Wind renewable energy potential in Samoa

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Abstract

Renewable energy is a critical component of Samoa's strategy for economic growth and social development. The demand for energy in Samoa has risen exponentially making Samoa rely on fossil fuel such as petroleum. It is predicted such non renewable energy sources will not last for another 100 years. Today, more developed countries are tapping into renewable energy sources to drive some of its electrical energy demand and Samoa is following this trend to obtain its electrical energy from renewable energy sources (Samoa Ministry of Finance 2007). This paper presents data from an initial two-year study conducted to assess the feasibility of wind as a renewable energy source to generate electricity in Samoa. Two sites namely, Satitoa and Afulilo were selected due to their location and exposure to south easterly trade winds. Wind data such as mast heights and wind speeds were collected from wind masts located at the two sites daily, at 10 minute interval for almost two years. Findings show the potential of wind energy to drive electricity demand in the country from the two sites are not feasible. Discussions of the latter are presented in the paper including recommendations for consideration by the national authorities.

Introduction

In the mid 1990s, when the Ta'elefaga hydropower station project was completed (funded by the European Union and the Government of Samoa) 85 percent of Samoa's electrical energy needs were met from this renewable source. This figure has decreased to 40 percent because of the growing rate of energy demand of four percent per annum for development activities in the country, such as tourism industry, infrastructure and population growth (Samoa Ministry of Finance 2007). Increased demand will depend on fossil fuel supplies that are depleting over time (Middleton 2009) and will certainly become very expensive in the future. As a result Samoa's electricity supply and cost will be seriously affected.

This concern has caused developed countries to research and develop new technologies to extract and harness energy from renewable sources for their electrical energy supply (Middleton 2009). Dr Mark Diesendolf, a former principal researcher at the Commonwealth Scientific Institute of Research Organisation (CSIRO) in Australia believes that Australia's electricity supply could be 100 percent renewable by the year 2030 (Middleton 2009). Similarly, New Zealand is targeting the year 2025 to obtain 90 percent of its electricity from renewable sources.'

To be in line with international trends, Samoa's national energy policy also promotes the use of sustainable natural resources from the environment (or renewable sources) such as wind, solar, biomass to generate electric energy (Samoa Ministry of Finance 2007).

This paper reports the results from an initial study that was conducted to assess the feasibility of wind energy as a renewable source for the generation of electricity in Samoa. In order to ascertain whether the wind energy available on island is feasible to meet the national electrical energy demands of the country, the following questions were needed to be asked:

- How often does the monthly wind speed exceed the five metres per second (m/s) at the two study sites?
- What is the wind speed pattern at the highest height of each site over the duration of the study?

Background

Samoa's current daily electrical power need is between 20 to 30 mega watts according to reports from Iese (2006). Commercial wind turbines available on the global market require wind speed range of five m/s to 25 m/s (Wairarapa 2009).

Methodology

Two sites on the island of Upolu were selected, namely Afulilo (Site A) and Satitoa (Site B), because it was assumed that south easterly trade winds were considered stronger at these two locations.

To answer the two specific focus questions, wind masts were installed at the two sites to measure wind speed during the two year study. Wind speeds were recorded at Site A at heights of 10 metres (m), 20 m and 30 m, while site B measurements were taken at heights 10 m and 30 m. The wind speed measurements were taken by anemometers which were installed at the different specified heights. Average wind speed were recorded by the data logger at every 10 minute interval for 24 hours over the period of two years. This data was then exported to a Microsoft excel spreadsheet for analysis using the statistical package R-software.

Data analysis

To answer the first specific question, a count of occurrences of wind speed exceeding five m/s at the two sites was conducted with the aid of histograms. For the second specific focus question, since the 30 m height was the highest, a box plot diagram was used to show the wind speed pattern every month over the duration of the study.

Results

Overall results for Site A (Afulilo)

Figures 1, 2 and 3 show that the wind speed distribution skewed to the left. The mean therefore is affected by extremes, and is better used as a measure of central tendency. An ideal distribution is when the median, mean and mode are all greater than five m/s. Figures 1, 2 and 3 show that the wind speeds are less than five m/s most of the time. In comparison, the wind speed at the height of 30 m is greater than wind speeds at 10 m and 20 m heights. The wind speeds at 20 m is also greater than 10 m so there is a positive correlation between wind speed and height.

