# Solar and Wind Energy Resource Assessment in Nepal

# Final Report

Submitted to:

**Alternative Energy Promotion Center**
**His Majesty's Government**
**Ministry of Environment, Science and Technology**
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Submitted by:

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**Institute of Engineering**
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**Pulchowk, Lalitpur**

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Prof. Jagan Nath Shrestha
Director

# Executive Summary

In order to provide a detail solar and wind resource data and geographic information assessment tools to public and private sector executives who are involved in the renewable energy market development, the Environment fund of UNEP and Alternative Energy Promotion Center Signed the SWERA Project in 12 March 2003. The project was for 3 years from 2002 to 2004 and has been extended till the end of 2005. A memorandum of understanding was signed between the Alternative Energy Promotion Center (AEPC), National executive agency and the Center for Energy Studies (CES), Institute of Engineering (IOE) on 10 March 2004 to carry out the Solar and Wind Energy Resource Assessment (SWERA) in Nepal.

Global Horizontal Solar Irradiance is developed based on a linear regression model that has been developed to correlate the theoretical and ground measured solar irradiance on the basis of available ground measured Global Horizontal Solar Irradiance at three locations: a) Syangboche (Solukhumbu) b) Pulchowk (Lalitpur) and c) Prakashpur (Sunsari). These locations represent the three different geographical regions: Mountain, Hill and Plain. The model is used for converting the theoretical Global Horizontal Solar Irradiance to actual solar irradiance in 15 meteorological stations spread throughout the country. Interpolating the data obtained at these stations, a map has been developed using ArcView GIS software. Each of these stations is located at each geographical region in five-development region. The solar map developed shows 4.7 $kWh/m^2$/day annual average Global Horizontal Solar Irradiance in Nepal. At present, on absence of any solar energy mapping, the map developed might be useful for estimating solar energy potential in the country. In order to make it more accurate, more ground measured data should be further analysed and included. Thus, recording of ground measured data should be initiated and continued for several years.

The existing methodology for projecting wind speed at 2m height from DHM meteorological station data to 10m height, shows a deviated figures. In other to develop wind map, valid methodology is required which can project the low height wind speed to higher heights. The projected data (Thini and Thakmarpha) when compared with the ground measured data for consistency, power coefficient obtained is found to be variable. It primarily depends upon the geographic locations and the particular month. Also, the wind speed varies a lot as per the surrounding environment. Thus the analysis of the wind data and modeling in this study shows

an initial result on wind speed projection. Thus, with further analysis on this part, fruitful result can be expected but it is really important and is a must to install anemometers at different height at the same stations so that a valid relation between wind speed at different height could be projected. WAsP software might be very useful in this analysis. Hence, measurement of wind data at the existing sites need to be continued and installations of more wind data measurement stations in different region should be initiated. In order to predict effectively the wind speed at different height the detail information including topography at the respective site should be made available so that WAsP analysis can be performed.

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# Abbreviations

| | |
|---|---|
| AEPC | Alternative Energy Promotion Center |
| AWS | Automated Weather Stations |
| CES | Center for Energy Studies |
| DHM | Department of Hydrology and Meteorology |
| GHI | Global Horizontal Irradiance |
| GIS | Geographical Information System |
| HMG | His Majesty's Government |
| IDW | Inverse Distance Weighted |
| IOE | Institute of Engineering |
| SWERA | Solar and Wind Energy Resource Assessment |
| TU | Tribhuvan University |
| UNEP | United Nations Environment Programme |

## 1. Introduction

In order to provide a detail solar and wind resource data and geographic information assessment tools to public and private sector executives who are involved in the renewable energy market development, the Environment fund of UNEP and Alternative Energy Promotion Center Signed the SWERA Project in 12 March 2003. The project was for 3 years from 2002 to 2004 and was extended till the end of 2005. A memorandum of understanding was signed between the Alternative Energy Promotion Center (AEPC), National executive agency and the Center for Energy Studies (CES), Institute of Engineering (IOE) on 10 March 2004 to carry out the Solar and Wind Energy Resource Assessment (SWERA) in Nepal.

Availability of data on solar irradiance and wind speed is essential for the development of national rural energy programs in general and in particular for the establishment of solar and wind energy technology. Solar Photovoltaic Systems, Solar Photovoltaic Water Pumping systems, solar thermal water heaters are some of the solar technologies that have been used in the country. Also, solar thermal space heating and illumination in buildings are already in practice. It is estimated about 2600 $kW_P$ of photovoltaic power (PV) is being utilized in various parts of Nepal by different organizations. Similarly, Solar thermal technologies, such as solar water heating systems, solar dryer, solar cookers are being utilizing in different parts of Nepal. An estimated 17,265 households, 270 commercial establishments and 26 public institutions are now using solar water heaters (SWH)[*]. Few wind power generators are being installed so far. His Majesty's Government of Nepal has put emphasis on promotion of renewable energy technologies like solar and wind energy in its five-year plans. There is possibility of large-scale development in solar and wind energy technologies in near future in the country.

