REPORT B :

WIND MONITORING

AND LONG TERM CORRELATION.

(IN SITU MEASUREMENT FROM 18TH APRIL 2001 TO 10 JULY 2002)

TABLE OF CONTENTS

I • INSTALLATION OF THE MONITORING MAST

The conclusion of the numerical simulation was that the most appropriate site is South-Est from Oneroa village, on the hill where Tumakatea village Water Tanks are already installed.

A survey prepared in close co-operation with SPC and the Ministry of Works, Energy and Physical Planning (MOWEPP) was carried out between 15 and 21 april 2001, to install the wind monitoring mast on the selected site. Beside the installation of the mast, this survey was used to install a logger of electric parameters in the Power plant.

The training of people concerned by the follow up of the monitoring campaign (MOWEPP, Mangaia Power Plant staff, Mangaia School teachers) was also carried out during this period.

Pictures below show the installation of the 30 meters height monitoring mast, which monitors the wind direction, and wind speeds at 20 and 30 meters above ground level.

erection of the mast

30 meters wind monitoring mast

Data collection started on 18^{tth} April 2001. The last data file received from Mangaia is covering until 10th July 2002. We then have more than one year of data available, which is quite good to draw up a precise evaluation of the wind potential of the site.

II • IN SITU MONITORING

II.1 • DATA LOGGER

The data collection is realised with NRG Systems devices, at two heights above ground level (agl).

Data available on this station is :

- 10 minutes interval average wind speeds at 20 and 30 meters agl
- Standard deviation on both speeds for this interval
- 10 minutes average wind direction at 30 m agl

II.2 • MONITORING PERIOD AND QUALITY OF DATA

The monitoring campaign started on 18th april 2001. Data retrieval has been made each month. To date, 19 data files were transmitted to VERGNET, covering a period from 18/04/01 to 10/07/02, meaning more than one year of available data.

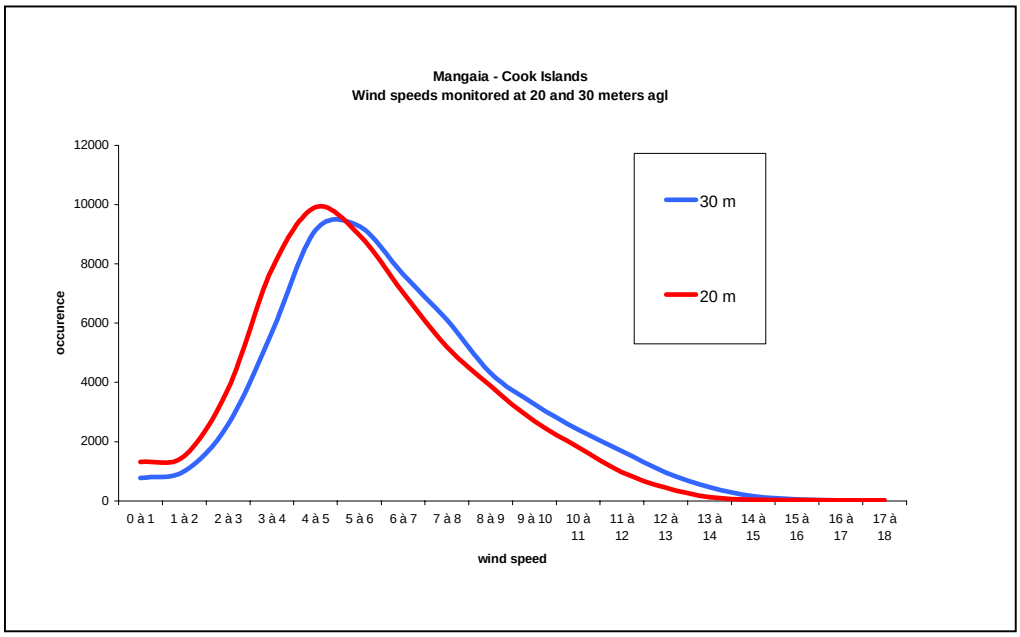
The first data retrieval included some « gaps » probably corresponding with an error in the file creation. After some correspondences between the MOWEPP and SPC-VERGNET on the right procedure to create data files, the whole data was correctly saved.

