ADEBANJI OLANREWAJU ADEWUMI

EVALUATION OF WIND ENERGY POTENTIAL IN NORTHERN NIGERIA AS POWER GENERATION SOURCE

NEU 2019

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A THESIS SUBMITTED TO THE GRADUATE SCHOOL OF APPLIED SCIENCES OF NEAR EAST UNIVERSITY

By
ADEBANJI OLANREWAJU ADEWUMI

In Partial Fulfillment of the Requirements for the Degree of Master of Science in Mechanical Engineering

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Approval of Director of Graduate School of Applied Sciences

Prof. Dr. Nadire ÇAVUŞ

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I hereby declare that, all the information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

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ACKNOWLEDGEMENTS

From the beginning of my journey in Near East University until this day, Assoc.Prof. Dr. Hüseyin ÇAMUR, the godfather of Mechanical Engineering Department's students, and Assist. Dr. Youssef KASSEM, my mentor and my very first advisor, were the most helpful and supportive people I met in the department. Their endless encouragement and advises was the main cause of this study completion, they believed in me since day one, for all these, words are powerless to express my gratitude to both of you, Thank you so much.

To my beloved family especially my parents who were always keen to listen to my challenges and supported me in all ways to the best of their ability, I am so thankful for your support, I would have never reach to this point without you, and I greatly appreciate you all.

To my parents, with love…

ABSTRACT

In this thesis, a 10 year data of 2008 – 2017 of 2 norther states in Nigeria namely; Jigawa and yobe was obtained from the Nigerian Meteorological Center was analyzed. The thesis aimed to study the potential of wind energy in these stations in order determine the viability of these station for the installation of wind turbines to generate electricity. The motive behind this study is to challenge the appalling current generation of electricity for the country.

For the analysis that was carried out, 10 distribution functions were used, and the Kolmogorov Smirnov test was performed to select the most suitable distribution function that would be used for the analysis. The wind performance analysis was also performed. The results showed that the yearly mean wind speed shows a range between 4.96 knots & 12.3 knots at a height of 10 meters. This validates these stations as having a high wind potential. Based on the analysis, and the results, the conclusion was made that the Horizontal Axis Wind Turbine would be most sufficient for the rural area because of the lack of urbanization and access to large spaces and land mass which permit uninterrupted flow of air.

It was observed that out of all the Horizontal Axis Wind Turbines that was analyzed, the suzlon S82 1.5MW with a power rating of 1500 KW proved to produce the lowest cost of energy production. While YDF-1500-87 model with a power rating of 1500 KW which proved to be the best performing wind turbine for the energy production for the Horizontal Axis Wind Turbines.

Keywords: Northern-Nigeria; probability distribution functions; statistical modeling; wind speed characterization; wind turbines

ÖZET

Bu tezde, Nijerya'daki 10 norther eyaletlerinin 2008 – 2017 yıllarının 2 yıl verileri; Nijerya Meteoroloji Merkezi'nden Jigawa ve yobe elde edildi. Tez, elektrik üretmek için rüzgar türbinlerinin montajı için bu istasyonun uygulanabilirliğini belirlemek için bu istasyonlardaki rüzgar enerjisinin potansiyelini incelemeyi amaçladı. Bu çalışmanın arkasındaki sebep, ülke için korkunç elektrik üretimine meydan okumaktır.

Yapılan analiz için 10 dağıtım fonksiyonu kullanıldı ve analiz için kullanılacak en uygun dağıtım fonksiyonunu seçmek için Kolmogorov Smirnov testi yapıldı. Rüzgar performans analizi de yapıldı. Sonuçlar, yıllık ortalama rüzgar hızının 10 metre yükseklikte 4.96 knot ve 12.3 knot arasında bir aralık gösterdiğini gösterdi. Bu, bu istasyonları yüksek bir rüzgar potansiyeline sahip olarak doğrular.Analiz ve sonuçlara dayanarak, yatay eksenli rüzgar türbininin, kentleşmenin olmaması ve kesintisiz hava akışına izin veren geniş alanlara ve kara kütlesine erişim nedeniyle kırsal alan için en yeterli olacağı sonucuna varılmıştır.

Analiz edilen tüm yatay eksenli rüzgar türbinlerinin, 1500 kW'lık bir güç derecesine sahip suzlon s82 1.5 MW'NİN en düşük enerji üretim maliyetini ürettiğini kanıtladığı gözlenmiştir. En yüksek gücü üreten 4,500 kW'lık bir güç derecesine sahip Gamesa G128 modeli, aynı zamanda yatay eksenli rüzgar türbinleri için en yüksek enerji üretim maliyetine sahiptir.

Anahtar kelimeler: Kuzey-Nijerya; olasılık dağılım fonksiyonları; istatistiksel modelleme; rüzgar hızı karakterizasyonu

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LIST OF ABBREVIATIONS USED

$\boldsymbol{A}$	Swept Area
$\boldsymbol{C_{omr}}$	Cost of operation and maintenance
$\boldsymbol{CF}$	Capacity factor
$\boldsymbol{C_p}$	Coefficient of performance
$\boldsymbol{d}$	Distance from the sun
$\boldsymbol{E}$	Total amount of wind energy density
$\boldsymbol{E_{wt}}$	Total energy generated
$\boldsymbol{f(v)}$	Probaility density function
$\boldsymbol{i}$	Inflation rate
$\boldsymbol{I}$	Investment
$\boldsymbol{J}$	The intensity of the radiation
$\boldsymbol{n}$	Life time of wind turbine
$\boldsymbol{P}$	The power of the electromagnetic radiation
$\boldsymbol{\overline{P}}$	Mean power density
$\boldsymbol{P_r}$	Rated power of wind turbine
$\boldsymbol{P_{wt}}$	Output power of wind turbine
$\boldsymbol{v}$	Wind speed
$\boldsymbol{v_{ci}}$	The cut-in wind speed
$\boldsymbol{v_{co}}$	Cut off wind speed
$\boldsymbol{v_i}$	Vector of possible wind speed
$\boldsymbol{v_r}$	Rated wind speed
$\boldsymbol{v_{10}}$	Wind speed at original height
$\boldsymbol{T}$	The period in hours
$\boldsymbol{z}$	Wind turbine hub height
$\boldsymbol{z_{10}}$	Measurment height (10m height)
$\boldsymbol{\rho}$	Air density
$\boldsymbol{\alpha}$	Surface roughness

CHAPTER 1
INTRODUCTION

Nigeria is a country in the western part of Africa, it is bordered by Cameroon to the east, Chad to the north-east, Niger to the north, Benin to the west and the Atlantic to the south. Nigeria has the 20th largest economy in the world, and it is popularly referred to as the "Giant of Africa". Simply because of the large economy and massive population.

Nigeria has a population of over 200 million people, and with such a large and growing population, the demand for electricity has greatly skyrocketed in recent years.

1.1 Electricity Problem of Nigeria

In Nigeria, electricity is generated by 6-generation companies, 1 transmission company, and 11 distribution companies. (Awosope). The government owns the transmission company while the private sector owns the distribution companies.

The country has an installed capacity of about 12000 MW of electric power, but current Generation of electricity is a number shy of 4000MW of electric power which is not enough for the stated population. In addition, more than 70% of all electric power produced is gotten from fossil fuels which causes all kinds of environmental issues and also a causative factor of global warming.

Renewable energy generation is proposed in order to reduce the negative issues that ensue with current electricity production methods.

1.2 Renewable Energies

Renewable energies as the name implies, refers to generation of energy that can be replenished i.e. renewed unlike the current mainstream energy generation methods today which are gotten from fossil fuels, release toxic harmful waste as by products into the atmosphere and the source of such energy cannot be replenished. There are several renewable energy sources such as, sunlight, wind, geothermal, hydro, geothermal, tidal, waves, etc.

Of all these renewable energy sources, for this thesis, generation of electrical energy from wind source will be analyzed and evaluated.

Practically, with the current economic affairs and the facts given by technology renewable energy cannot immediately solve the energy problems of the world. But overtime with huge efforts to slowly decrease energy production from conventional energy sources and gradually increases the generation of electricity by renewable energy, it is possible to avoid catastrophe problems that could be looming in the future from the continued use of fossils to generate electricity.

1.2.1 Solar energy

Solar energy is the most popular method of generating energy from a renewable source, it simply just involves the use of photo-voltaic cells to capture rays of sunlight during the day when the sun is shining and converts that sun energy into usable electricity.

The enormously large magnitude of solar energy that is reflected on the surface of the earth is an appealing source of energy for electricity. An example of a photo-voltaic cell is shown below in Figure1.1.

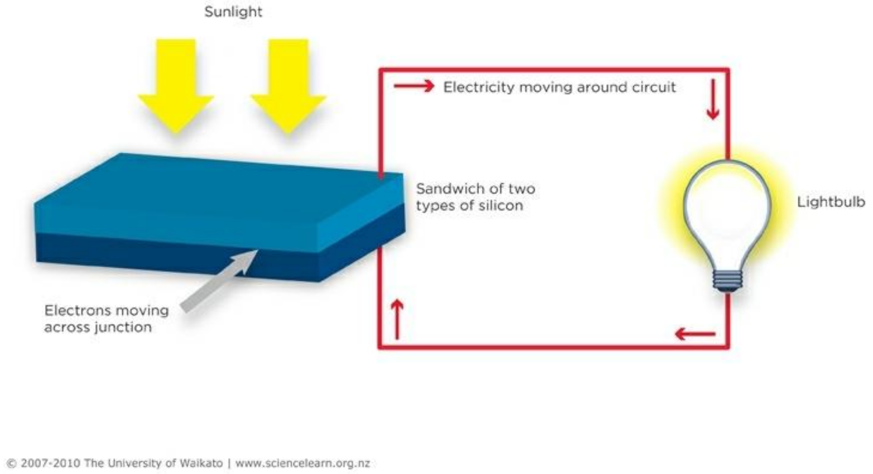

Figure1.1: A photo-voltaic cell (sciencelearn, 2010)

1.2.2 Geothermal

Geothermal energy can be regarded as thermal energy stored beneath the earth's crust. The temperature of matter is determined by geothermal energy. Materials that have undergone radioactive decay are the main sources of geothermal energy. The difference between the earth's core and the surface of the earth is referred to as the geothermal gradient. This gradient is responsible for continuously conducting thermal energy as heat between the earth's core all the way up to its surface.

1.2.3 Hydroelectric power

Hydro-electric power is another very popular renewable method of generating electricity. The operating principle is rather simplistic. It involves a large body of water such as a river, and dam is built on it, water is stored in a reservoir and is released through a guided path to flow through a turbine which then spins it. The turbine is connected to a generator that converts the spinning mechanical energy, into electrical energy.

Nigeria has 2 hydro-electric dams which produce about 1,900 MW of electricity for the country. An illustration of a hydro-electric power generation is given below.