Studies suggest high potential solar and wind energy resource in the country. Basically river corridors in mountain valleys have been observed to have high wind potential. Possibly, there could have been an extensive investment in these technologies from government and private sectors. But the unavailability of the measure of solar irradiance and wind speed in the country has been the major barrier so far for its development and investments on these technologies.

[*] Renewable Energy Perspective Plan 2000-2020

Thus this project aims to develop an indicator for solar and wind energy resource through out the country. This project mainly demonstrates the use of this indicator in investment and builds up decision-making capacity in policy level. The project will enable private sector investors and public policy makers to assess the technical economical and environmental potential for large-scale investment in solar and wind energy technology in the country.

## 2. Objective

The main objective of the SWERA project is to make available and accessible reliable, high resolution solar and wind energy resource information, thereby removing a significant barrier to widespread use of clean solar and wind technology. The availability of these data will facilitate better planning for Solar and/or Wind Energy development.

## 3. Scope of work

The scope of the project consists of resource assessment methodology and information review; collection, gathering and maintaining of the resource database in the standard formats; development of the resource mapping methodologies; process data sets and perform critical analysis of data quality with reference to the cross-model comparisons and validations studies; and come out with the standard time series database and methodologies on the resource mapping for the solar and wind resource assessment. The results obtained from the solar resource assessment and wind resource assessment of the project should help in an effective manner to facilitate solar technology investment and wind technology investment in the country, help to develop understanding of how the resource data are developed, help to improve the ability to undertake measurement programs for further validation of data as well as site-specific pre-feasibility studies. The outcomes of the project should equally helpful for the investors, energy planners, academicians and all the energy related professionals.

## 4. Methodology:

### 4.1 Solar Energy Mapping

*Linear Regression Analysis*

A linear regression analysis is carried out in order to develop a relationship between the ratio of Sunshine hour and the theoretical day length to the ratio of the ground measured solar radiation data and the theoretical solar radiation data for two districts (Kathmandu and Sunsari) where ground measured data and measured sunshine hour data was available for five stations in each district. This methodology is generally used to predict the solar irradiance using calculated theoretical solar irradiance. The equation used for linear regression is as follows:

$$(H_i/H_d) = a + b\,(n_i/N_d) \text{ --------------------------- } (1)$$

Where, $H_i$ = theoretical clear sky solar radiation, $kWh/m^2$
$H_d$ = ground measured global horizontal irradiance, $kWh/m^2$
$n_i$ = theoretical day length, hr
$N_d$ = Sunshine hour measured, hr

But the regression analysis obtained for equation (1) was not satisfactory. The regression coefficients for five stations within the same district highly deviates from its average values. Basically, for this analysis, the monthly average values were used for the regression for each station. The measured monthly average sunshine hour data is only available. So, the regression was based on the 12 data points. Thus, it can be concluded that the 12 monthly data point is not enough for this kind of regression analysis. Also, the results obtained shows that the coefficients vary as per the geographical region.

*Modified Linear Regression Analysis*

A modified linear regression analysis between ground measured solar irradiance with theoretical solar irradiance for every day has been done. The analysis has been done for three different geographical regions i.e. Mountain, Hill and Plain.

The theoretically calculated global irradiance is generated using PVSYST V3.3 software. For generating global irradiance, the software uses well-established random algorithms generated by Aguiar et al., which produce hourly distributions presenting statistical properties very close to real data. The algorithm first constructs a random sequence of daily values, using a Library of Markov Transition Matrices (probability matrices) constructed from real meteo hourly data of several dozen of stations all over the world. Then it applies a time-dependent, Autoregressive, Gaussian Model for generating the hourly sequences for each day.

The linear regression equation obtained for modeling is as below:

$$I_{mi} = a_i + b_i * I_{ti} \text{ ----------------------------------- } (2)$$

Where, $I_m$ = Ground measured average daily Global Solar Irradiance, kWh/m$^2$/day

$I_t$ = Theoretically calculated daily Global Solar Irradiance, kWh/m$^2$/day

$a_i$ and $b_i$ = regression coefficients for *i* region

$i = m$, *h* and *p* for geographic regions i.e. *m* for Mountain, *h* for Hill and *p* for Plain.

The three stations being used for the modeling (Eq. 2.) is given in Table 1. The selection of these stations is based on the fact that the ground measured solar irradiance is available only at these stations so far.