From this immediate analysis, it is assumed that there is sufficient wind speed and most likely available at 30 m height.

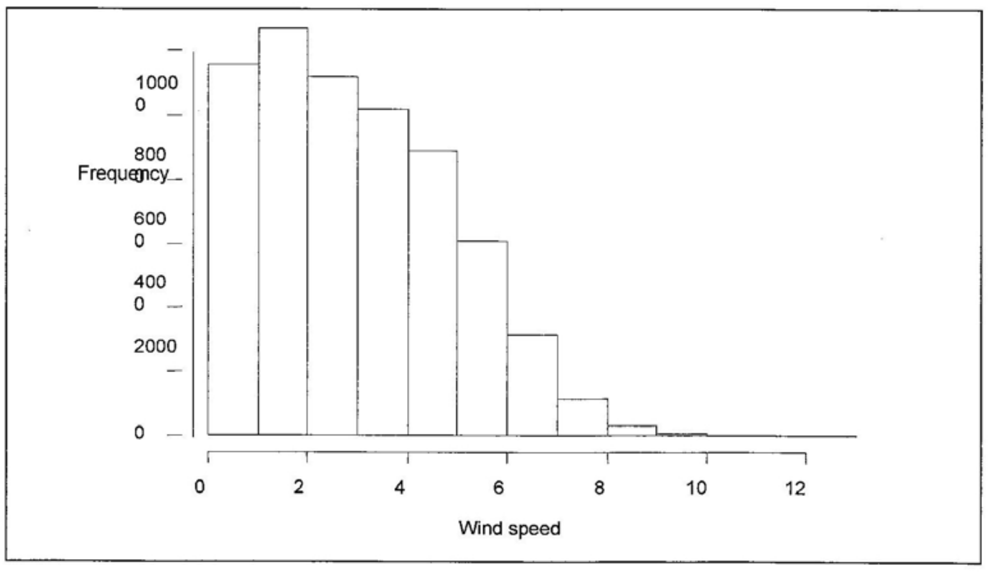

Figure 1: Frequency distribution of wind speed at site A at 10 metre height

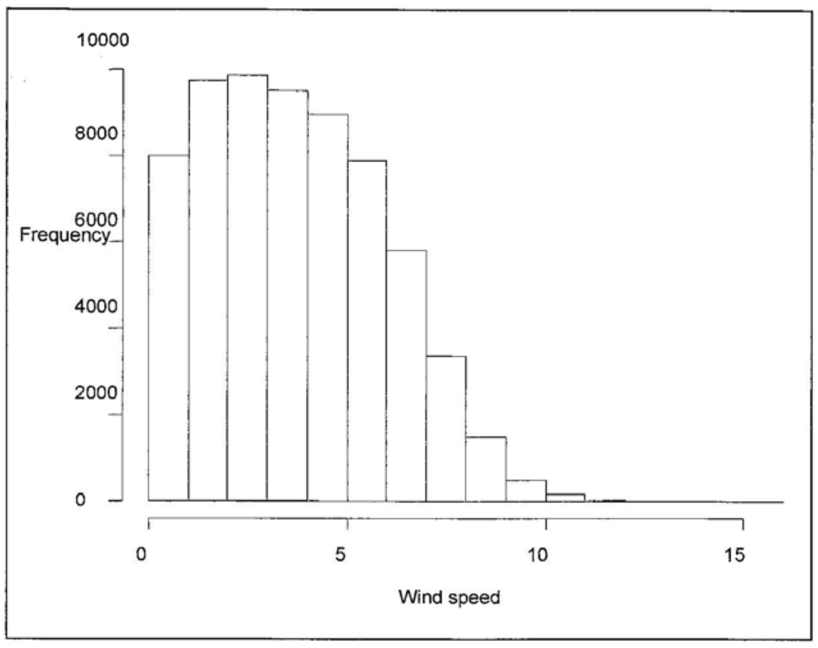

Figure 2: Frequency distribution of wind speed at site A at 20 metre height

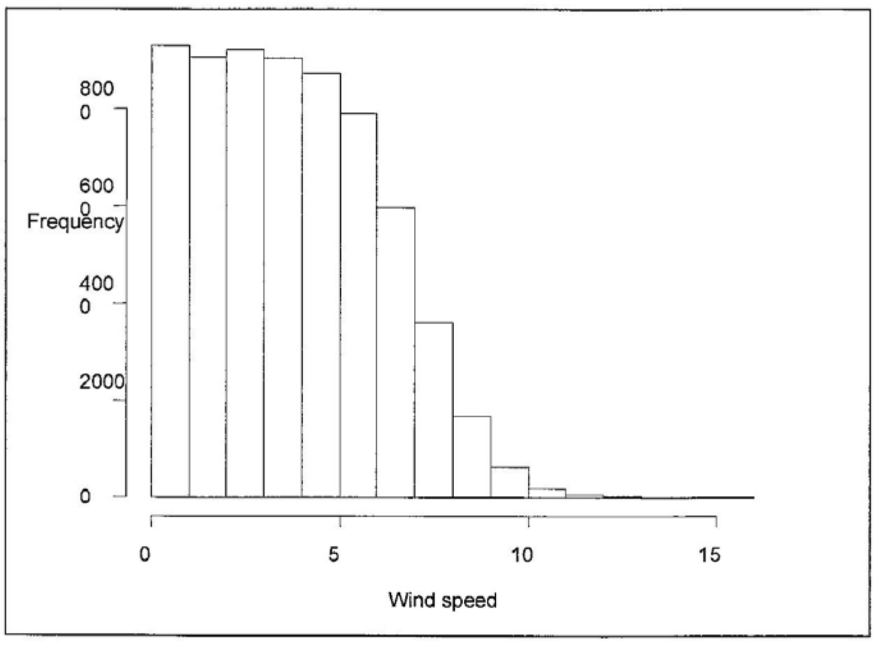

Figure 3: Frequency distribution of wind speed at site A at 30 metre height

When all three heights were compared, it confirmed what has been stated previously as shown in Figure 4. All medians are below the five m/s mark. For the 30 m, a 95 percent confidence interval is 3.58 and 3.62, which is below five m/s. Hence, wind speed of five m/s and above are