in line with national and international strategies plan. In this context, the wind farm layout study area was selected from the suitable area (as stated above) and identified the site locations (> 20 % CUF) as shown in Fig.3. The demonstrated wind farm area is in Kyonkadun village, Pyapon Township, Pyapon District, Ayeyarwaddy Region, Myanmar as shown in Fig. 4. The previous study has already reported the designed optimum wind farm layouts in this area by considering maximum energy yield and minimum wake losses [26].

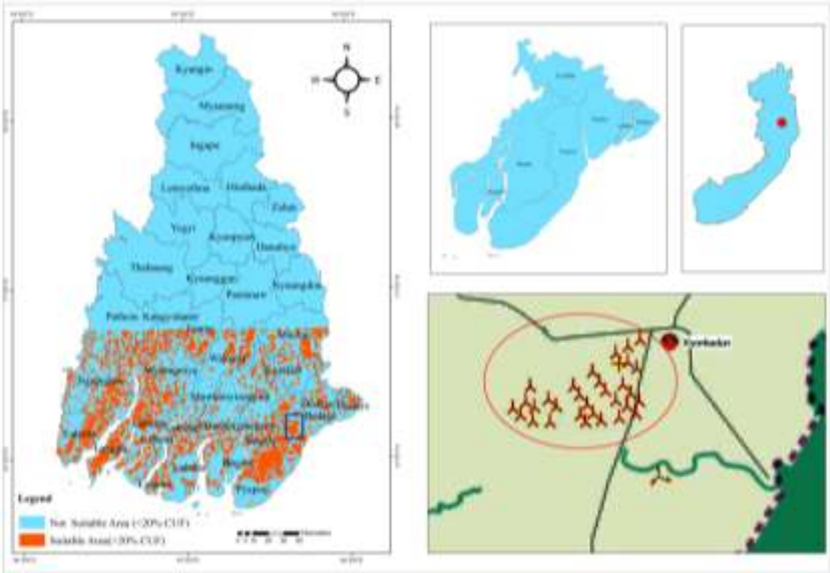


Fig.3 Wind farm site location

Regarding to the present study results, one can state that wind farm area is demonstrated in this study in addition for the social and environmental assessment and carried out the possible impacts on local habitat and other living being near wind turbines/farms, who were likely to be affected by noise and shadow flicker.

1) Noise Propagation

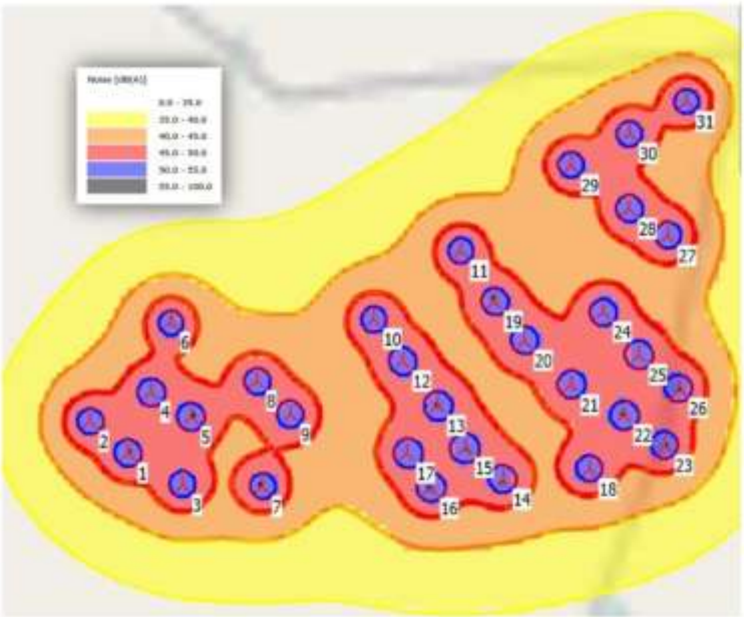
In the wind farm area, wind turbine noise and construction noise impact to local residents. Sound emissions from wind turbine are from mechanical components and rotor blade. Nowadays, manufacturers consider at design stage the noise emission with better engineering practices. The commercial wind turbines are operating under normal conditions. However, self-induced noise of the blades becomes predominant under certain conditions when the rotor rotates in different wind speeds. Generally, wind farms are located in windy areas, where background noise is higher, and this background noise tends to mask the noise produced by the turbines. Alternatively if background noise is lower as it is in country side or remote locations, the wind turbine noise could be annoying or disturbing to the life in the habitat.