Table 1: Stations used for the regression modeling

| S. N. | Region | Location | Latitude ($^o$N) | Longitude ($^o$E) | Altitude (m) | Regression Coefficients | |
|---|---|---|---|---|---|---|---|
| | | | | | | *a* | *b* |
| 1. | Mountain | Syangboche | 27.81 | 86.71 | 3700 | 3.892 | 0.1538 |
| 2. | Hill | Pulchowk | 27.64 | 85.38 | 1310 | 4.658 | 0.063 |
| 3. | Plain | Prakashpur | 26.64 | 87.15 | 67 m | 1.641 | 0.348 |

*Data processing*

In order to develop a map, attempt is made to select one existing meteorological station from each geographical region for each development region of Nepal. These meteorological stations are being selected for data processing such that these stations spread over the country map. The description of the stations being selected are given in Table 2:

Table 2: Description of met station points selected

| S. N. | Development Region | Geographical Region | Station Name | Latitude (°N) | Longitude (°E) | Altitude (m) |
|---|---|---|---|---|---|---|
| 1. | Eastern | Mountain | Chepuwa | 27.8 | 87.4 | 2590 |
| 2. | Eastern | Hill | Ilam | 26.9 | 87.9 | 1300 |
| 3. | Eastern | Plain | Biratnagar | 26.5 | 87.3 | 72 |
| 4. | Central | Mountain | Timure | 28.3 | 85.4 | 1900 |
| 5. | Central | Mountain | Dhunche | 28.1 | 85.3 | 1982 |
| 6. | Central | Hill | Rammechap | 27.3 | 86.1 | 1395 |
| 7. | Central | Plain | Simara | 27.2 | 85.0 | 130 |
| 8. | Western | Mountain | Chame | 28.6 | 84.2 | 2680 |
| 9. | Western | Hill | Damauli | 28.0 | 84.3 | 358 |
| 10. | Western | Plain | Lumbini | 27.5 | 83.3 | 95 |
| 11. | Mid Western | Mountain | Simikot | 30.0 | 81.8 | 2800 |
| 12. | Mid Western | Hill | Surkhet | 28.6 | 81.6 | 720 |
| 13. | Mid Western | Plain | Nepalgunj | 28.1 | 81.6 | 144 |
| 14. | Far Western | Hill | Chainpur | 29.6 | 81.2 | 1304 |
| 15. | Far Western | Plain | Dhangadi | 28.7 | 80.9 | 195 |

Source: Department of Hydrology and Meteorology, HMG/Nepal

The theoretical global solar irradiance is generated for each meteorological station point using PVSYST 3.3 Software for a year. Predicted ground global solar irradiance for each meteorological station is estimated using Eq. 2 (*Annex 2*).

*Generation of Map*

The predicted ground global solar irradiance estimated for each meteorological station is being averaged for each month. These monthly average data are being entered into ArcView GIS 3.2 Software as points located at each meteorological station. The Inverse Distance Weighted (IDW) interpolator is being used to interpolate the data in between points.

4.2 Wind Energy Mapping

As per the proposed methodology, wind speed measured at different meteorological stations of Department of Hydrology and Meteorology (DHM), HMG of Nepal needed to be projected for different heights. These wind anemometer installed at these stations are at the height of 2m to 4m height. Theoretically wind speed increases with the height with respect to ground height or surface level. The standard empirical formula by Ir. H. Svel is given as below which is in general used to project the observed wind speed to the wind speed at desired height (This law is also known as Power Law):

*Power Law*:

$$\frac{V_h}{V_{ref}} = \left[\frac{h}{h_{ref}}\right]^x \text{ ---------------------- (3)}$$

Where, '$V_{ref}$' is wind velocity at reference height '$h_{ref}$' of wind measuring station where wind speed data is available and '$V_h$' is the wind velocity at the desired height '$h$', '$x$' is the power.

Similarly, Prandle law gives the projected wind speed as per following expression, which is also known as Logarithmic Law:

*Logarithmic Law*:

$$V_1 = V_2 \frac{\log \frac{h_1}{H_0}}{\log \frac{h_2}{H_0}} \text{ ------------------------------ (4)}$$

Where, '$V_1$' and '$V_2$' are respectively wind velocity at height $h_1$ and $h_2$ respectively. $H_0$ is the roughness height and is taken as 0.3m, which is generally taken for farmland with many trees, forests etc. villages

## 5. Data Collection and Results

### 5.1 Solar Energy

*Ground Measured Data*

CES, with support from AEPC had conducted Solar Energy Resource Mapping in 2000/01 in two districts: Kathmandu and Sunsari. Global Horizontal Solar Irradiance was recorded in five stations in each district. The data from Syangboche was collected from DHM Archive. DHM has been recording Global Horizontal Irradiance by using an Automated Weather Station (AWS) in

Syangboche for last few years. The ground measured Global Horizontal Solar Irradiance recorded in these three stations are given in Table 3. The data was recorded in different time period. Syangboche data was recorded in year 2002 for 12 months. The data for Pulchowk and Sunsari were recorded in 2000 from June to December and in 2001 from January to May.