rare. Furthermore, at the 30 m height, 65,395 readings were taken all together and more than 68 percent of these were below the sufficient mark of five m/s.

In Figure 4, extreme wind speed occur beyond 11 m/s which is equivalent to 0.15 percent of readings and is only 94 out of 65,395 readings. Thus, these extreme wind speeds are insignificant.

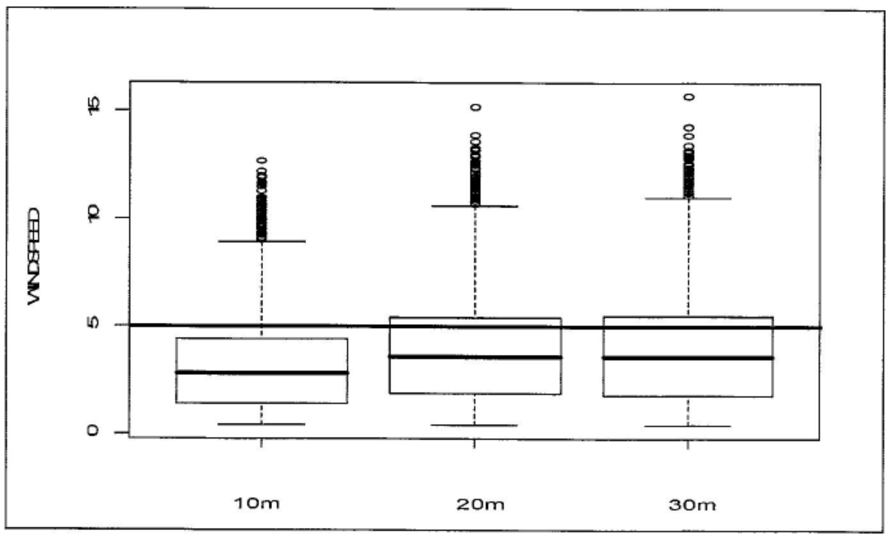

Figure 4: Comparison of wind speed at Site A

Figure 5, indicates the median wind speed are all less than the sufficient mark of five m/s, except for June 2007 and August 2007. But although these two months recorded wind speed beyond five m/s, they do not guarantee sufficient wind speed to turn a wind turbine all the time because of the huge variance as indicated in Table 1.