We notice a few blanks in the data : between the 6th of july 2001 and the 3rd august 2001, between the 31rst January 2002 and the 4th February 2002, between the 4th march 2002 and the 19th march 2002, and between the 15th may and the 28th may, no data are available.

III • WIND DATA ANALYSIS

III.1 • WIND SPEED

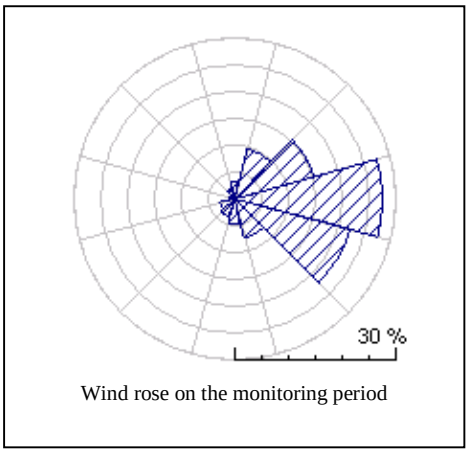
The graph presented below shows for both heights agl the distribution of the wind speeds for the whole data collection period.



We can notice that the wind potential clearly rises with the height above ground level. At 20 meters, wind speeds are 10% below 30 meters ones. The surrounding vegetation is a « brake » for the wind close to the ground. Moreover, the marked relief around the site creates, as expected, a strong speed up of the wind.

III.2 • WIND DIRECTION

The wind rose for the monitoring period is shown below.