To analyse this condition, this study investigated noise disturbance on surroundings of wind farm by using Noise calculation model: Danish 2007 and running in WindPro 3.1.579 software. The objective is to avoid annoyance or interference in the quality of life of the nearby residents. The demonstration wind farm configuration laid out in 5D× 7D with thirty one wind turbines (2MW normalized wind turbine, 100 m Rotor diameter and 100 m Hub height). The Danish model is employed in the layout, and investigates noise level in different wind speed (6m/s and 8m/s). According to the standard, Danish 2007, the aspect demandsareassumed as 37 dB (A) in 6m/s and 39dB (A) in 8m/s. The simulation results of wind turbine noise emission to local resident area were observed at 30.7dB (A) in 6 m/s wind speed and 31.7dB (A) in 8 m/s wind speed as shown in Table 1.

TABLEI
NOISESENSITIVE POINT: DANISH 2007 – RESIDENTIALAREAS

Wind speed(m/s)	Demands dB(A)	WTG noise dB(A)	Demands fulfilled?
6	37	30.7	YES
8	39	31.7	YES

Therefore, the noise sensitive level is lower than the standard case and within the acceptable range. Simultaneously, the study model reported that each turbine noise was noticeable and annoying only at higher speeds beyond/close to 8m/s. At this speed, the wind was strong enough to turn the blades and the noise from wind turbine can be 50-55 dB (A) indicated with blue colour line in Fig.4. The thirty one wind turbines noise levels can be seen in the different distance between the wind turbine and the resident area. At higher speeds, the noise from the wind itself masked the turbine noise. The distance of the nearest sensitive point of wind turbine noise in the area is at about 45-50 dB (A) indicated with red colour line in Fig.4.



No.	Distance [m]	Sound distance [m]
1	9,398	9,398
2	9,661	9,661
3	8,986	8,986
4	8,841	8,842
5	8,513	8,514
6	8,330	8,331
7	8,165	8,165
8	7,610	7,611
9	7,431	7,432
10	6,016	6,017
11	4,728	4,729
12	5,933	5,934
13	5,865	5,865
14	5,878	5,879
15	5,933	5,934
16	6,570	6,571
17	6,507	6,508
18	5,136	5,137
19	4,607	4,608
20	4,559	4,560
21	4,484	4,485
22	4,367	4,368
23	4,431	4,432
24	3,605	3,606
25	3,671	3,672
26	3,742	3,743
27	2,407	2,409
28	2,650	2,652
29	3,163	3,165
30	2,407	2,409
31	1,710	1,712

Fig.4 Noise level investigation in wind farm

Nevertheless, for the residential area those who heard noise indoors and at night were generally located in far awayareas, where the overall noise impact has been less than 45 dB (A) of noise guideline level for unreasonable interference or sleep disturbance referenced to the World Health Organization community [4,2,6]. The distance of closest wind turbine (31-Wind Turbine) is greater than 1km from the habitat. Thus, this study ofmodelling noise levels showed very less impacts in the demonstration area according to recommended safe distances between wind farms and habitations in developing wind farm in countries [2].

2) Shadow Flickering

Shadow flickering occurs from the wind turbine blade. When the blades are rotating, the shadow flicker casts on and off over the farm land, vegetation area, crop land and near by the resident houses. The shadow cast by wind turbine may be a few hundred square meters.Generally, if the weather is overcast or calm, if the wind direction forces the rotor plane of the WTG (Wind Turbine Generator) to be parallel with the line between the sun and the neighbour, or if there is a non-transparent obstacle between the neighbour and the sun in the direction of the WTG, the WTG will not produce Shadow Impacts, but the impact will still appear in the calculations.The purpose of the study is to analyse ground shading the shadow pattern of the wind turbines that may affect the surrounding areas. The shadow flows behind the wind turbines corresponding to sunshine hours. In the study, the resource average daily sunshine hours is taken from nearby regional (Bangkok)of WindPro library file and is employed along with wind turbine operating time in WindPro shadow flickering model (worst case). Flickering or shadow impact are calculated as how often the neighbour can be affected by shadows generated by one or more WTGswith two cases (green house mode in all direction and single window mode) and marked at specified point (B,C,D,E) in the wind farm study area as shown in Fig. 5.