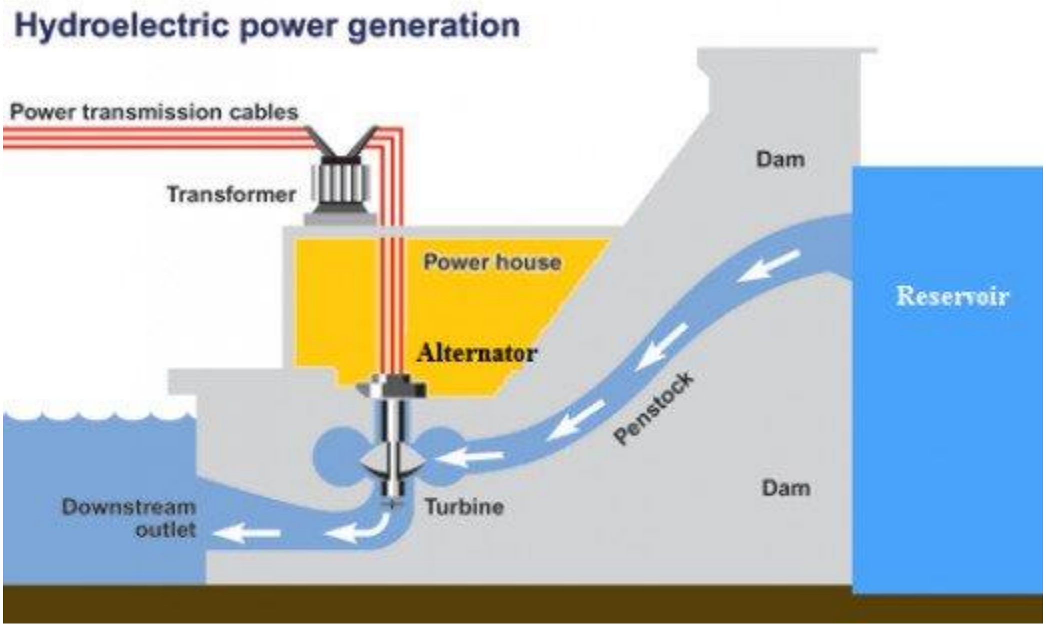

Figure1.2: Hydroelectric power generation. (Environment Canada, 2016)

1.2.4 Wind energy

The use of wind energy has been in existence for a long time, since wind mills were used in farms for the processing of farm produce. The operating principle revolves around air foils on a wind turbine. The wind flows over the surface of the blades of the turbine, and this causes the blades of the wind turbine to start spinning thereby rotating a shaft that is connected to a generator that is then used to produce electricity.

The advantages of wind turbine far outweigh its draw backs, because it is environmentally friendly and electricity can be produced irrespective of the time of day as long as the wind continues to flow. Figure 1.4 shows the continued growth in the installation as use of wind turbines to generate electricity.

Although for the sake of fuss and vibrations, wind turbines are not suitable for use above houses. Figure 1.3 shows the working principle of a wind turbine.

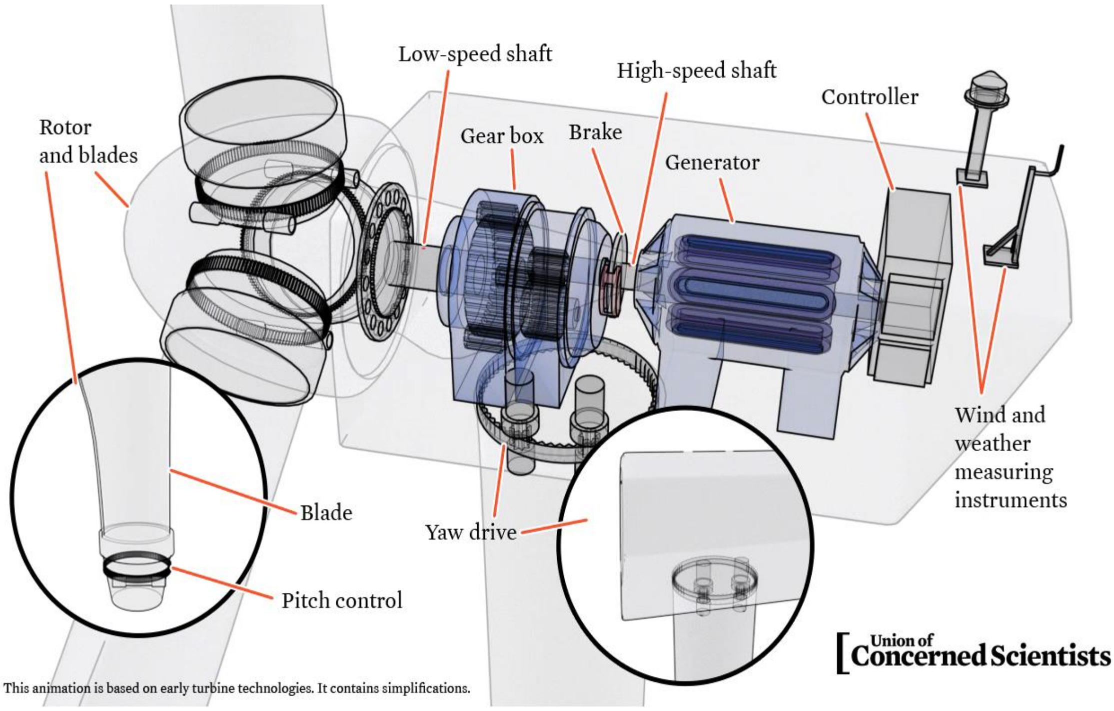

Figure 1.3: Working Principle of a wind turbine (Union of concerned Scientists)

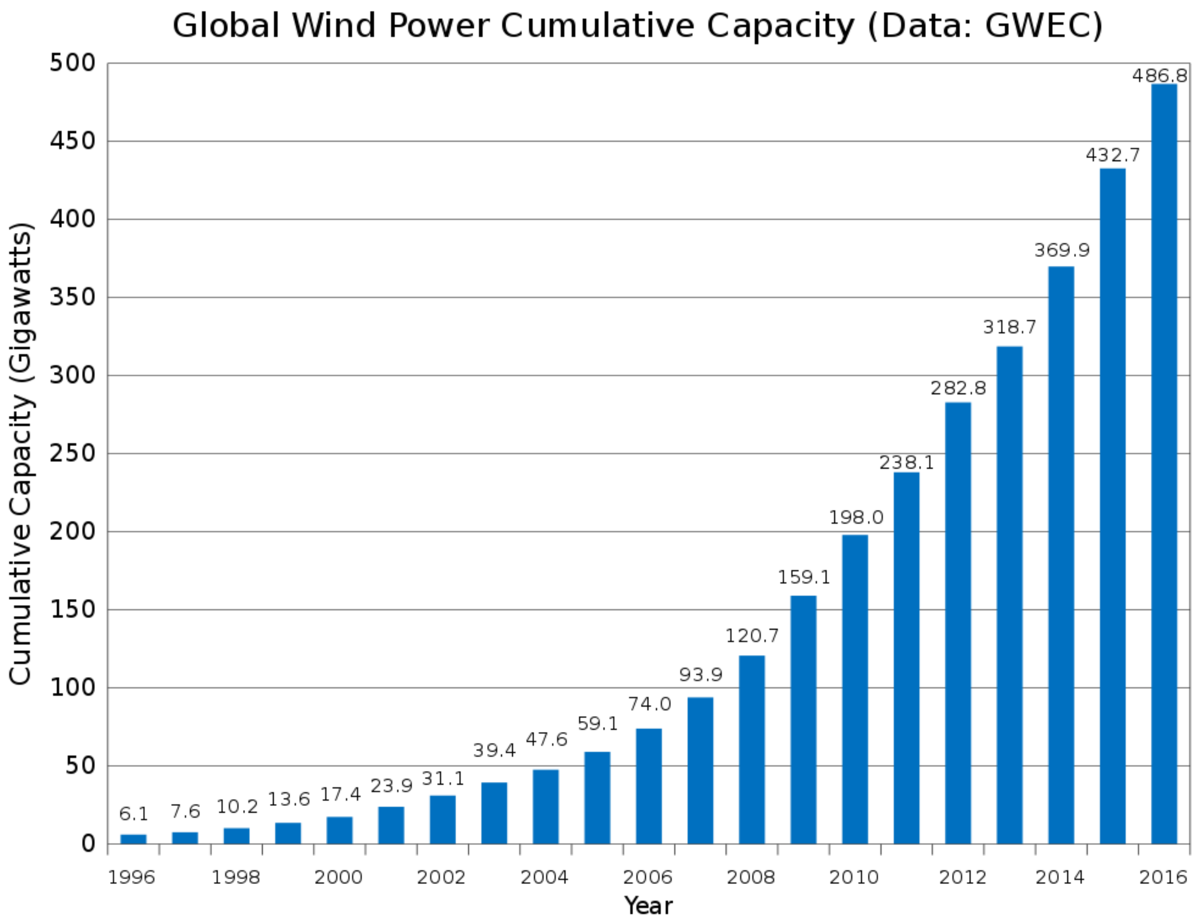

Figure 1.4: Global wind power cumulative capacity (GWEC, 2016)

1.3 Wind Turbine Classification

Generally, wind turbines are categorized into two, these are; Horizontal Axis Wind Turbines (HAWT) and Vertical Axis Wind Turbines (VAWT).

1.3.1 Horizontal axis wind turbine (HAWT)

In the horizontal axis wind turbine, the axis of rotation (i.e. the rotational axis) is parallel with the ground. Such a wind turbine could be installed in the windward or leeward direction of the wind. The HAWT are usually sized from medium to large because they have the capacity to generate more electricity and the unused electricity energy generated can then be sold to the electric grid.

1.3.2 Vertical axis wind turbine (VAWT)

In the vertical axis wind turbine, the axis of rotation is perpendicular to the ground surface. Although vertical axis wind turbines could be used to generate electricity, it is mostly in use for mechanical activities such as pumping water. (Steeby, 2012).

Vertical axis wind turbines are usually small scaled and can be used for batter charging, powering of traffic lights, and also generating electricity for small homes in urban areas.