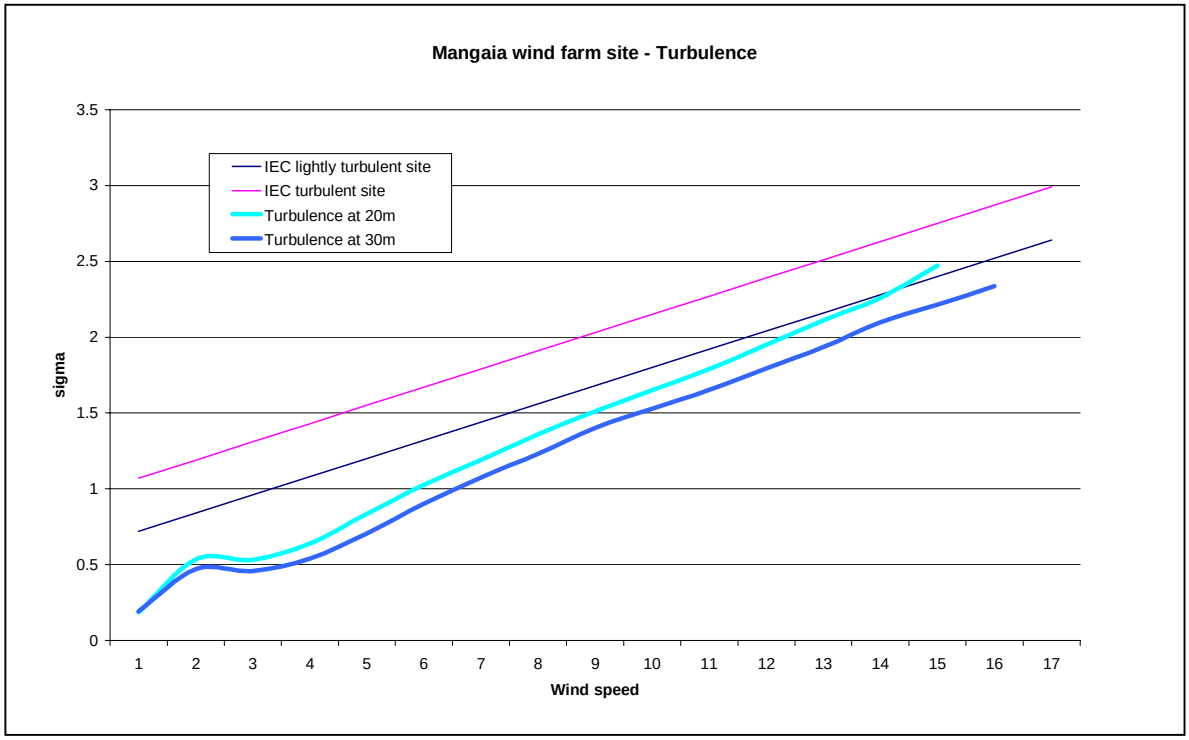


Wind rose on the monitoring period

We can notice that most of the time, **wind is coming from the East or South-East**, which is corresponding to main trade winds in the South Pacific.

III.3 • WIND TURBULENCE

The graphs below show turbulence distribution for both heights of measurements, compared with IEC 64100-1 standards for Wind Turbine Generators (WTG) holding.



We can notice that turbulence levels are below IEC standards, and are increasing as the height is decreasing. Turbulence is an important parameter as it has effects on :

- The output of the wind farm (high turbulence will lower the efficiency)
- The lifetime of the WTG (turbulence will reduce the lifetime as the constraints are increasing on the mechanical train)
- The wind power integration in the diesel grid (turbulence creates variations in the wind power, and then a strong use of the diesel gensets regulations)

Mangaia's turbulence levels 30m agl. are in the normal range, and under IEC standards. This parameter is then compatible with the implementation of the diesel connected wind project on the selected site.

III.4 • WIND SPEED SHEAR RATIO

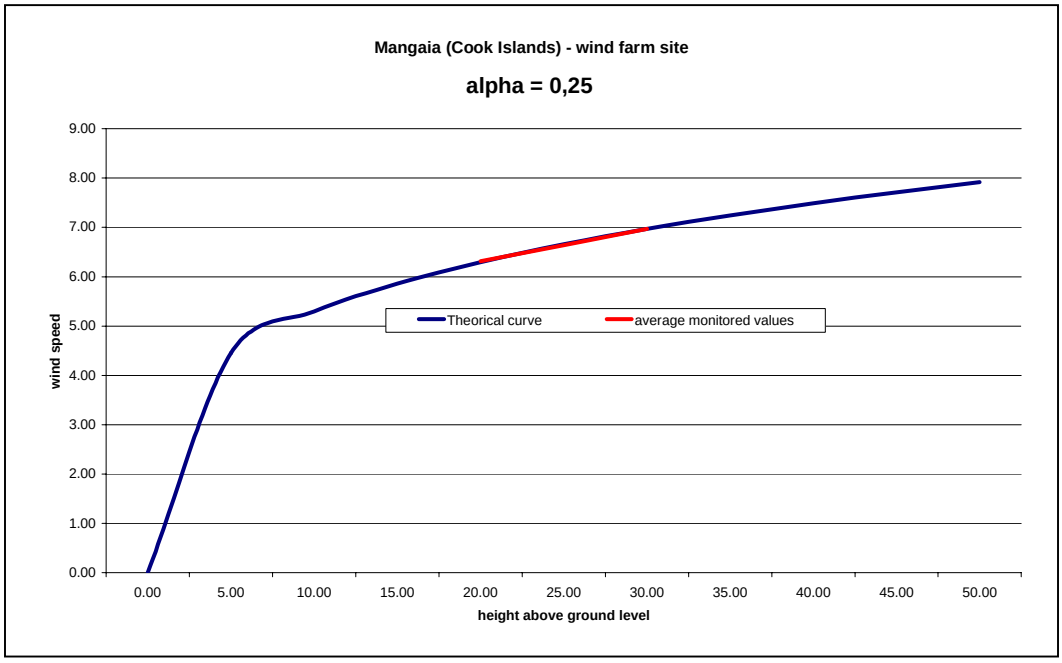
Land cover and marked relief have an important effect on wind speed up to 400 meters agl. This effect create a wind shear (the speed increases with height agl), specific to each site. The standard formula for this phenomena is shown below :

$$V_{h1} = V_{h0} \times (h1/h0)^{\alpha}$$

Where :

V_{h1}	speed at height h1
V_{h0}	speed at height h2
h1 & h0	heights of monitoring or calculating of wind speed
α	Wind shear ratio, specific for each site

In our case, we have available numerous monitored wind speeds at 20 and 30 meters agl. This data allows us to represent the wind shear and then if necessary calculate wind speeds at different heights.