Fig.5 Shadow flickering map level investigation in wind farm

Only few countries have regulations indicating the maximum acceptable flicker (Eg. in Sweden, it is said that less than 10 hours "real case" must be accepted). However, not only the number of hours is important for evaluating the specific case but also the time of the day and year can be even more important. Therefore, the simulation result of the study shows when flickering might appear along with indication of the time of day covering all the twelve months, from wind turbine. In the study results, the worst case calculation was predicted a scenario presenting the potential risk of Shadow Impact. The shadow impact may occur when the WTG blades pass through the sunrays seen from a specific point (B, C, D, E). The marking point C investigated on Kyonkadun village by assuming that theelevation of the sun is 90 degrees at sunrise and sunset from the horizonin both cases. The marking point B and E observed with green house mode i.e. in all directions.The specified point D is investigated with the WTG shadow impact by single window mode. When the elevation of the sun is 90 degrees at sunrise and sunset from the horizon, the flicker might appear in the morning and evening at around the resident area (Point C) as shown in Fig.6.The shadow hours per year (worst case) are not much significant impact to the resident in the wind farm area. In the case of greenhouse mode in all direction, the shadow impact may occuraround area as shown in Fig.7.The WTG no.15 shadow impact is described with blue colour and might appear in the afternoon during the rainy season (from May to September). The shadow impact of WTG no.17 and WTG no.18are described with green and brown colour and these might appear in the morning and evening during the months of March and October. In the point E, the shadow of WTG no.30 (yellow colour) may appear in the evening during month of January as shown in Fig.8. The WTG no.31 shadow (pink colour) may occur in the afternoon during three months (May, August and September). In the case of single window mode (point D), the WTG no.3 shadow (blue colour) may occur in the morning (March and November) as shown in Fig.9.

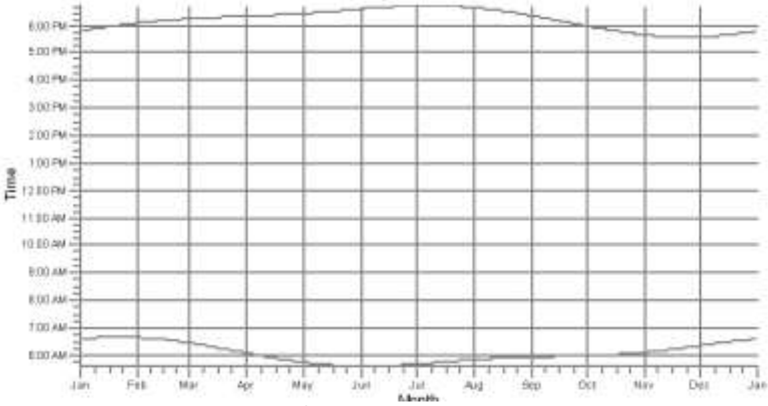


Fig.6 Calendar graph of point C shadow receptor(slope 90 degree)

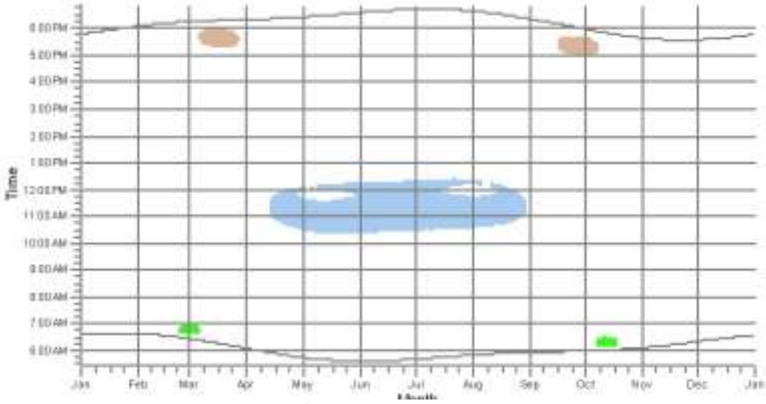


Fig.7 Calendar graph of point B shadow receptor(slope 90 degree)