Table 3. Monthly average Ground Measured Global Horizontal Solar Irradiance, $kWh/m^2/day$

| Location | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Syangboche** | 4.61 | 4.66 | 6.15 | 7.14 | 5.17 | 5.04 | 4.53 | 4.71 | 4.28 | 4.99 | 4.81 | 4.03 | 5.01 |
| **Pulchowk** | 4.75 | 6.49 | 5.51 | 5.63 | 4.3 | 5.14 | 5.62 | 4.59 | 4.68 | 6.57 | 4.12 | 4.01 | 5.12 |
| **Prakashpur** | 4.41 | 3.55 | 4.41 | 5.61 | 4.74 | 4.41 | 4.31 | 4.47 | 4.03 | 4.95 | 3.42 | 3.57 | 4.32 |

*Theoretical Data*

The theoretical data are generated for the meteorological stations of Syangboche, Kathmandu and Sunsari for the stations Syangboche, Pulchowk and Prakashpur (Table 4). PYSYST V3.3 Software is used to generate these data.

Table 4 Monthly average Theoretical Global Horizontal Solar Irradiance, $kWh/m^2/day$

| Location | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Syangboche** | 4.92 | 6.02 | 7.35 | 8.47 | 9.10 | 9.30 | 9.19 | 8.69 | 7.75 | 6.45 | 5.20 | 4.55 | 7.25 |
| **Pulchowk** | 4.61 | 5.66 | 6.92 | 7.98 | 8.57 | 8.75 | 8.64 | 8.17 | 7.27 | 6.02 | 4.84 | 4.24 | 6.81 |
| **Prakashpur** | 4.58 | 5.58 | 6.77 | 7.74 | 8.26 | 8.41 | 8.31 | 7.90 | 7.08 | 5.92 | 4.80 | 4.23 | 6.63 |

The regression coefficients obtained for these regions are given in Table 5.

Table 5. Regression coefficients obtained

| Region | Location | Regression Coefficients | |
|---|---|---|---|
| | | *a* | *b* |
| Mountain | Syangboche | 3.892 | 0.1538 |
| Hill | Pulchowk | 4.658 | 0.063 |
| Plain | Prakashpur | 1.641 | 0.348 |

Using Eq. 2, Global Horizontal Irradiance is projected to 15 meteorological stations for each month. The annual average GHI for each meteorological station is given in Table 6. According to this result, the annual average GHI for Nepal, is obtained as 4.7 kWh/m2/day.

Table 6. Annual Average Global Horizontal Solar Irradiance for Nepal

| **Meteorological Station** | **GHI (kWh/m$^2$/day)** |
|---|---|
| Biratnagar | 4.0 |
| Chainpur | 5.1 |
| Chame | 5.0 |
| Chepuwa | 5.0 |
| Damauli | 5.1 |
| Dhangadhi | 3.9 |
| Dhunche | 4.9 |
| Ilam | 5.1 |
| Lumbini | 3.9 |
| Nepalgunj | 3.9 |
| Ramechhap | 5.1 |
| Simara | 3.9 |
| Simikot | 5.0 |
| Surkhet | 5.1 |
| Timure | 5.0 |
| **Average** | **4.7** |

The Global Horizontal Solar Irradiance Map for annual average interpolated using ArcView GIS 3.2 Software is given in Figure 1. The Global Horizontal Solar Irradiance Map for every month obtained for the country is given in Annex 1 to 12.

Figure 1
Annual Average Global Horizontal Solar Irradiance, kWh/m$^2$/day

## 5.2. Wind Energy Mapping

*Ground Measured Data*

AEPC has been recording wind data for last several years. The details of the stations are as below:

1. Nagarkot - Year 2001, 2002, 2003 (Anemometer height: 10m and 20m)
2. Butwal - Year 2001, 2002, 2003, Palpa Year 2003 (Anemometer height: 10m and 20m)
3. Kagbeni – Year 2001, 2002, 2003 (Anemometer height: 10m and 20m)
4. Thini – Year 2001, 2002, 2003 (Anemometer height: 10m and 20m)
5. Okhaldhunga – Year 2001, 2002, 2003 (Anemometer height: 10m and 20m)

The ground measured data from these stations were collected from Mr. Mangal Maharjan, AEPC. These data were recorded in the interval of 1 hour and at 10m anemometer height and 20m anemometer height.