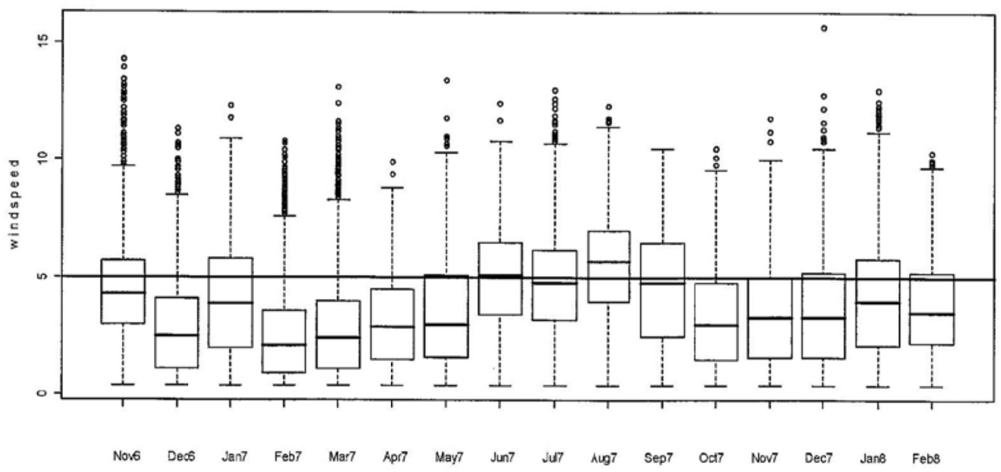

Figure 5: Monthly comparison of wind speed at 30 metre height at site A

Table 1: Statistical data for the months of June and August 2007 at 30 metre height

	Monthly median	Monthly variance	Number of readings	95% Confidence Interval	Proportion greater than 5 m/s
Jun-07	5.1	4.5399	4320	(5.0365, 5.1635)	0.52
Aug-07	5.7	4.6130	4464	(5.6370, 5.7630)	0.63

Overall results for Site B (Satitoa)

Similar to Site A, Figures 6 and 7 show that wind speed distributions skewed to the left. Again, as done for Site A, the median was used for the estimate, as the distributions show the presence of extremes.