The wind shear ration of the site is **α = 0,25**. This ratio is lightly higher than commonly expected for « European » sites (0,15), but not critical for the holding of WTGs. In fact a higher ratio introduces strong variations of the constraints on the rotor (speed at top of the rotor is far higher than at bottom). Even if there is no Standard on this ratio, it is accepted that a wind shear higher than 0,35 is not compatible with WTGs holding on the long term.

III.5 • FIRST CONCLUSIONS

It is now possible to draw up some preliminary conclusions on the wind potential of the site, regarding to the above paragraphs :

- Turbulence and wind shear ratio are not critical factors for the implementation of WTGs on the site.

- **The wind regime at 30 meters agl is much more interesting than at 20m. Wind speed is 10% higher, which means that the Output of WTGs will increase of 33% while going from 20 to 30 meters agl.**

- **A wind farm is then clearly technically feasible regarding to the wind regime, particularly with WTGs equipped by masts of 30 meters. In order to estimate the energy output, it is now important to study the monthly variations of the climate, and calculate the long term wind regime of the site**.

IV • MONTHLY CORRELATION OF THE MONITORED DATA

Data correlation between in situ monitoring and a meteorological station where long term data is available is important to characterise the wind regime of the site. Seasons and annual climate changes will affect the monitoring period and this correlation allows to get rid of these fluctuations.

As no statistic data is available on Mangaia, it is necessary to use data from an other island in the region. Decision was taken to use data from Rurutu Island (French Polynesia) instead of Rarotonga (Cook Islands) Meteo Station for the following reasons :

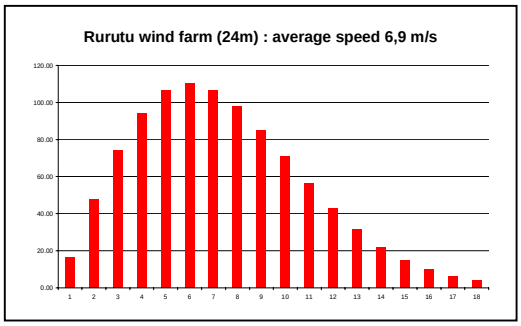
- Mangaia is located between Rurutu and Rarotonga. Distance from Mangaia to both islands are respectively 700 and 200 km. As these three islands are located almost at the same latitude (22° for Mangaia & Rurutu, 21° for Rarotonga), and no obstacle between them, they are subject to the same meteorology in terms of wind regime. Rurutu is then a correct choice for a correlation even if this island is a bit farther than Rarotonga.

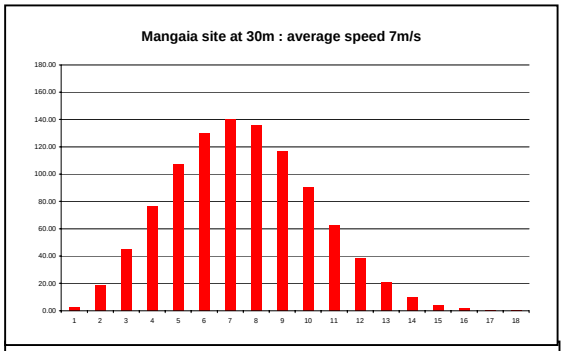
- On Rurutu is installed a wind farm, and wind is monitored permanently. Long term data is available on this site, which is well exposed to trade winds, like Mangaia site (summit of a hill, facing East, whereas Rarotonga meteo station is on the airport, sheltered from trade winds, at sea level)