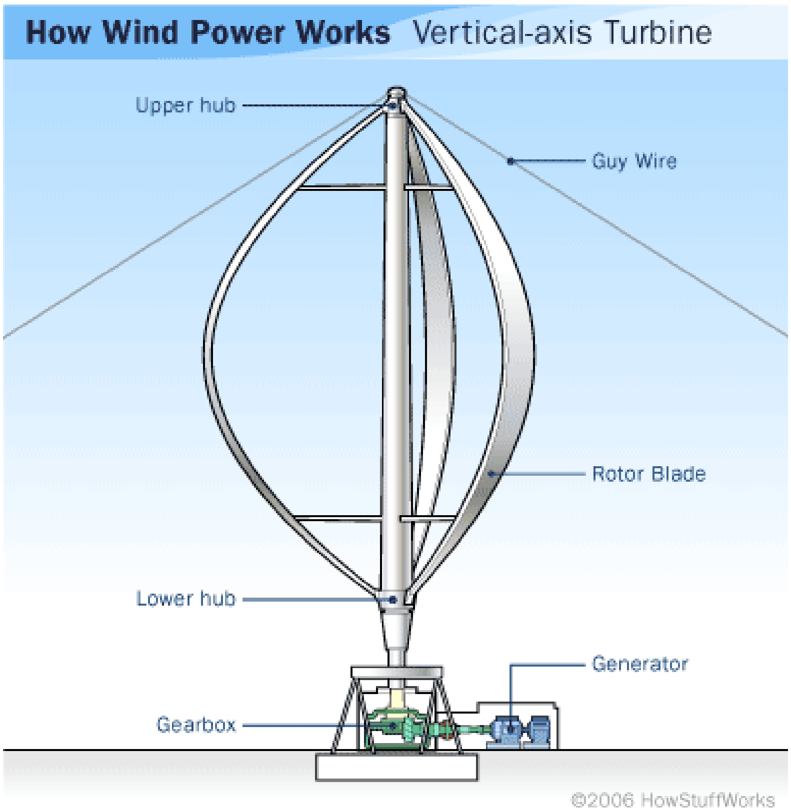

Figure 1.5: Vertical Axis Wind Turbine (How stuff works, 2006)

1.4 The Aim of This Thesis

The aim of this thesis is to determine the potential of the wind energy at the two selected stations namely; Jigawa and Yobe in northern Nigeria.

The research objectives are as stated below:

- Determination of the wind speed potential at the selected stations
- The changes of the wind speed to timely relations (i.e. monthly, yearly).
- The increase in altitude and the corresponding change in wind speed
- For the collected data, finding the most suitable distribution function to estimate the wind potential
- Which of the two stations would provide a higher capacitance with less cost
- To determine the most suitable wind turbine that best suits each station

1.5 Thesis Outline

This sector briefly describes this thesis report:

Chapter1: gives an introduction and overview of the thesis topic and describes the electricity problems of Nigeria. Also it describes the renewable energy source discussed in this study and features other renewable energy methods. It also highlights the main points of discussion of this thesis work.

Chapter2: discusses the literature review done on this study. It discusses the techno-economics, wind power density and economic analysis of wind turbines.

Chapter 3: discusses in greater detail the selected stations of this study and the overall methodology employed in the analysis of the stations.

Chapter 4: this chapter generally just presents the results and discussion of the wind data analysis, parameters of the distribution functions and summary of chosen sites.

Chapter 5: this chapter discusses the conclusions arrived at from the analysis of this study and proposes some future work to be done.

CHAPTER 2
LITERATURE REVIEW AND ECONOMIC ANALYSIS

2.1 Previous Studies on Wind Potential

Adaramola M.S et al., (2011) performed an economic analysis on six stations in Nigeria towards the north central. The data that they used spanned an average of 28 years. Also they used the levelized cost method to perform the economic analysis. The results of their analysis showed that there is a distinctive variance in the energy produced per KWh in all six stations.

The case study of using three of the selected wind turbines also showed that if the maintenance and cost of operation were increased by 10%, this lead to a 7% increase in unit energy cost. They also discovered that if they increased the inflation rate by 5% they would be able to reduce the cost of energy by roughly 29%, reducing the discount rate by 5.31%

Olayinka et al., (2011) studied the energy potential of wind in Jos a Nigerian state. The wind speed data that they used for their analysis was measured at a vertical distance of 10 meters also the data was for 37 years.

Their analysis determined to see if Jos was a suitable station for the installation of wind turbines. In their study they analyzed 2 wind turbines AN Bonus 1MW/54 and AN Bonus 300 kW /33 using capacity factor and rated power output.

(Ayodele T.R et al., (2013)). The aim of their study was to produce scientific information to secure investment in wind energy generation technology, so they analyzed 15 stations across all geopolitical zones of the country. The data they used was daily mean wind speed, which is considered to be the best and most accurate data for analysis. Their data spun within a four to sixteen year period.

Using the capacity factor and rated power output they analyzed some wind turbines and using present value cost Method (PVC), they were able to conclude that grid integration was viable in the northern states of Nigeria, but would not be very effective in the southern states.

Ohunakin et al., (2011) used a thirty-six year wind speed data, that was analyzed by a 2-parameter Weibull analysis for seven stations in north-western part of Nigeria. The mean wind speed was calculated and the mean wind power density was also calculated.

Their results showed that the states of Kano, Katsina and Sokoto are viable states for the installation of wind turbines. Also they analyzed the possible wind turbine that would be best to use for the considered states using the capacity factor ant he rated power output.

A highlight of the particular wind attributes that are important for the implementation of wind turbine are important for the implementation of wind turbine and location viability is done by Ayodele et al., (2013).

Hirmri et al., (2010) conducted a study in 3 stations in Algeria to install energy conversion stystems using data from a ten year period.

Luiand Al-Hadhrami (2014). Made analysis on small-scale wind turbines, which were generally to be used in application for off grid. In their results, which was based on the capacity factor, they discovered that HAWT was preferred for generating electricity on a small scale.

The study that was conducted by Ayodele et al (2012) in South African coastal areas. Their aim was to analyze and select the best wind turbine that would be suited to the particular region. In their results, they found that a turbine specification of 3m/s cut in wind speed, 1600kW power rated, 20 m/s cut out wind speed and a hub height above 70 meters was the most suitable for the region.

Wind speed data was evaluated by DeMeij et al., (2016) of the Palestine state. Alongside determining the yearly energy production and the density of the wind power.

In their conclusion, Gaza was found to be unsuited for wind energy production application, while Hebron which is on the eastern part was found to be a reliable location for wind energy applications.

In Nigeria, Jimoh et al., (2012) studied the inability of the country's generating capacity of 5500MW for a population of 170 million people in 2012. Their work further describes the negative effects of the low generation capacity on the entire country and its economy. They then propose a solution to generate more power from renewable energies especially wind, as it was seen that many states in the country possessed suitable wind potential.

2.2 Density of Wind Power

The density of wind power or wind power density (WPD) for a location is regarded as the wind energy potential performance value. The WPD is dependent on both the wind speed and the air density.

$$\frac{P}{A} = \frac{1}{2}\rho v^3 \qquad (2.1)$$

Where:

P – Wind Power (W)

ρ - Density of air (1.225 kg/m3)

A – Wind turbine swept Area (m^2)

In addition, the mean density of wind power can be calculated for a period represented by $\overline{WPD}$ In KW/m2 by equation:

$$\frac{\bar{P}}{A} = \frac{1}{2}\rho \bar{v}^3 \qquad (2.2)$$

Where:

$\bar{P}$ is wind speed (m/s)

$\bar{v}$ is wind power (W)

The variation of the wind speed at various hub heights is the most frequently used method, which is known as the power law technique as expressed in the equation below:

$$\frac{v}{v_{10}} = \left(\frac{z}{z_{10}}\right)^{\alpha} \qquad (2.3)$$

Where:

v is the wind speed at the wind turbine hub height z,

v_{10} is the wind speed at the original height z_{10},

α is the surface roughness coefficient, which depends on the characteristics of the region

In this study, the wind speed data was measured at the height of 10 m above the ground level; therefore, the value of α can be obtained from the following expression

$$\alpha = \frac{0.37 - 0.088\ln(v_{10})}{1 - 0.088\ln\left(z_{10}/10\right)} \qquad (2.4)$$

2.3 Analysis of Wind Performance

2.3.1 Output energy of wind turbines

From the energy curve, the energy generated by the wind turbines could be estimated.

In addition, the energy output of wind turbines can be calculated by the following equation:

$$P_{wt(i)} = \begin{cases} P_r \frac{v_i^2 - v_{ci}^2}{v_r^2 - v_{ci}^2} & v_{ci} \le v_i \le v_r \\ \frac{1}{2}\rho A C_p v_r^2 & v_r \le v_i \le v_{co} \\ 0 & v_i \le v_{ci} \; and \; v_i \ge v_{co} \end{cases} \qquad (2.5)$$

$$E_{wt} = \sum_{i=1}^{n} P_{wt(i)} \times t \qquad (2.6)$$

Where:

v_i is the vector of the possible wind speed at a given site

$P_{wt(i)}$) is the vector of the corresponding wind turbine output power in W,

v_{ci} is the cut-in wind speed (m/s),

P_r is the rated power of the turbine in W,

v_{co} is the cut-out wind speed (m/s) of the wind turbine

v_r is the rated wind speed (m/s).

C_p is the coefficient of performance of the turbine

The coefficient of performance is considered to be constant for the whole range of wind speed and can be calculated as

$$C_p = 2\frac{P_r}{\rho A v_r^3} \qquad (2.7)$$

Where:

C_p is the turbine's performance coefficient

ρ is the air density

A is the swept area of the wind turbine

2.3.2 Capacity factor (C_f)

The capacity factor (CF) of a wind turbine is the fraction of the total energy generated by the wind turbine over a period of time to its potential output if it had operated at a rated capacity throughout the whole time period. The capacity factor of a wind turbine based on the local wind program of a certain site could be calculated as

$$CF = \frac{E_{wt}}{P_r.t} \tag{2.8}$$

2.4 The Economic Analysis of Wind Turbines

One of the most important factors that control the cost of power (Golcek et al., 2007)

- The capital costs, foundation, the wind turbines, the construction of the road, the grid connection.
- The cost to operate and maintain the system
- The characteristics of the wind turbine and geographical position determine the electricity production.

The highlighted factors are reviewed differently in the different countries of the world (Golcek et al., 2007). On the basis of an estimated wind turbine power. Table 2.1 presents a cost analysis of turbines.

Table 2.1: Wind turbine cost based on power rating (Mathew, 2007)

Power Rate (kW)	Specific cost ($/kW)	Average cost ($/kW)
10–20	2200–2900	2550
20–200	1500–2300	1900
>200	1000–1600	1300

Various methods have been used to calculate the wind energy cost such as PVC methods [23]. The present value of costs (PVC) is given in the following equation:

$$PVC = \left[I + C_{omr}\left(\frac{1+i}{r-i}\right) \times \left[1 - \left(\frac{1+i}{1+r}\right)^{n}\right] - S\left(\frac{1+i}{1+r}\right)^{n}\right] \qquad (2.9)$$

Where:

r is the discount rate,

Comr is the cost of operation and maintenance,

n is the machine life as designed by the manufacturer,

i is the inflation rate,

I is the investment summation of the turbine price and other initial costs, including provisions for civil work, land, infrastructure, installation, and grid integration.