DHM has been collecting wind speed data in several meteorological stations (about 64 stations) spread throughout the country for last several years. But the wind data recorded by DHM were mainly for agriculture purpose and were not much useful for wind energy purpose since most of the anemometer heights were at 2m to 3m. However some of these anemometers heights were at the height of 4m-5m and even 10m from the ground. But these anemometers were being kept on the roof of the station building. No data on direction of winds and surround environment were recorded consistently.

*Wind Data Projection*

In order to construct wind map, an attempt is made to project the wind speed at 2m height from DHM meteorological station data to 10m height. The projected data is then compared with the ground measured data for consistency. A case study of Thini station is carried out for this purpose. Thini station has ground measured 10m and 20m height anemometer station and it is recording wind speed and direction data since 2001. Thakmarpha is the nearest DHM meteorological station to Thini. For the purpose of this analysis, it is assumed that the average wind speed does not vary much between these two stations. The wind speed at 2.7m height at

Thakmarpha is projected to 10m height wind speed using Power law (Eq. 3) and Logarithmic Law (Eq. 4) (Table 7).

Table 7. Projection of wind speed at 10m height

| Wind Speed | | | | |
|---|---|---|---|---|
| | **DHM** | **Measured in Thini** | **Power Law (x = 1/7)** | **Logarithmic Law** |
| Height | 2.7m | 10m | 10m | 10m |
| Units | m/s | m/s | m/s | m/s |
| Jan | 4.7 | 4.8 | 5.7 | 7.5 |
| Feb | 5.0 | 5.0 | 6.0 | 7.9 |
| Mar | 5.5 | 6.5 | 6.6 | 8.7 |
| Apr | 4.1 | 6.1 | 4.9 | 6.5 |
| May | 4.9 | 7.4 | 5.9 | 7.8 |
| Jun | 5.2 | 8.9 | 6.3 | 8.3 |
| Jul | 5.1 | 8.3 | 6.1 | 8.1 |
| Aug | 4.9 | 7.3 | 5.9 | 7.8 |
| Sep | 4.6 | 7.3 | 5.5 | 7.3 |
| Oct | 4.3 | 6.0 | 5.2 | 6.8 |
| Nov | 4.3 | 5.5 | 5.2 | 6.9 |
| Dec | 3.8 | 5.3 | 4.6 | 6.1 |

The comparison shows deviation from the measured wind speed (Figure 2). Two things can be noted in the figure. First, the deviation is high during June in Power Law and low in other months but in Logarithmic Law the deviation is high in other months except June where it is low. Second, the deviation is not consistent in the months for both laws. Thus, for this study Power law is chosen for further modeling. Since the deviation is not consistent, power (x) is further explored in order to predict the exact measured wind speed using Power law. The values for power (x) is obtained as in Figure (3)

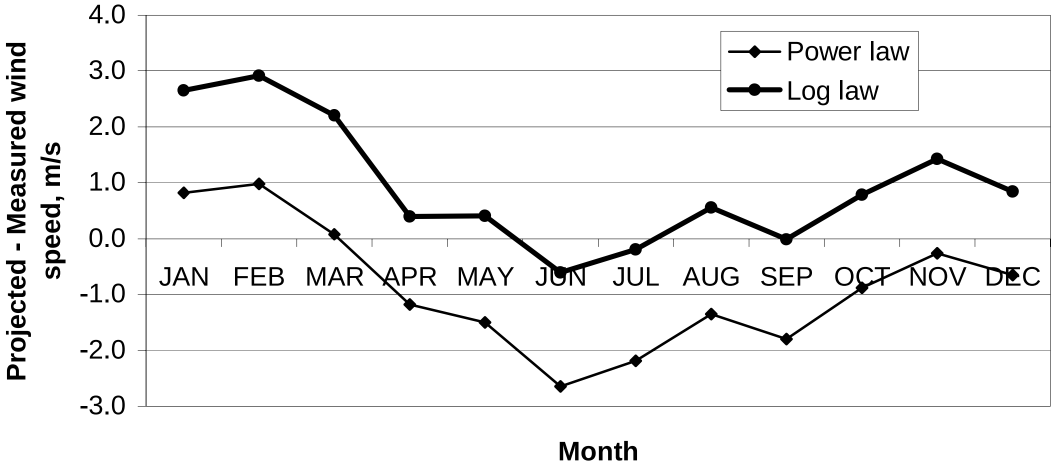



Figure 2. Deviation of projected wind speed for Thakmarpha station

It can be noted that 'x' in Power law is different for different month and might be different for different places. An attempt was tried to predict the values of 'x' using the ambient temperatures, but it could not establish good correlation and is subject to further research analysis.