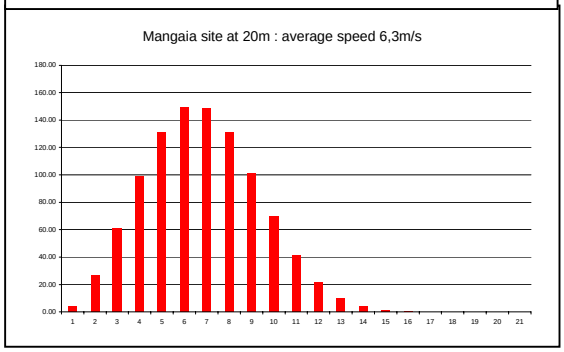
We can then consider that data from Rurutu is more suitable for the correlation, and that the local monitoring conditions are more similar to Mangaia's.

IV.1 • CORRELATION ON THE FIRST MONITORING PERIOD (7 MONTHS)

Comparison of wind data between Rurutu wind farm and Mangaia site is given below, for the monitoring period between the 18th of april 2001 and the 12th of October 2001.







We can notice that the wind regime on Mangaia site at 30 meters agl is lightly higher than on Rurutu at 24 m agl. This property is normal considering the aspects of both sites :

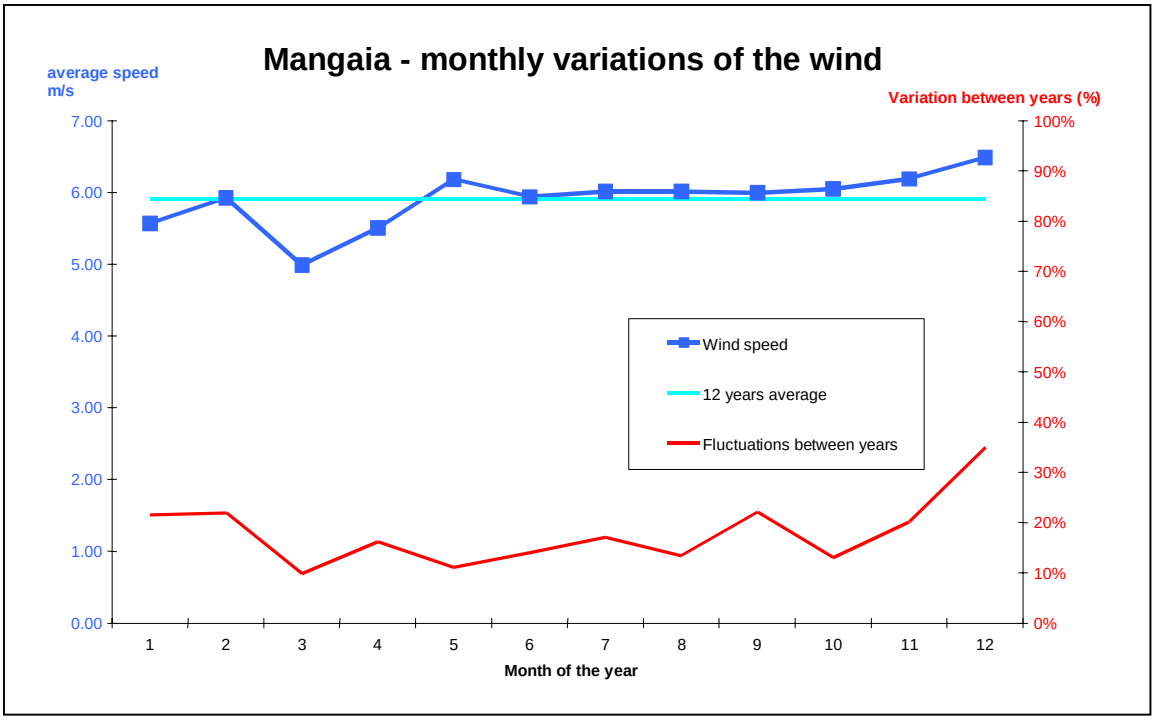
- Located at the same latitude, both islands face the same global climatic conditions
- Rurutu wind farm is facing the trade winds, located on a ridge at 250 meters above sea level. The wind speed up on this site is similar to Mangaia (110 m asl)
- The wind speed on Rurutu wind farm is monitored at 24m agl whereas on Mangaïa site at 30 m agl, which explains why we have more wind on Mangaia.