S is the scrap value of the turbine price and civil work

The cost per kWh of electricity generated (UCE) can be determined by the following expression

$$EGC = \frac{PVC}{t \times P_r \times CF} \qquad (2.10)$$

Table 2.2: Parameters of PVC (Diaf and Notton 2013)

Parameter	**Value**	**Parameter**	**Value**
r[%]	8	*I* [%]	68
i[%]	6	*S* [%]	10
n [year]	20	& [%]	7

CHAPTER 3

METHODOLOGY

3.1 Materials and Methods

In this chapter, the analysis of 2 stations in northern Nigeria is discussed, this includes the statistical analysis at a vertical height of 10 meters. Furthermore, in this section, in order to determine the wind power density, 10 distribution functions were used. Additionally, in order to determine and estimate the speed of the wind at different hub heights, the power law was used. The capacity factor, the energy annual output and cost of producing electricity from medium to large scale wind turbines are also discussed. The Figure 3.1 below is a flow chart that describes the analysis procedure.

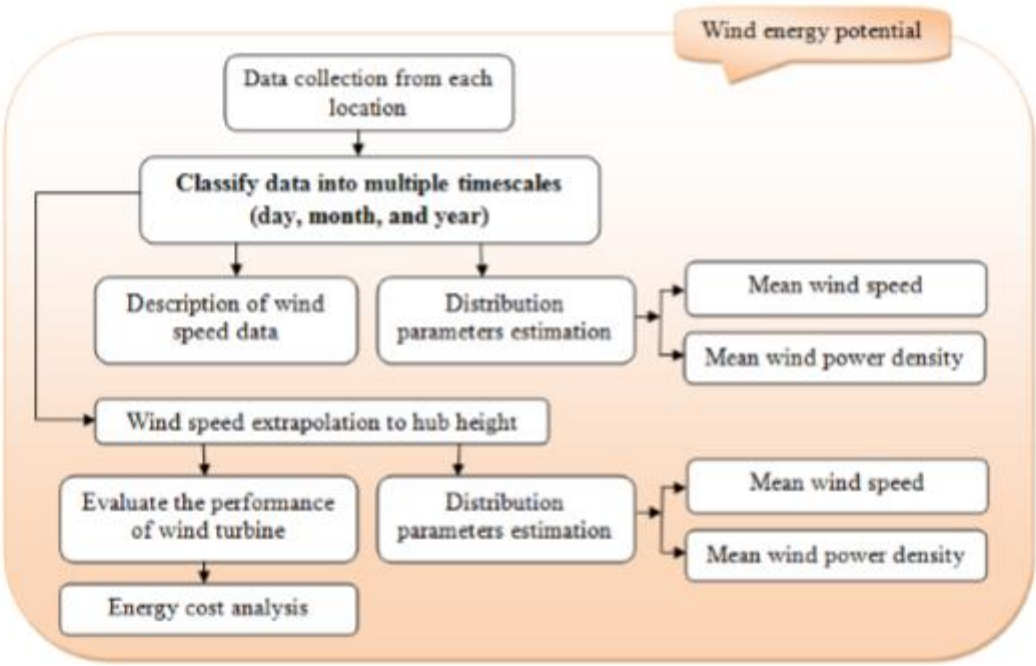

Figure 3.1: Flowchart description of analysis study.

3.2 Wind Data Source

The wind measurement data was collected from the Meteorological Center in Lagos, Nigeria, and was used for the analysis of this study. The data was measured on an hourly basis using an anemometer at a vertical distance of 10meters.

The data used in this study is the monthly data for a period of 10 years (2008 – 2017) as collected from the Meteorological Center. The coordinates, records period as well as the characteristics of the studied areas are presented in Table 3.1 below. Additionally, the geographical representations of the selected stations used in this study are presented in Figure 3.1.

Table 3.1: Characteristics of selected Stations used in this study

Station Name	Latitude	Longitude	Characteristics of Station
Jigawa	12.4460° N	9.7233° E	Rural
Yobe	12.1871° N	11.7068° E	Rural

Figure 3.2: Map of Nigeria showing the location of the selected stations used in this study.

3.3 Description of the Selected Stations

3.3.1 Jigawa

Jigawa can be found in the north-western part of Nigeria between latitudes 11.0 N° to 13.0 N° and longitudes 8.0 E° to 10.15 E°. It is bordered to the west by Kano State along with Katsina state. It is bordered to the east by Bauchi state and bordered to the north-east by Yobe state. Finally, it is bordered to the north by The Republic of Niger.

It has 22,410 km^2 of land area, it has a population of 3.6 million inhabitants and more than 90% of the state is rural.

3.3.2 Yobe

Yobe can be found in the northeastern part of Nigeria, between latitudes 12.187 °N and longitudes 11.7068 °E, it is bordered to the west by Jigawa and Bauchi states, it is bordered to the south by Gombe state and bordered to the east by Borno state. To the north, it is also bordered by The Republic of Niger.

It has a landmass area that spans about 45,502 km^2. It has a population of about 2.7 million people and also categorized as a rural settlement.

3.4 Distribution Functions and Estimation Model

Wind renewable resource require wind speed data for assessment In the chosen stations wind speed data are provided for various distribution functions (Ouarda et al., 2015; Aries et al., 2018; Allouhi et al., 2017). For this thesis, ten distribution functions were applied to the wind speed data given for the selected stations. The ten distribution functions which are expressed as probability distribution function (PDF) and cumulative distribution function (CDF) are briefly described below.

Weibull distribution function (W)

The Weibull distribution function is expressed as probability distribution function (PDF) and as cumulative distribution function (CDF)

$$PDF = \left(\frac{k}{c}\right)\left(\frac{v}{c}\right)^{k-1} \exp\left(-\left(\frac{v}{c}\right)^{k}\right) \tag{3.1}$$

$$CDF = 1 - \exp\left(-\left(\frac{v}{c}\right)^{k}\right) \tag{3.2}$$

Gamma Distribution function (G)

The expressions of the probability distribution function (PDF) and the cumulative distribution function (CDF) in terms of the Gamma Distribution function are:

$$PDF = \frac{v^{\beta-1}}{\alpha^{\beta}\Gamma(\beta)} \exp\left(-\frac{v}{\beta}\right) \tag{3.3}$$

$$CDF = \frac{\gamma\left(\beta, \frac{v}{\alpha}\right)}{\Gamma(\beta)} \tag{3.4}$$

Lognormal Distribution Function (LN)

The expressions of the probability distribution function (PDF) and the cumulative distribution function (CDF) in terms of the lognormal distribution function are:

$$PDF = \frac{1}{v\sigma\sqrt{2\pi}} exp\left[-\frac{1}{2}\left(\frac{ln(v)-\mu}{\sigma}\right)^2\right] \tag{3.5}$$

$$CDF = \frac{1}{2} + erf\left[\frac{ln(v)-\mu}{\sigma\sqrt{2}}\right] \tag{3.6}$$

Logistic (L)

The expressions of the probability distribution function (PDF) and the cumulative distribution function (CDF) in terms of the Inverse Gaussian distribution function are:

$$PDF = \frac{\exp\left(-\frac{v-\mu}{\sigma}\right)}{\sigma\left\{1+\exp\left(-\frac{v-\mu}{\sigma}\right)\right\}^2} \tag{3.7}$$

$$CDF = \frac{1}{1+\exp\left(-\frac{v-\mu}{\sigma}\right)} \tag{3.8}$$

Log-Logistic Distribution Function (LL)

The expressions of the probability distribution function (PDF) and the cumulative distribution function (CDF) in terms of the Log-logistic distribution function are:

$$PDF = \left(\left(\frac{\beta}{\alpha}\left(\frac{v}{\alpha}\right)^{\beta-1}\right) \Big/ \left(1+\frac{v}{\alpha}\right)^{\beta} \right)^{2} \quad \textbf{(3.9)}$$

$$CDF = \frac{1}{\left(1+\frac{v}{\alpha}\right)^{-\beta}} \quad \textbf{(3.10)}$$

Inverse Gaussian Distribution Function (IG)

The expressions of the probability distribution function (PDF) and the cumulative distribution function (CDF) in terms of the Inverse Gaussian distribution function are:

$$PDF = \left(\frac{\lambda}{2\pi v^2}\right)^{1/2} e^{\left[\frac{-\lambda(v-\mu)^2}{2\mu^2 v}\right]} \quad \textbf{(3.11)}$$

$$CDF = \Phi\left(\sqrt{\frac{\lambda}{v}}\left(\frac{v}{\mu}-1\right)\right) + exp\left(\frac{2\lambda}{\mu}\right)\Phi\left(-\sqrt{\frac{\lambda}{v}}\left(\frac{v}{\mu}+1\right)\right) \quad \textbf{(3.12)}$$

Generalized Extreme Value Distribution Function (GEV)

The expressions of the probability distribution function (PDF) and the cumulative distribution function (CDF) in terms of the Generalized Extreme Value distribution function are:

$$PDF = \frac{1}{\alpha}\left[1 - \frac{\zeta(v)-\mu}{\alpha}\right]^{\frac{1}{\zeta}-1} \exp\left[-\left(1 - 1 - \frac{\zeta(v)-\mu}{\alpha}\right)^{\frac{1}{\zeta}}\right] \quad (3.13)$$

$$CDF = \exp\left[-\left(1 - 1 - \frac{\zeta(v)-\mu}{\alpha}\right)^{\frac{1}{\zeta}}\right] \quad (3.14)$$

Nakagami Distribution Function (Na)

The expressions of the probability distribution function (PDF) and the cumulative distribution function (CDF) in terms of the *Nakagami* distribution function are:

$$PDF = \frac{2m^m}{\Gamma(m)\Omega^m} v^{2m-1} e^{\left(-\frac{m}{\Omega}G^2\right)} \quad (3.15)$$

$$CDF = \frac{\gamma\left(m,\frac{m}{\Omega}v^2\right)}{\Gamma(m)} \quad (3.16)$$

Normal Distribution Function (N)

The expressions of the probability distribution function (PDF) and the cumulative distribution function (CDF) in terms of the *Normal distribution function* are:

$$PDF = \frac{1}{\sqrt{2\pi\sigma^2}} \exp\left(-\frac{v-\mu}{2\sigma^2}\right) \tag{3.17}$$

$$\mathrm{CDF} = \frac{1}{2}\left[1 + \mathrm{erf}\left(\frac{\mathrm{v}-\mu}{\sigma\sqrt{2}}\right)\right] \tag{3.18}$$

Rayleigh Distribution Function (R)

The expressions of the probability distribution function (PDF) and the cumulative distribution function (CDF) in terms of the *Rayleigh distribution function* are;

$$PDF = \frac{2v}{c^2} e^{-\left(\frac{v}{c}\right)^2} \tag{3.19}$$

$$CDF = 1 - exp\left[-\left(\frac{v}{c}\right)^2\right] \tag{3.20}$$

The ten distribution functions used in this thesis is presented in a summary in Table 3.2

Table 3.2. Expressions of statistical distributions used in this thesis.