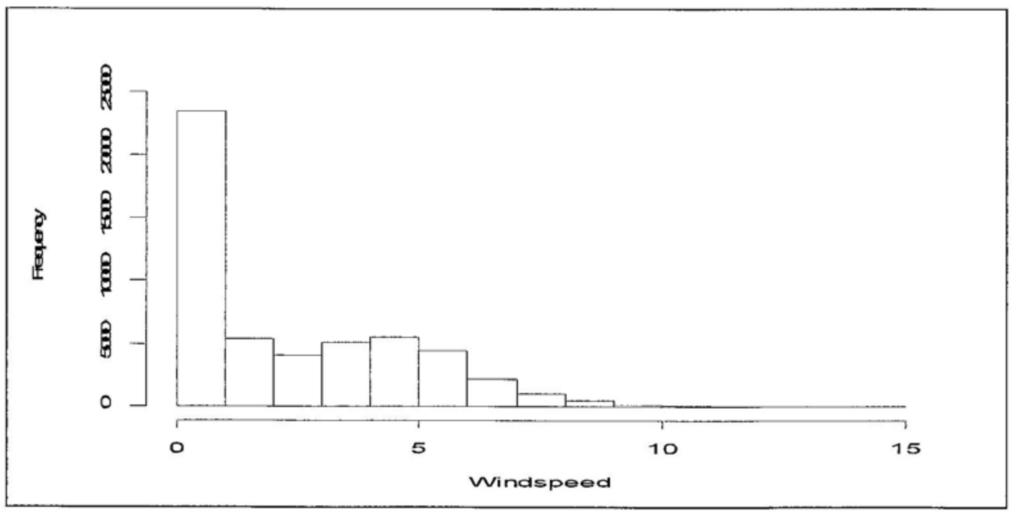

Figure 6: Frequency distribution of wind speed at site B at 10 metre height

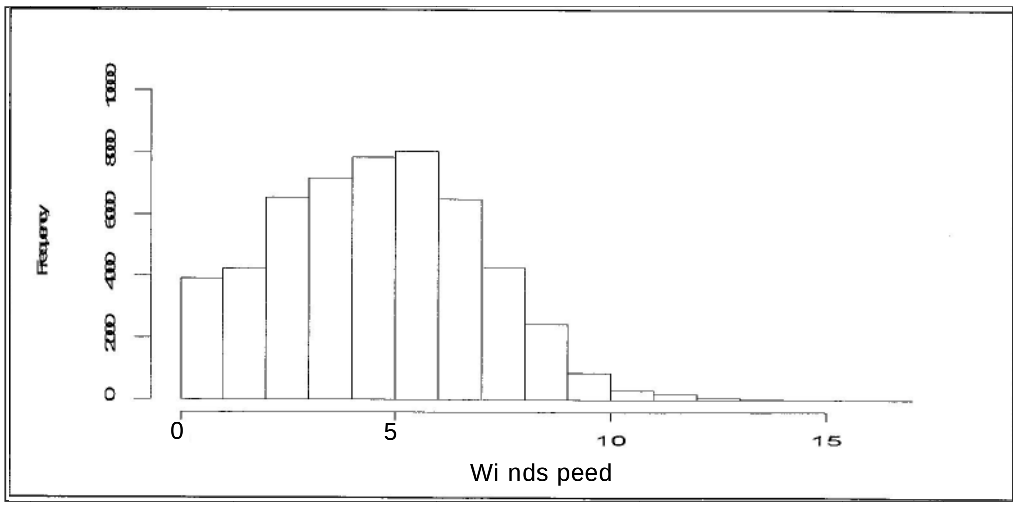

Figure 7: Frequency distribution of wind speed at site B at 30 metres height

However, Figure 6 shows that at 10 m, Site B is worse in terms of wind speed than Site A. Hence, the wind catch at this height is far from sufficient to generate electricity. The wind speed at 10 m height dropped from then onwards for this analysis.

Figure 7 shows a much better trend in terms of being feasible for generating electricity. Although the mode is 0.4, it peaked at a point greater than five m/s, which means that the modal class has both its lower class level (LCL) and upper class level (UCL) at greater than five m/s. With the mean of 4.61133 and median of 4.6, the distribution is approaching normal. Therefore, estimates using the normal distribution is much safer here than those of Site A.

Figure 8 shows distribution at the height of 30 m. About 45 percent of the readings are five m/s or more with a 95 percent estimate of the expected wind speed between 4.58 and 4.62 m/s (or an estimate of 4.6 with a margin of error of 0.02).

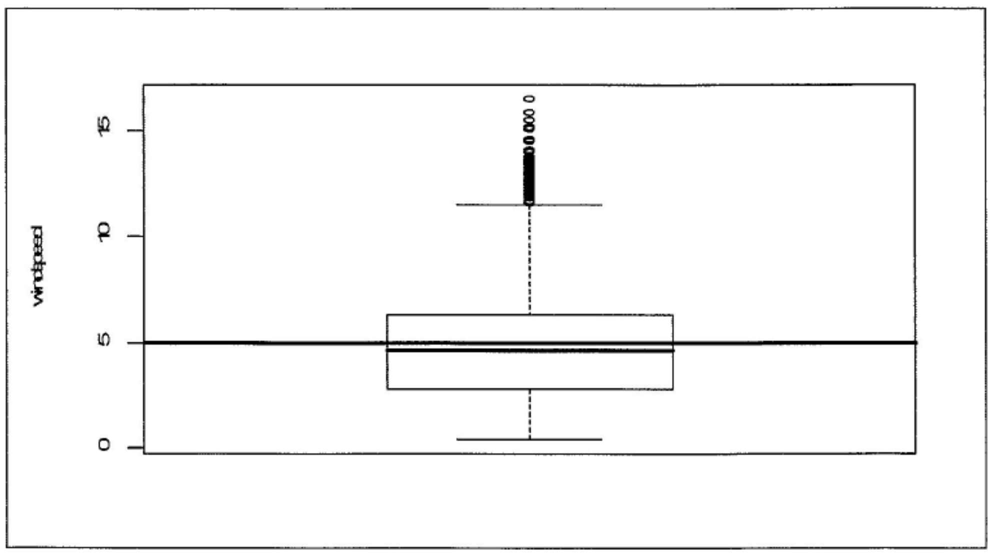

Figure 8: Box plot for wind speeds at 30 metres height at site B

Figure 9 and Table 2 show that there were only five months (June, July, August and September of 2007 and June 2008) in which wind speed exceed the five m/s mark, but according to their monthly variance the wind speed variability is great.