IV.2 • COMPARISON OF THE MONITORING PERIOD WITH LONG TERM WIND REGIME

IV.2.1 • Monthly variations on Mangaia

In 2000, a numerical wind mapping for Mangaïa Island has been done, using long term data (12 years) which allows us now to draw up the following graph to illustrate the monthly wind variations on Mangaia. The following parameters are shown (above the ocean, without perturbations) :

- Average 12 years wind speed 10 m asl. (SSMI point 160°W, 22°S).
- Monthly averages.
- Annual variations (expressed in percentage of the mean speed).



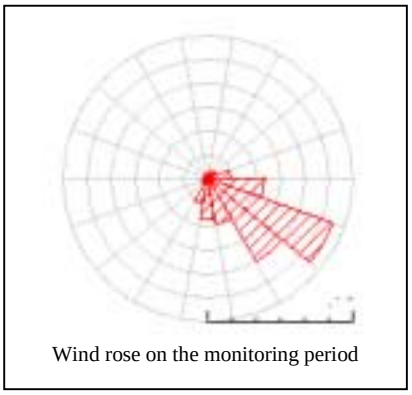
Annual variations are most important for the warm season, probably because of some active cyclonic years (El Nino). This climate phenomenon is responsible for changes in wind regime for the south pacific region. We notice a lower wind speed for many wind sites during the last two years. One of the consequences is that the average wind speed for Rurutu wind farm is now 7,4 m/s 24m agl.

The last few months (from November 2001 to July 2002) of the monitoring period on Mangaia are representative of this phenomenon. For the same period, it has been observed on Rurutu wind farm.

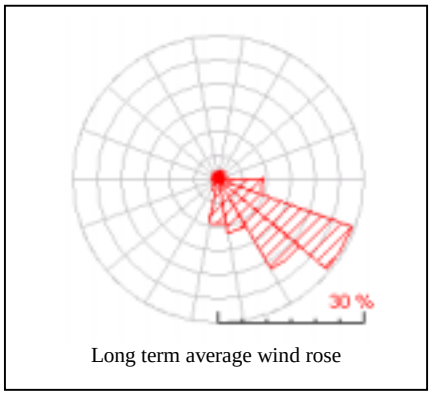
IV.2.2 • Correlation with Rurutu wind farm

IV.2.2.1 Wind direction

Graphs below are presenting the comparison between concerned period and long term statistics in terms of wind directions for the wind farm of Rurutu.



Wind rose on the monitoring period



Long term average wind rose

The observed wind on Rurutu during Mangaia's monitoring period is strictly similar to long term statistics. **The period is representative of the normal climate on the region**.

IV.2.2.2 Wind speed

With the two last years of wind statistics (2001-2002), the average wind speed (WS) on Rurutu wind farm for the last fourteen years has decreased from 7,7 m/s (long term statistics for the first twelve years) to 7,4 m/s :

average WS at 24m on Rurutu : 7,4 m/s

During the period corresponding to the data received from Mangaia, synchronous monitoring on Rurutu wind farm give the following results :

WS during the period at 24 m on Rurutu : 6,1 m/s

This average wind speed is very close to the observed wind speed at 30m on Mangaia site :

WS during the period at 30 m on Mangaia : 6,3 m/s

On Mangaia Te Are Toa site, the mean average wind speed at 30 m agl will then be :

Average Wind Speed	**7,5 m/s**
Weibull A factor	**8,4**
Weibull k factor	**2,8**

V • CONCLUSION ON THE WIND REGIME OF THE SITE

Regarding to the above paragraphs, it is now possible to conclude on the wind regime of the selected site :

- The observed wind speed confirms a good potential on the selected site..
- The characteristics of the wind regime (turbulence, wind shear) are not restrictive factors for the implementation of a wind project.

It is proved that the wind regime on the selected site of Mangaia is suitable for a wind farm. The project implementation is then confirmed. The following reports will study the technical and economical aspects of the wind project.