Distribution function	PDF
Weibull (W)	$PDF = \left(\frac{k}{c}\right)\left(\frac{v}{c}\right)^{k-1} exp\left(-\left(\frac{v}{c}\right)^{k}\right)$
Gamma (G)	$PDF = \frac{v^{\beta-1}}{\alpha^{\beta}\Gamma(\beta)} exp\left(-\frac{v}{\beta}\right)$
Lognormal (LN)	$PDF = \frac{1}{v\sigma\sqrt{2\pi}} exp\left[-\frac{1}{2}\left(\frac{ln(v)-\mu}{\sigma}\right)^{2}\right]$
Logistic (L)	$PDF = \frac{exp\left(-\frac{v-\mu}{\sigma}\right)}{\sigma\left\{1+exp\left(-\frac{v-\mu}{\sigma}\right)\right\}^{2}}$
Log-Logistic (LL)	$PDF = \left(\left(\frac{\beta}{\alpha}\left(\frac{v}{\alpha}\right)^{\beta-1}\right)\Big/\left(1+\frac{v}{\alpha}\right)^{\beta}\right)^{2}$
Inverse Gaussian (IG)	$PDF = \left(\frac{\lambda}{2\pi v^{2}}\right)^{1/2} e^{\left[\frac{-\lambda(v-\mu)^{2}}{2\mu^{2}v}\right]}$
Generalized Extreme Value (GEV)	$PDF = \frac{1}{\alpha}\left[1-\frac{\zeta(v)-\mu}{\alpha}\right]^{\frac{1}{\zeta}-1} exp\left[-\left(1-1-\frac{\zeta(v)-\mu}{\alpha}\right)^{\frac{1}{\zeta}}\right]$
Nakagami (Na)	$PDF = \frac{2m^{m}}{\Gamma(m)\Omega^{\mathrm{m}}} v^{2m-1} e^{\left(-\frac{m}{\Omega}G^{2}\right)}$
Normal (N)	$PDF = \frac{1}{\sqrt{2\pi\sigma^{2}}} exp\left(-\frac{v-\mu}{2\sigma^{2}}\right)$
Rayleigh (R)	$PDF = \frac{2v}{c^{2}} e^{-\left(\frac{v}{c}\right)^{2}}$

Table 3.2. Continued

Distribution function	**CDF**
Weibull (W)	$CDF = 1 - exp\left(-\left(\frac{v}{c}\right)^{k}\right)$
Gamma (G)	$CDF = \frac{\gamma\left(\beta, \frac{v}{\alpha}\right)}{\Gamma(\beta)}$
Lognormal (LN)	$CDF = \frac{1}{2} + erf\left[\frac{ln(v) - \mu}{\sigma\sqrt{2}}\right]$
Logistic (L)	$CDF = \frac{1}{1 + exp\left(-\frac{v-\mu}{\sigma}\right)}$
Log-Logistic (LL)	$CDF = \frac{1}{\left(1 + \frac{v}{\alpha}\right)^{-\beta}}$
Inverse Gaussian (IG)	$CDF = \Phi\left(\sqrt{\frac{\lambda}{v}}\left(\frac{v}{\mu} - 1\right)\right) + exp\left(\frac{2\lambda}{\mu}\right)\Phi\left(-\sqrt{\frac{\lambda}{v}}\left(\frac{v}{\mu} + 1\right)\right)$
Generalized Extreme Value (GEV)	$CDF = exp\left[-\left(1 - 1 - \frac{\zeta(v) - \mu}{\alpha}\right)^{\frac{1}{\zeta}}\right]$
Nakagami (Na)	$CDF = \frac{\gamma\left(m, \frac{m}{\Omega}v^2\right)}{\Gamma(m)}$
Normal (N)	$CDF = \frac{1}{2}\left[1 + erf\left(\frac{v-\mu}{\sigma\sqrt{2}}\right)\right]$
Rayleigh (R)	$CDF = 1 - exp\left[-\left(\frac{v}{c}\right)^{2}\right]$

Table 3.2. Continued

Model		Parameter	Model		Parameter	Model		Paramter
W	**k**	Shape parameter	LL	$\boldsymbol{\beta}$	Shape parameter	Na	$\boldsymbol{m}$	Shape parameter
	c [m/s]	Scale parameter		$\boldsymbol{\alpha}$	Scale Parameter		$\boldsymbol{\Omega}$	Scale parameter
G	$\boldsymbol{\beta}$	Shape parameter	IG	$\boldsymbol{\lambda}$	Shape parameter	N	$\boldsymbol{\sigma}$	Standard deviation
	$\boldsymbol{\alpha}$	Scale Parameter		$\boldsymbol{\mu}$	Mean parameter		$\boldsymbol{\mu}$	Mean parameter
LN	$\boldsymbol{\sigma}$	Shape parameter	GEV	$\boldsymbol{\mu}$	Area Parameter	R	**c [m/s]**	Scale parameter
	$\boldsymbol{\mu}$	Scale Parameter		$\boldsymbol{\zeta}$	Scale Parameter			
L	$\boldsymbol{\mu}$	Area Parameter		$\boldsymbol{\alpha}$	Shape Parameter			
	$\boldsymbol{\sigma}$	Scale Parameter						

CHAPTER 4
RESULTS

4.1 Description of Wind Speed Data

The Annual descriptive statistics of the wind speed for the two selected stations during the investigation period is presented in Table 4.1 which includes the mean velocity, standard deviation, variance coefficient, minimum velocity, maximum velocity, median velocity, Skewness and Kurtosis. For both areas at a height of 10 m, the mean wind speeds are varied from 4.958 knots to 12.333 knots. The mean speed and standard deviation values suggest that there is good consistency in the wind behavior. During the investigation period for Jigawa, the Skewness value is negative in the years 2011, 2013, 2014 and 2017, which indicates that these distributions are left-skewed. However, the Skewness values in the years 2008-2010, 2012, 2015 and 2016 are positive, meaning that all distributions are right-skewed. Likewise, in Yobe the distributions in the years 2008-2010, 2016 and 2017 are left-skewed. And the distributions in the years 2011-2015 are right-skewed.

Table 4.1: Collected data for Jagawa

Variable	Mean	StDev	Minimum	Median	Maximum	Skewness	Kurtosis
2008	8.925	1.401	7.3	8.65	11	0.24	-1.72
2009	8.925	1.185	7.3	8.7	11.1	0.55	-0.75
2010	8.5	1.608	6.8	7.75	11.5	0.86	-0.82
2011	8.55	1.665	5.3	8.9	11.2	-0.37	-0.23
2012	8.767	1.578	6.3	9.05	11.4	0.16	-0.62
2013	9.6	2.543	4.8	9.85	12.7	-0.83	0.13
2014	12.333	2.036	7	12.3	14.5	-1.7	3.9
2015	8.125	2.349	5.2	8.2	12.2	0.26	-1.01
2016	6.967	1.482	5.4	6.95	10.2	0.87	0.48
2017	7.833	1.794	4.2	8.05	10.2	-0.53	-0.02

Table 4.2: Collected data for Yobe

Variable	Mean	StDev	Minimum	Median	Maximum	Skewness	Kurtosis
2008	6.467	2.353	0.6	7	9	-1.5	2.75
2009	6.258	2.054	0.7	6.7	9	-1.84	5.04
2010	6.75	0.886	5.1	7.15	7.8	-0.89	-0.64
2011	5.342	1.155	4	4.9	8	1.32	1.27
2012	5.167	1.384	3.2	5.3	7.8	0.25	-0.39
2013	4.958	1.194	3.4	4.8	8	1.41	3.33
2014	7.25	1.642	4.7	6.85	9.8	0.42	-0.71
2015	7.575	1.993	4.4	7.425	10.9	0.14	-0.91
2016	8.623	2.012	5.84	9.3	11.5	-0.1	-1.62
2017	7.567	1.65	4.3	7.9	9.6	-0.75	-0.33

4.2 Characteristics of Wind Speed

4.2.1 Monthly wind speed

The first step of analyzing wind speed is the study of its behavior in reference to time. Figure 4.1 and Figure 4.2 shows on a monthly basis, the mean wind speed variation for the selected sites.

The analysis begins with Jigawa, the highest mean wind speed occurs in the month of June with a value of 11.3knots, while the lowest mean wind speed occurs in the month of October with a value of 6.6knots

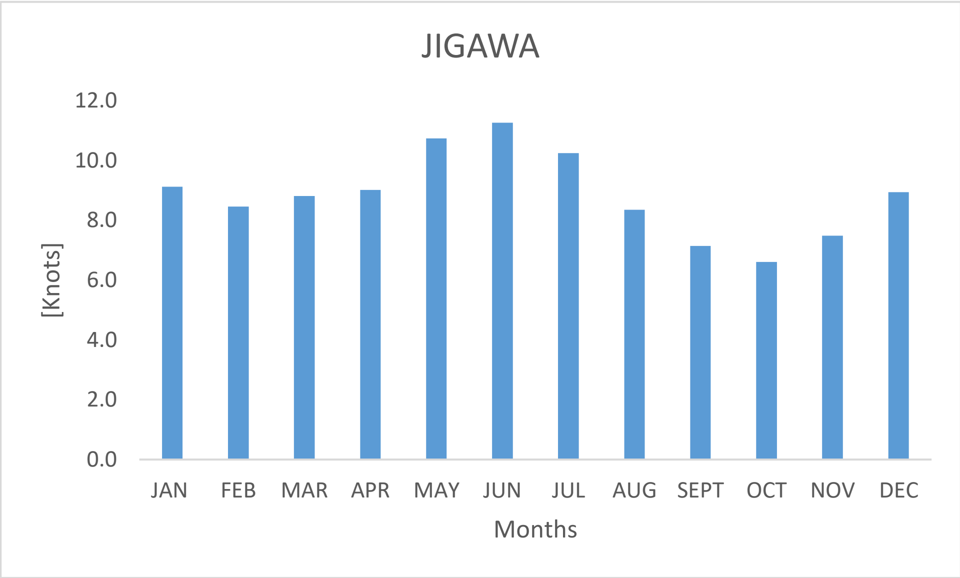

Figure 4.2: Average mean monthly wind speed in Jigawa

Moving on to the analysis of Yobe, the highest mean wind speed value occurs in the month of May with a value of 7.88 knots. Although very close to the highest mean wind speed is a value of 7.745 knots which occurs in the month of November. The lowest mean wind speed occurs in the month of September with a value of 4.94 knots

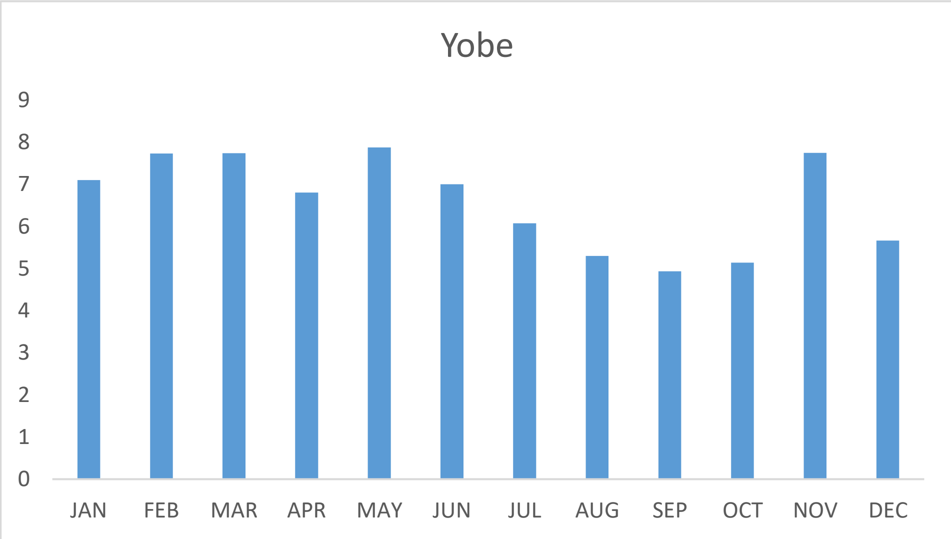

Figure 4.3: Average mean monthly wind speed in Yobe

4.2.2 Characteristics of wind speed at a 10 meter height

Analysis of the yearly mean wind speed data is the initial step. Figure 4.3 shows yearly mean wind speed data for the two selected stations over the 10 year study period.