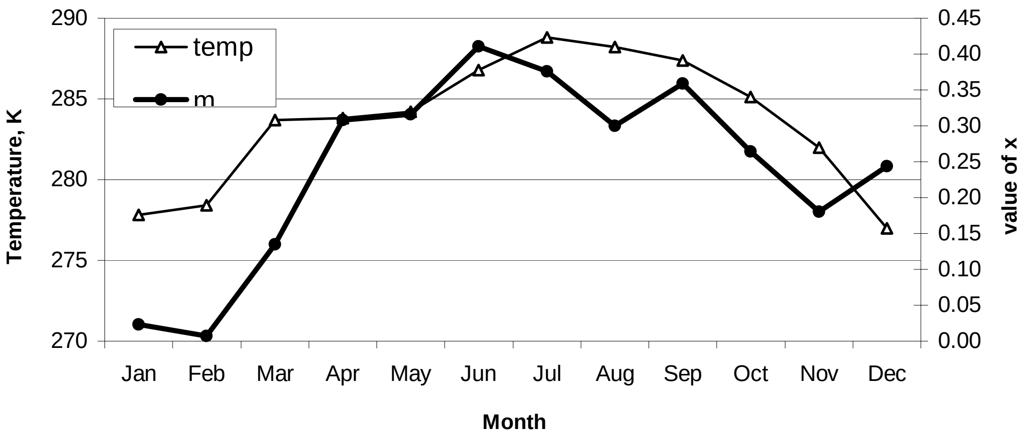



Figure 3. Variation in 'x' values in Power law observed for Thakmarpha station

One critical thing to be noted in above analysis, that 2.7m height wind speed is not measured at exactly same place where 10m height anemometer is located and the recording period is not concurrent. Studies also suggest that wind speed differ even if the wind speed is recorded at same region but at different location (Hydro Engineering, 2001). All the 10m and 20m height anemometer stations installed for wind speed measurement does not have anemometers at 2m height due to which the analysis may not be appropriate.

A study on Okhaldhunga wind speed projection also has similar kind of result for 'x' values (Table 8). The study was carried out for 6 months in 2001 (Hydro Engineering, 2001).

Table 8. 'x' values in Power law for Okhaldhunga

| **Month** | **x** |
|---|---|
| May | 0.3406 |
| June | 0.3437 |
| July | 0.3471 |
| August | 0.4747 |
| September | 0.6313 |
| October | 0.4482 |

As per the MoU signed, CES received WAsP software from Risoe Laboratory for wind energy assessment. The available hourly wind data received from Mr. Mangal Maharjan, AEPC are tried to process using this software. Wind roses are developed and summary of the wind data at the particular station are developed for 10m and 20m height. As WAsP projects the wind speed according to the obstacles and the roughness change around the station, further calculation are not possible due to the lack of topography and the information about the obstacles in the site.

Wind roses developed for Butwal, Nagarkot and Thini are given in Figure 4, 5 and 6 respectively.

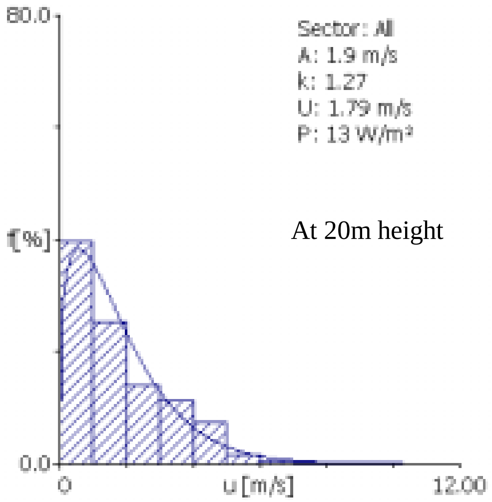
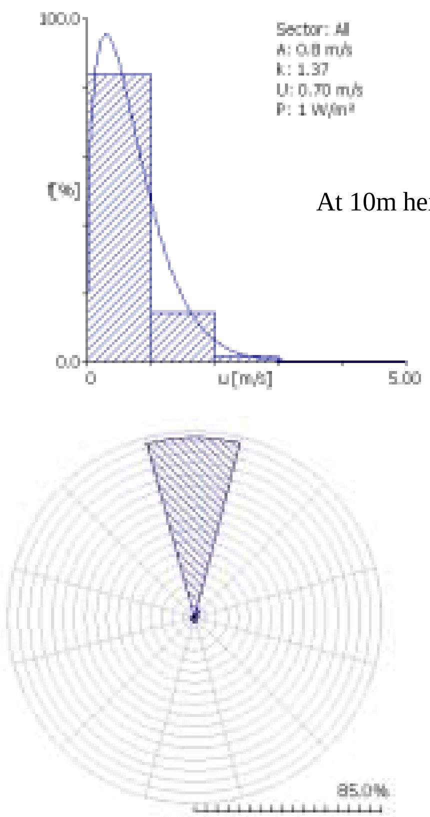