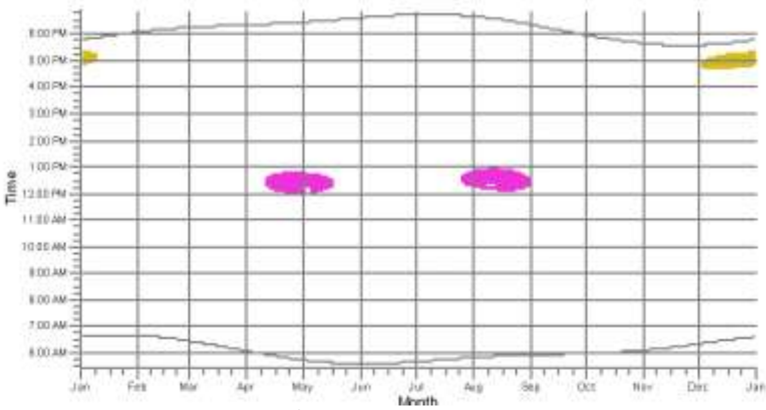


Fig.8 Calendar graph of point E shadow receptor (slope 90 degree)

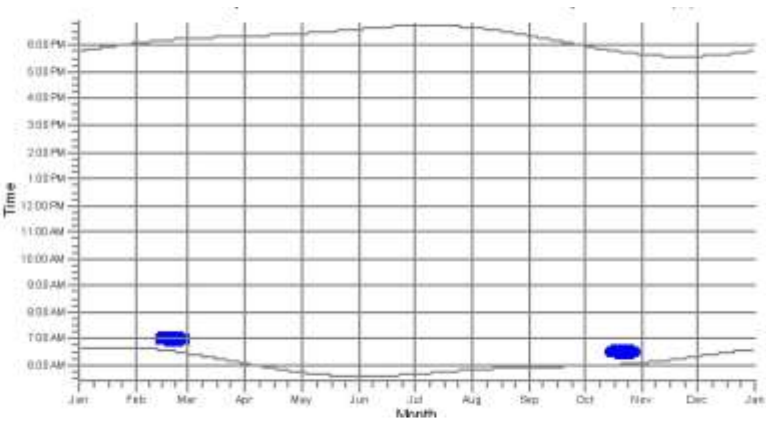


Fig.9 Calendar graph of shadowpoint Dreceptor (slope 90 degree)

Thus, the results on shadow hours per year (worst case) may not be of much significant impact to the residents (Kyonkadun village)from the wind farm siting. The flickering from the wind turbines may be a very less negative aspect of placing wind turbines because the siting is not so close to resident area. However, the flickering might appear around the area themselves during the day timein the windy months from the wind turbines.

CONCLUSION

This study addressed land use availability for future wind farms in Ayeyarwaddy Regionby considering national social and environmental strategies on, noise created from the turbines blades to the local residents by using Noise calculation model: Danish 2007and the effects of flicker predicted in worst case of Shadow flicker model run by using WindPro Software to assess social and environmental impact in Kyonkadun village, Pyapon Township, Pyapon District,Ayeyarwaddy Region. From the results, this study introduced comprehensive legislative guidelines for land use of wind farm siting,without any disturbance to possible residential property development within the limits of internationally approved noise restrictions and shadow flicker affecting residential properties. As the demonstration modelsused for siting could decrease "wind farm social and environmental impact", the study couldguide the decision making to achieve social and environmental benefits such as to access the energy demand from wind power (62MW, 104.09GWh/yr) [26], and to decrease the environmental impact of rice-husk gasifer by replacing equivalent capacity wind power plants, to mitigate greenhouse gas emission (CO_2emission, 52450 ton/yr) [27], and to generate job opportunity in wind power project, to improve livelihood of local regional/rural area. The observations based on results can assistto theplanning guidance and better practice by balancing both positive and negative environmental effects on local residents of Kyonkadun village, AyeyarwaddyRegion, Myanmar. Thus, this study might provide the best balance between protecting local communities and socially acceptable wind farm implementationinstead of rice husk gasifierwhile also providing clarity to wind energy firms who seek to develop wind power projects in Myanmar.

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