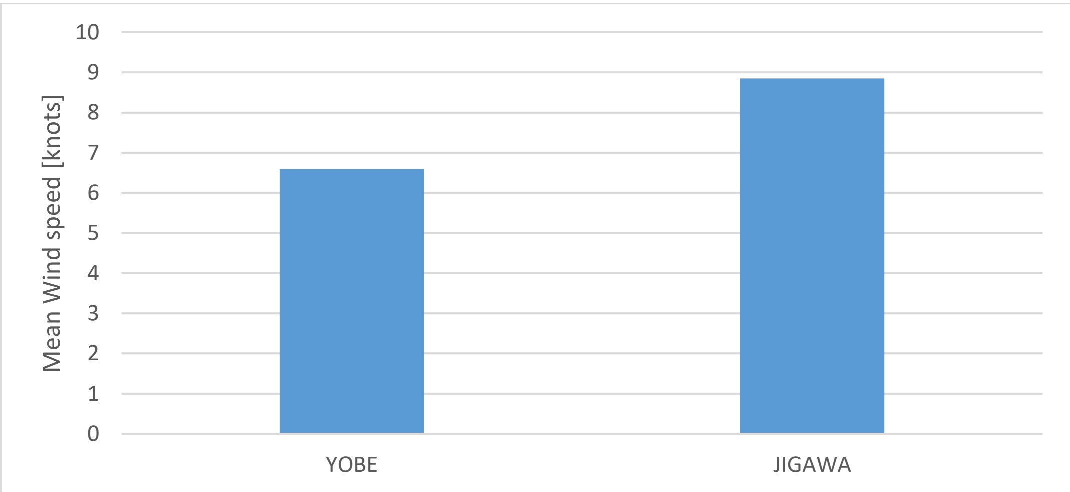

Figure 4.4: Annual mean wind speed at selected stations

In the years from 2008 to 2017 in Jigawa, it was observed from the Figure 4.4 that the highest annual mean wind speed occurred in 2014 with a value of 12.3 knots. However, for the same station, the lowest annual mean wind speed occurred in 2016 with a value of 7.0 knots.

In the same year period, the observations for Yobe also show that the highest annual mean wind speed occurred in the year 2016 with a value of 8.63 knots and the lowest annual mean wind speed occurred in 2013 with a value of 4.96 knots.

It is also worthy to note that the year with the lowest value in annual mean wind speed in Jigawa was also the year with the highest mean wind speed in Yobe.

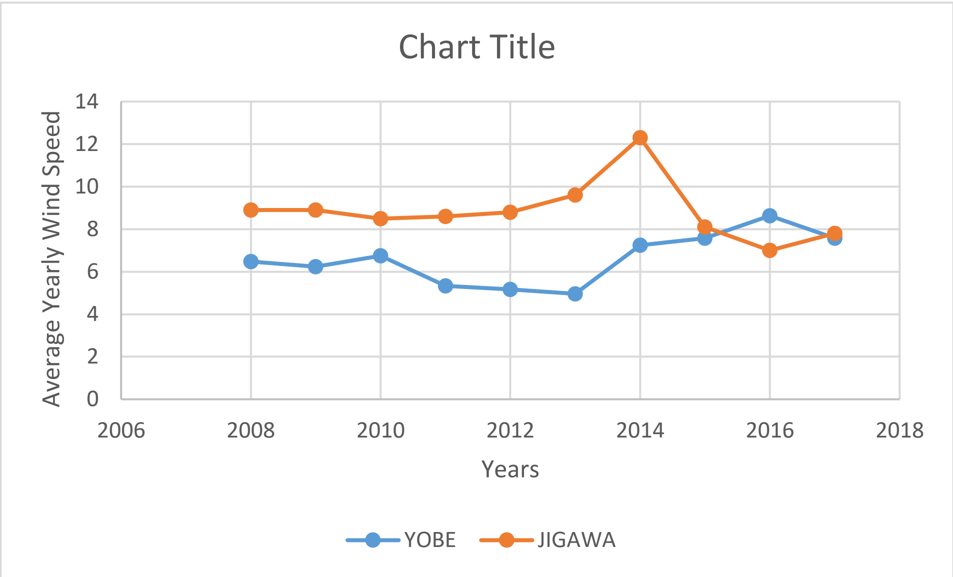

Figure 4.5: Annual mean wind speed graph at the selected areas during the studied period

4.3 Wind Direction

The wind direction data of the studied stations namely; Jigawa and Yobe for the 10-year period was collected and analyzed. The Table 4.3 shows the wind mostly flows in the SW direction 36% of the time and it least flows in the North-East (NE) direction and the West (W) direction each 16% of the time. The wind does not flow in the North or South direction.

Table 4.3: Direction of wind flow in Jigawa for the studied period.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2008	E	E	NE	SW	SW	SW	SW	SW	SW	W	NE	NE
2009	E	E	W	SW	SW	SW	W	W	SW	E	E	E
2010	E	E	E	W	W	SW	W	SW	W	SW	E	E
2011	E	NE	E	E	SW	SW	SW	W	W	W	E	NE
2012	NE	E	E	SW	SW	SW	SW	SW	SW	SW	NE	NE
2013	E	E	E	W	SW	W	W	NE	NE	NE	NE	NE
2014	E	NE	NE	SW	SW	W	SW	SW	W	W	NE	E
2015	E	E	NE	SW	SW	SW	W	W	W	E	E	E
2016	E	E	NE	SW	SW	SW	SW	SW	SW	SW	E	E
2017	E	E	NE	SW	SW	SW	SW	SW	SW	E	E	NE

The Table 4.4 shows that the wind mostly flows in the E 31.6% of the time and it least flows in the South (S) direction 0.83% of the time. The wind does not flow in the North (N) direction

Table 4.4: Direction of wind flow in Yobe for the studied period.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2008	NE	NE	NE	SW	SW	SW	S	SW	SW	SW	NE	NE
2009	E	E	E	E	W	W	W	W	W	E	E	E
2010	E	E	E	W	W	W	W	W	NW	NW	SE	SE
2011	E	E	NE	SW	SW	SW	SW	SW	SW	E	E	NE
2012	E	E	E	NE	SW	SW	SW	W	W	SW	E	NE
2013	E	NE	E	SW	SW	SW	SW	SW	SW	SW	E	E
2014	E	E	NE	SW	SW	SW	SW	SW	SW	W	NE	NE
2015	E	E	W	SW	SW	SW	W	W	SW	E	E	E
2016	E	E	E	W	W	SW	W	SW	W	SW	E	E
2017	E	NE	E	E	SW	SW	SW	W	W	W	E	NE

4.4 Parameters of Distribution Function and Density of Wind Power at a 10m Height

Using the monthly wind speed data that was collected, the method of maximum likelihood was applied and the parameters for the various distribution functions was determined. Kolmogorov- Smirnov test was performed on the distribution function in order to identify the optimum distribution function.

The information presented in Table 4.6 shows the estimated parameter values as well as their average velocities, for the chosen locations.

In the following figures, the PDF and CDF modes for the wind speed data is shown for both stations for the ten-year period. In addition, the selected distribution function will be the distribution function having the lowest value from the Kolmogorov-Smirnov test, as it will be regarded as the optimum model. This test result is shown in Figure 4.7.

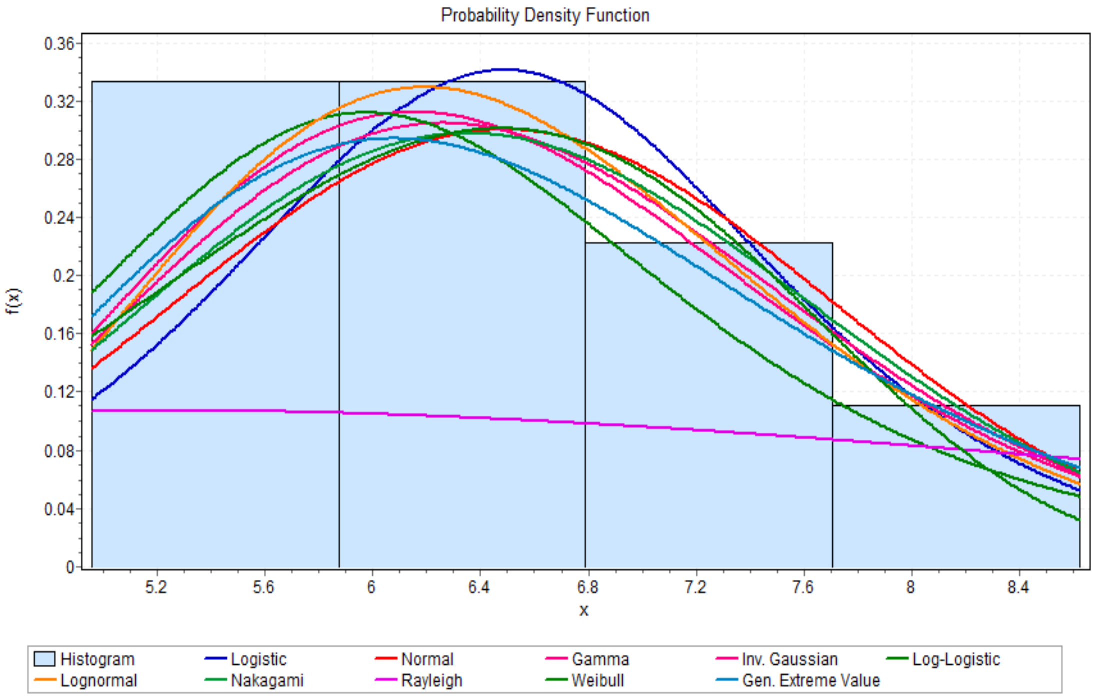

Figure 4.6: Probability density function (PDF) for Jigawa of wind speed data at a height of 10m