Figure 4: Wind Speed at Butwal (Wind Vane not working)



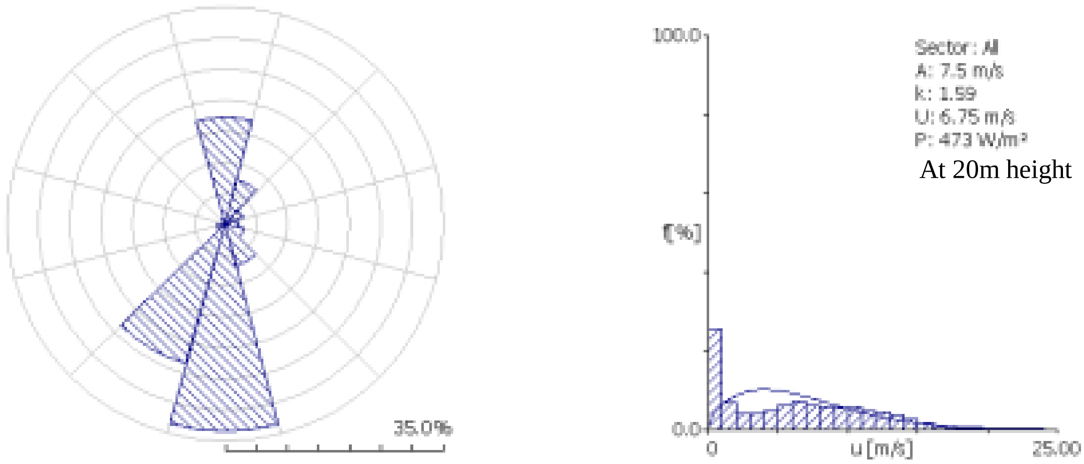
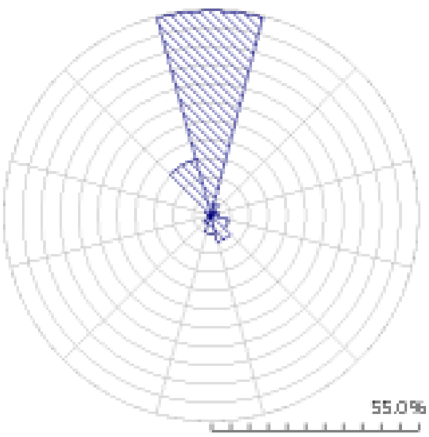



Figure 5: Wind Speed at Thini

These wind speed distribution needed to be further analyzed to explore the seasonal variation. Also the topographical details along with the obstacles present in the station are required in order to further analyze the wind energy potential in the respective site.