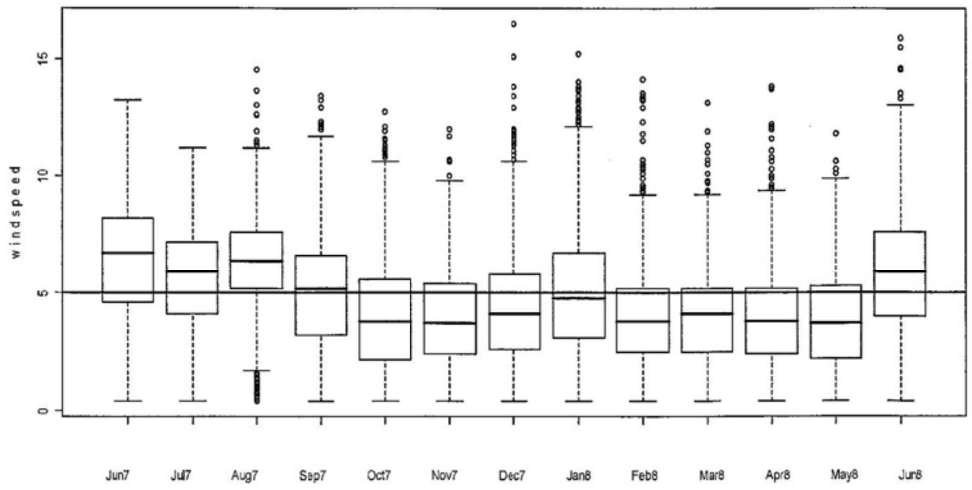

Figure 9: Monthly comparison of wind speed at 30 metre height at site B

Table 2: Statistical data at 30 metre height at site B

	Monthly median	Monthly variance	Number of readings	95% Confidence interval	Proportion greater than 5 m/s
Jun-07	6.7	6.7560	2226		
Jul-07	5.9	4.5765	4464	(5.8372, 5.9628)	0.65
Aug-07	6.4	3.4570	4464	(6.3455, 6.4545)	0.80
Sep-07	5.2	5.1200	4320	(5.1325, 5.2675)	0.56
Jun-08	5.9	6.4259	1818	(5.7835, 6.0165)	0.65

Discussion

Results from Site A show that wind energy source does not meet the required speed of five m/s. There were only two months out of the fifteen (15) months, that were able to record wind speed that satisfies the required specification for a wind turbine to operate. As indicated in Figure 5, although the wind speed at these two months of June and August 2007 seem to be feasible, the statistical analysis in Table 1 show that they do not guarantee to operate satisfactorily because of the large variance. A large variance means that wind speeds vary a lot and are not stable to an average value. Wind turbines by design require continuous stable wind flow for constant electricity supply, whereas huge wind speed variability is undesirable for its operation. Again, Site B shows similar results as in Site A, but Site B seems to be more promising as there were more months that recorded the median wind speed beyond the target speed of five m/s as indicated in Figure 9 and Table 2. But as the results in Site A, Table 2 shows that all the five months had huge variance indicating unstable wind speed, which were not desirable for wind turbine operation. Therefore, none of the months were feasible in Site B.

Conclusion

This initial two year feasibility study on wind energy in Samoa indicate that the two sites were not feasible to drive commercial wind turbines. There was no month throughout the study that satisfactorily met the require specification although there were wind speed beyond five m/s but the monthly variance were great which were undesirable for wind turbines operation.

Recommendations

The current analysis should not be discouraging for Samoa's hope in wind renewable energy as an energy source as this is just an initial wind energy assessment.

Future research should consider the following:

1. Previous studies have found that there is a direct positive correlation between wind speed and height. The maximum height in which wind speed was collected in this study was 30 m. Therefore, it was expected that wind speed above the 30 m height was feasible. Commercial wind turbines that are used to generate electricity in many

developed countries have wind turbines installed at heights way above 65 m. Therefore, further assessment at similar heights for Samoa could be done.

2. There were only two sites selected for this study. It is important that more studies are to be done to locate potential sites for wind power generation, as wind speed vary according to Samoa's mountainous topologies (Tuiafiso 2009).

3. The period of the study was only two years. Therefore, a long term based study is necessary as the behaviour of prevailing trade wind patterns may alter due to climate change and global warming.

Acknowledgements

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