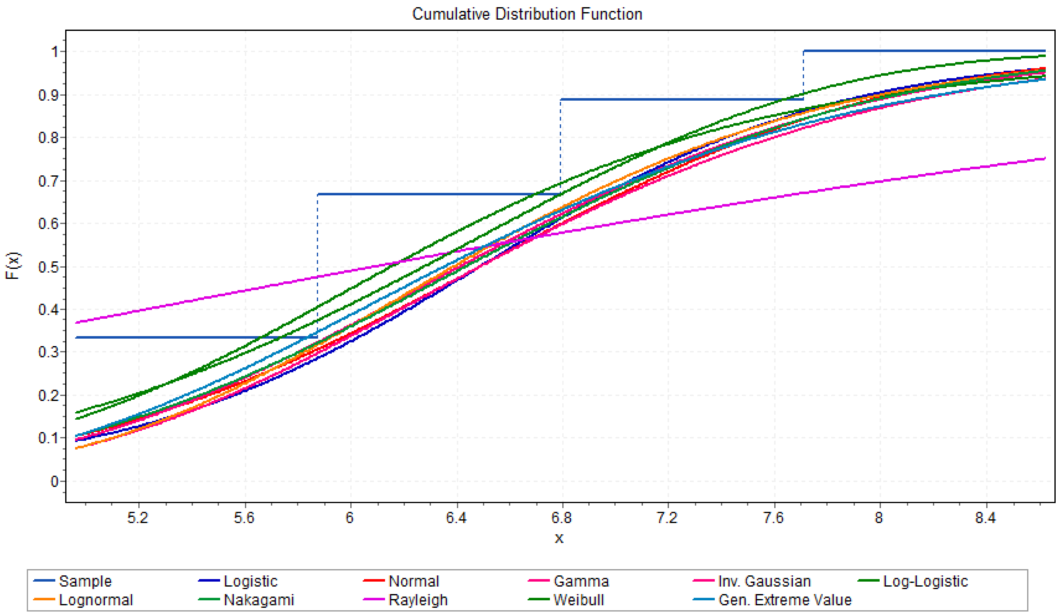

Figure 4.7: Cumulative distribution function (CDF) for Jigawa of wind speed data at a height of 10m

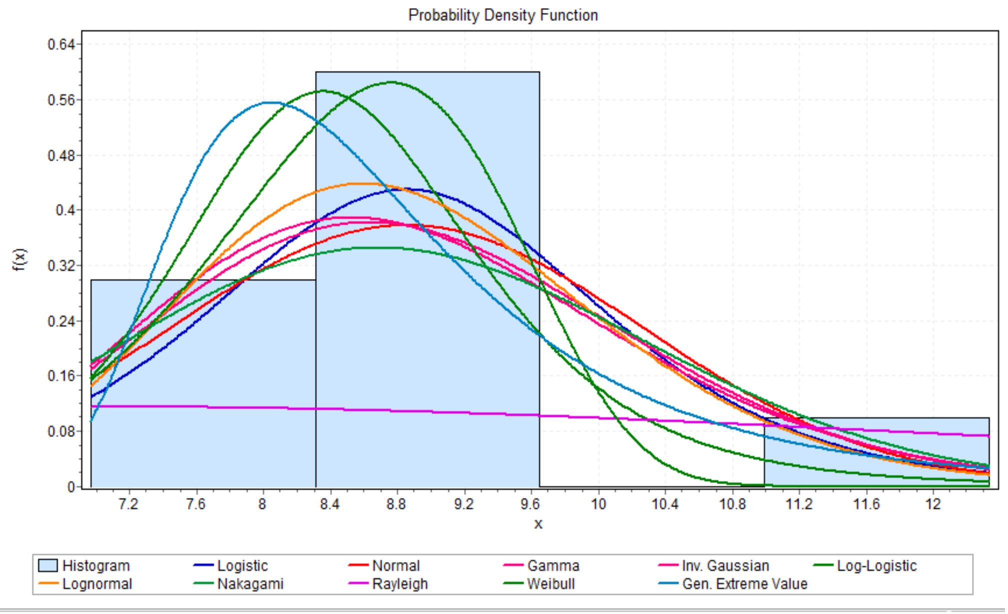

Figure 4.8: Probability density function (PDF) for Yobe of wind speed data at a height of 10m

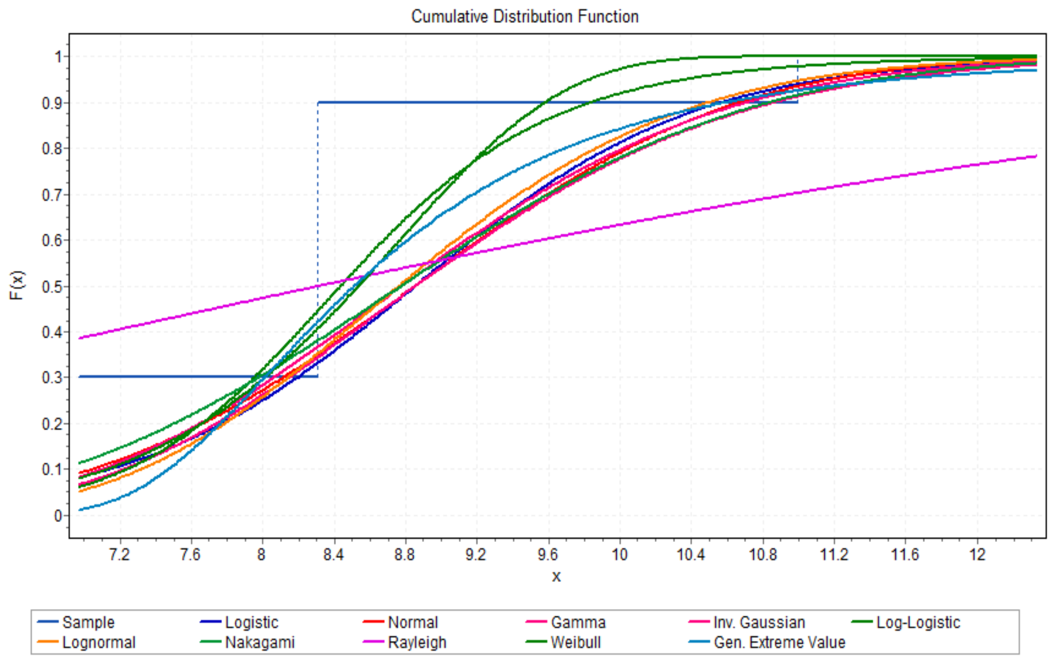

Figure 4.9: Cumulative distribution function (CDF) for Yobe of wind speed data at a height of 10m

Table 4.5: Annual Distribution parameters for the selected stations at 10 m height

Distribution Functions	Actual Mean	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
		8.93	8.93	8.50	8.55	8.77	9.60	12.3	8.13	6.97	7.83
G	Mean	8.93	8.93	8.50	8.55	8.77	9.60	12.33	8.13	6.97	7.83
	Variance	1.79	1.25	2.21	2.76	2.31	7.31	4.73	5.14	1.89	3.36
	a	44.62	63.66	32.66	26.53	33.32	12.61	32.18	12.86	25.70	18.25
	b	0.20	0.14	0.26	0.32	0.26	0.76	0.38	0.63	0.27	0.43
GEV	Mean	8.90	8.92	8.77	8.55	8.76	9.77	11.26	8.10	7.01	7.78
	Variance	1.64	1.37	66.98	2.54	2.17	10.11	12.21	4.77	3.40	6.55
	k	-0.27	0.00	0.48	-0.47	-0.28	-1.08	-1.08	-0.21	0.21	-1.06
	sigma	1.28	0.91	0.82	1.71	1.47	3.06	3.37	2.09	0.97	2.49
	mu	8.44	8.39	7.56	8.14	8.23	9.87	11.38	7.25	6.19	7.84
IG	Mean	8.93	8.93	8.50	8.55	8.77	9.60	12.33	8.13	6.97	7.83
	Variance	1.80	1.25	2.18	2.97	2.37	8.74	5.50	5.46	1.89	3.80
	mu	8.93	8.93	8.50	8.55	8.77	9.60	12.33	8.13	6.97	7.83
	lambda	394.60	569.69	281.83	210.31	283.79	101.18	341.04	98.20	179.33	126.63
L	Mean	8.87	8.84	8.30	8.61	8.75	9.84	12.59	8.07	6.85	7.92
	Variance	2.31	1.50	2.72	2.90	2.62	6.22	3.20	6.05	2.17	3.27
	mu	8.87	8.84	8.30	8.61	8.75	9.84	12.59	8.07	6.85	7.92
	sigma	0.84	0.68	0.91	0.94	0.89	1.38	0.99	1.36	0.81	1.00
LL	Mean	8.92	8.88	8.35	8.71	8.83	10.10	12.69	8.27	6.92	8.06
	Variance	2.38	1.49	2.56	3.42	2.87	9.55	4.12	7.60	2.23	4.19
	mu	2.17	2.17	2.10	2.14	2.16	2.27	2.53	2.06	1.91	2.06
	sigma	0.09	0.07	0.10	0.11	0.10	0.16	0.09	0.17	0.12	0.13

Table 4.5: Continued

LN	Mean	8.93	8.93	8.51	8.57	8.78	9.69	12.38	8.16	6.98	7.87
	Variance	1.98	1.37	2.39	3.27	2.61	9.75	5.99	6.09	2.07	4.18
	mu	2.18	2.18	2.12	2.13	2.16	2.22	2.50	2.06	1.92	2.03
	sigma	0.16	0.13	0.18	0.21	0.18	0.31	0.20	0.30	0.20	0.26
Na	Mean	8.93	8.93	8.51	8.55	8.77	9.57	12.32	8.13	6.97	7.82
	Variance	1.78	1.26	2.27	2.62	2.27	6.45	4.22	4.97	1.93	3.10
	mu	11.31	15.90	8.09	7.10	8.58	3.66	9.11	3.43	6.43	5.05
	omega	81.46	80.94	74.62	75.64	79.14	98.09	155.91	71.07	50.55	64.31
N	Mean	8.93	8.93	8.50	8.55	8.77	9.60	12.33	8.13	6.97	7.83
	Variance	1.96	1.40	2.59	2.77	2.49	6.47	4.15	5.52	2.20	3.22
	mu	8.93	8.93	8.50	8.55	8.77	9.60	12.33	8.13	6.97	7.83
	sigma	1.40	1.18	1.61	1.66	1.58	2.54	2.04	2.35	1.48	1.79
R	Mean	8.00	7.97	7.66	7.71	7.88	8.78	11.07	7.47	6.30	7.11
	Variance	17.48	17.37	16.01	16.23	16.98	21.05	33.46	15.25	10.85	13.80
	B	6.38	6.36	6.11	6.15	6.29	7.00	8.83	5.96	5.03	5.67
W	Mean	8.93	8.90	8.48	8.56	8.76	9.64	12.38	8.14	6.94	7.85
	Variance	2.01	1.67	2.98	2.49	2.57	5.00	2.69	5.20	2.53	2.73
	A	9.51	9.44	9.17	9.20	9.41	10.50	13.07	8.98	7.56	8.51
	B	7.44	8.20	5.69	6.34	6.39	4.93	9.02	4.01	4.99	5.49