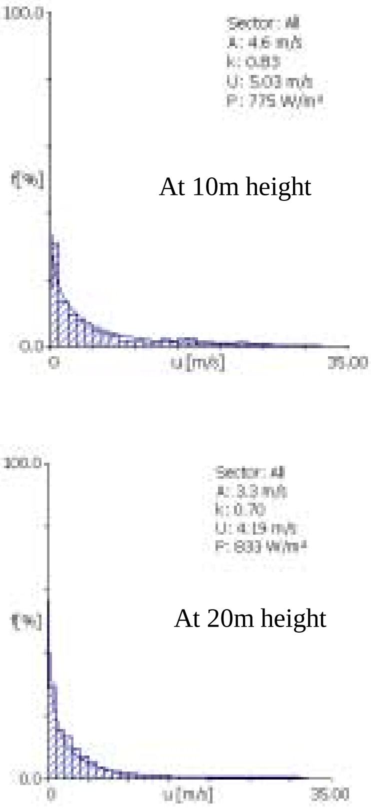




Figure 6: Wind Speed at Nagarkot

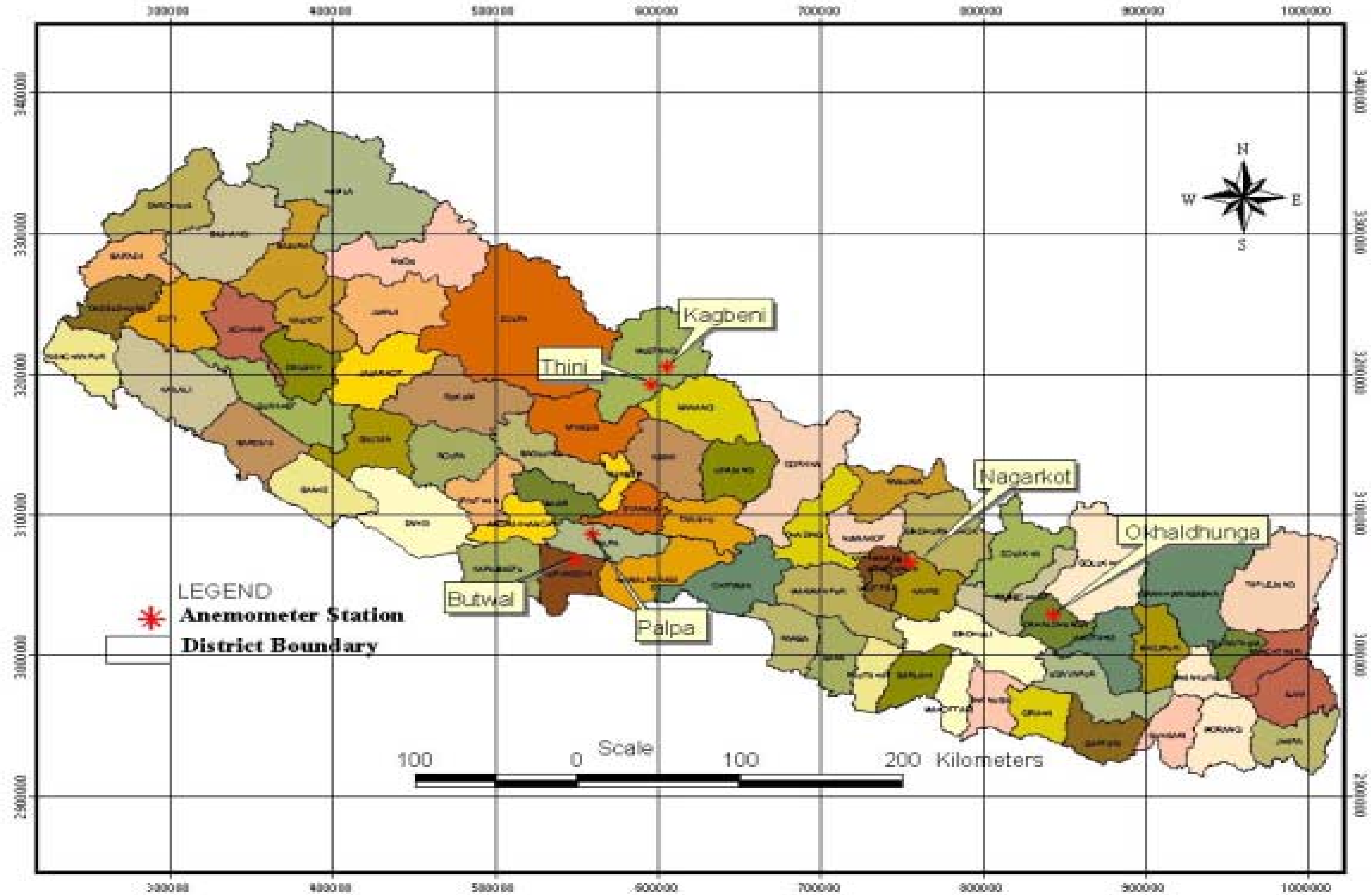



Figure 7: Location of wind anemometer stations

## 6. Conclusions and Recommendations

### 6.1 Solar Energy

The solar energy mapping constructed is on the basis of 3 ground measured data point recorded at Syangboche (Solukhumbu - Mountain side), Pulchowk (Lalitpur - hill side) and Prakashpur (Sunsari - Plain side). It is projected to 15 meteorological stations using simple linear regression analysis between theoretical values and the measured values for Global Horizontal Solar Irradiance. Each of these stations is located at each geographical region in five-development region. At present, on absence of any solar energy mapping, the map developed might be useful for estimating solar energy potential in the country. The solar map developed shows 4.7 $kWh/m^2/day$ annual average Global Horizontal Solar Irradiance in Nepal. In order to make it more accurate, more ground measured data should be further analysed and included. Thus, recording of ground measured data should be initiated and continued for several years.

### 6.2 Wind Energy

In other to develop wind map, valid methodology is required which can project the low height wind speed to higher heights. The analysis of the wind data and modeling in this study shows an initial result on wind speed projection. Thus, with further analysis on this part, fruitful result can be expected but it is really important and is a must to install anemometers at different height at the same stations so that a valid relation between wind speed at different height could be projected. WAsP software might be very useful in this analysis. Thus, measurement of wind data at the existing sites need to be continued and installations of more wind data measurement stations in different region should be initiated. In order to predict effectively the wind speed at different height the detail information including topography at the respective site should be made available so that WAsP analysis can be performed.

# ANNEX

a) Monthly maps Jan to Dec - 12 maps

b) Ground Measured Solar Irradiance at 3 locations

c) Predicted GHI at 15 locations

d) Wind speed data collected at five stations