Table 4.6: Annual Distribution parameters for the selected stations at 10 m height (Yobe)

Distribution Functions		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
	Actual Mean	8.93	8.93	8.50	8.55	8.77	9.60	12.3	8.13	6.97	7.83
G	Mean	8.93	8.93	8.50	8.55	8.77	9.60	12.33	8.13	6.97	7.83
	Variance	1.79	1.25	2.21	2.76	2.31	7.31	4.73	5.14	1.89	3.36
	a	44.62	63.66	32.66	26.53	33.32	12.61	32.18	12.86	25.70	18.25
	b	0.20	0.14	0.26	0.32	0.26	0.76	0.38	0.63	0.27	0.43
GEV	Mean	8.90	8.92	8.77	8.55	8.76	9.77	11.26	8.10	7.01	7.78
	Variance	1.64	1.37	66.98	2.54	2.17	10.11	12.21	4.77	3.40	6.55
	k	-0.27	0.00	0.48	-0.47	-0.28	-1.08	-1.08	-0.21	0.21	-1.06
	sigma	1.28	0.91	0.82	1.71	1.47	3.06	3.37	2.09	0.97	2.49
	mu	8.44	8.39	7.56	8.14	8.23	9.87	11.38	7.25	6.19	7.84
IG	Mean	8.93	8.93	8.50	8.55	8.77	9.60	12.33	8.13	6.97	7.83
	Variance	1.80	1.25	2.18	2.97	2.37	8.74	5.50	5.46	1.89	3.80
	mu	8.93	8.93	8.50	8.55	8.77	9.60	12.33	8.13	6.97	7.83
	lambda	394.60	569.69	281.83	210.31	283.79	101.18	341.04	98.20	179.33	126.63
L	Mean	8.87	8.84	8.30	8.61	8.75	9.84	12.59	8.07	6.85	7.92
	Variance	2.31	1.50	2.72	2.90	2.62	6.22	3.20	6.05	2.17	3.27
	mu	8.87	8.84	8.30	8.61	8.75	9.84	12.59	8.07	6.85	7.92
	sigma	0.84	0.68	0.91	0.94	0.89	1.38	0.99	1.36	0.81	1.00
LL	Mean	8.92	8.88	8.35	8.71	8.83	10.10	12.69	8.27	6.92	8.06
	Variance	2.38	1.49	2.56	3.42	2.87	9.55	4.12	7.60	2.23	4.19
	mu	2.17	2.17	2.10	2.14	2.16	2.27	2.53	2.06	1.91	2.06
	sigma	0.09	0.07	0.10	0.11	0.10	0.16	0.09	0.17	0.12	0.13

Table 4.6: continued

LN	Mean	8.93	8.93	8.51	8.57	8.78	9.69	12.38	8.16	6.98	7.87
	Variance	1.98	1.37	2.39	3.27	2.61	9.75	5.99	6.09	2.07	4.18
	mu	2.18	2.18	2.12	2.13	2.16	2.22	2.50	2.06	1.92	2.03
	sigma	0.16	0.13	0.18	0.21	0.18	0.31	0.20	0.30	0.20	0.26
Na	Mean	8.93	8.93	8.51	8.55	8.77	9.57	12.32	8.13	6.97	7.82
	Variance	1.78	1.26	2.27	2.62	2.27	6.45	4.22	4.97	1.93	3.10
	mu	11.31	15.90	8.09	7.10	8.58	3.66	9.11	3.43	6.43	5.05
	omega	81.46	80.94	74.62	75.64	79.14	98.09	155.91	71.07	50.55	64.31
N	Mean	8.93	8.93	8.50	8.55	8.77	9.60	12.33	8.13	6.97	7.83
	Variance	1.96	1.40	2.59	2.77	2.49	6.47	4.15	5.52	2.20	3.22
	mu	8.93	8.93	8.50	8.55	8.77	9.60	12.33	8.13	6.97	7.83
	sigma	1.40	1.18	1.61	1.66	1.58	2.54	2.04	2.35	1.48	1.79
R	Mean	8.00	7.97	7.66	7.71	7.88	8.78	11.07	7.47	6.30	7.11
	Variance	17.48	17.37	16.01	16.23	16.98	21.05	33.46	15.25	10.85	13.80
	B	6.38	6.36	6.11	6.15	6.29	7.00	8.83	5.96	5.03	5.67
W	Mean	8.93	8.90	8.48	8.56	8.76	9.64	12.38	8.14	6.94	7.85
	Variance	2.01	1.67	2.98	2.49	2.57	5.00	2.69	5.20	2.53	2.73
	A	9.51	9.44	9.17	9.20	9.41	10.50	13.07	8.98	7.56	8.51
	B	7.44	8.20	5.69	6.34	6.39	4.93	9.02	4.01	4.99	5.49

Table 4.7: The results of the goodness-of-fit and the selected distribution (in bold) for each area.

#	Distribution	PARAMETERS JIGAWA	PARAMETERS YOBE
1	Gamma	α=39.112 β=0.22634	α=28.439 β=0.22812
2	Gen. Extreme Value	k=0.1554 σ=0.89868 μ=8.172	k=-0.11267 σ=1.1529 μ=5.9389
3	Inv. Gaussian	λ=346.24 μ=8.8525	λ=184.5 μ=6.4877
4	Log-Logistic	α=14.311 β=8.4344	α=8.2596 β=6.1525
5	Logistic	σ=0.78041 μ=8.8525	σ=0.67072 μ=6.4877
6	Lognormal	σ=0.1408 μ=2.1703	σ=0.17634 μ=1.8544
7	Nakagami	m=8.2655 Ω=80.17	m=7.1219 Ω=43.406
8	Normal	σ=1.4155 μ=8.8525	σ=1.2166 μ=6.4877
9	Rayleigh	σ=7.0633	σ=5.1764
10	Weibull	α=10.417 β=8.8408	α=5.8803 β=6.6806

As stated previously, the results from the Kolmogorov Smirnov test is used to determine the most suitable distribution function for the wind speed data provide. After the test has been carried out the results are used to generate a ranking table showing in ranking order the most suitable to the least suitable distribution function for performing the analysis on the wind speed data. The table below shows this ranking order.

Table 4.8: The ranking of the distribution functions for both areas at a height of 10 m based on the goodness-of-fit statistics.

#	Distribution	Kolmogorov Smirnov			
		JIGAWA		**YOBE**	
		Statistic	Rank	Statistic	Rank
1	Gamma	0.25844	5	0.15985	3
2	Gen. Extreme Value	0.196	2	0.14212	1
3	Inv. Gaussian	0.27966	9	0.18374	8
4	Log-Logistic	0.22768	3	0.20184	9
5	Logistic	0.27679	7	0.17999	7
6	Lognormal	0.24763	4	0.17805	6
7	Nakagami	0.26103	6	0.15382	2
8	Normal	0.27958	8	0.16024	4
9	Rayleigh	0.38517	10	0.36793	10
10	Weibull	0.18521	1	0.16064	5

The mean power density is observed to have a range from 20.85 W/m2 to 170.49 W/m2. It can also be seen that in Jigawa the years with the highest mean density of wind power are 2013 and 2014 averaging 74.35 W/m2 and 151.51W/m2 respectively. Also it can also be observed from Table 4.9 that the year with the lowest mean density of wind power is in the year 2016 averaging around 27.38W/m2.

Table 4.9: The mean density of wind power (W/m2) of Jigawa at a height of 10 m.

Model	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Actual	59.27	59.27	51.20	52.11	56.17	73.76	156.41	44.72	28.19	40.07
G	59.27	59.27	51.20	52.11	56.17	73.76	156.41	44.72	28.19	40.07
GEV	58.83	59.09	56.26	52.14	55.96	77.68	119.17	44.24	28.77	39.31
IG	59.27	59.27	51.20	52.11	56.17	73.76	156.41	44.72	28.19	40.07
L	58.26	57.59	47.62	53.28	55.80	79.38	166.46	43.76	26.74	41.39
LL	59.26	58.35	48.58	55.13	57.43	85.85	170.49	47.13	27.67	43.62
LN	59.45	59.38	51.33	52.55	56.43	75.83	158.09	45.30	28.30	40.68
Na	59.29	59.30	51.31	52.03	56.18	73.13	155.76	44.80	28.27	39.93
N	59.27	59.27	51.20	52.11	56.17	73.76	156.41	44.72	28.19	40.07
R	42.66	42.26	37.41	38.18	40.85	56.37	112.97	34.77	20.85	29.93
W	59.32	58.80	50.81	52.32	56.02	74.58	158.06	44.96	27.87	40.35

The mean power density is observed to have a range from 7.65 W/m2 to 56.67 W/m2. It can also be seen that in Yobe the year with the highest mean density of wind power is 2016 averaging 52.63 W/m2. In addition, it can also be observed from Table 4.10 that the year with the lowest mean density of wind power is in the year 2013 averaging around 9.84W/m2.

Table 4.10: The mean density of wind power (W/m2) of Yobe at a height of 10 m.

Model	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Actual	22.55	20.44	25.64	12.71	11.50	10.16	31.77	36.24	53.45	36.12
G	22.55	20.44	25.64	12.71	11.50	10.16	31.77	36.54	53.34	36.12
GEV	23.30	20.50	25.69	12.82	11.43	10.17	31.54	36.31	53.59	35.41
IG	22.55	20.44	25.64	12.71	11.50	10.16	31.77	36.54	53.34	36.12
L	25.96	23.13	26.97	11.50	11.40	9.48	30.31	35.92	54.25	38.32
LL	34.02	28.34	27.31	11.81	11.64	9.90	31.67	38.20	56.67	40.07
LN	32.79	27.73	25.73	12.73	11.64	10.20	31.98	36.98	53.85	36.62
Na	20.43	18.73	25.62	12.76	11.51	10.22	31.82	36.55	53.32	35.98
N	22.55	20.44	25.64	12.71	11.50	10.16	31.77	36.54	53.34	36.12
R	18.63	16.38	18.27	9.42	8.81	7.65	23.69	27.87	39.96	26.80
W	21.32	19.36	26.00	12.51	11.51	9.97	31.72	36.69	53.86	36.59

4.5 Parameters of Distribution Function for the Studied Periods

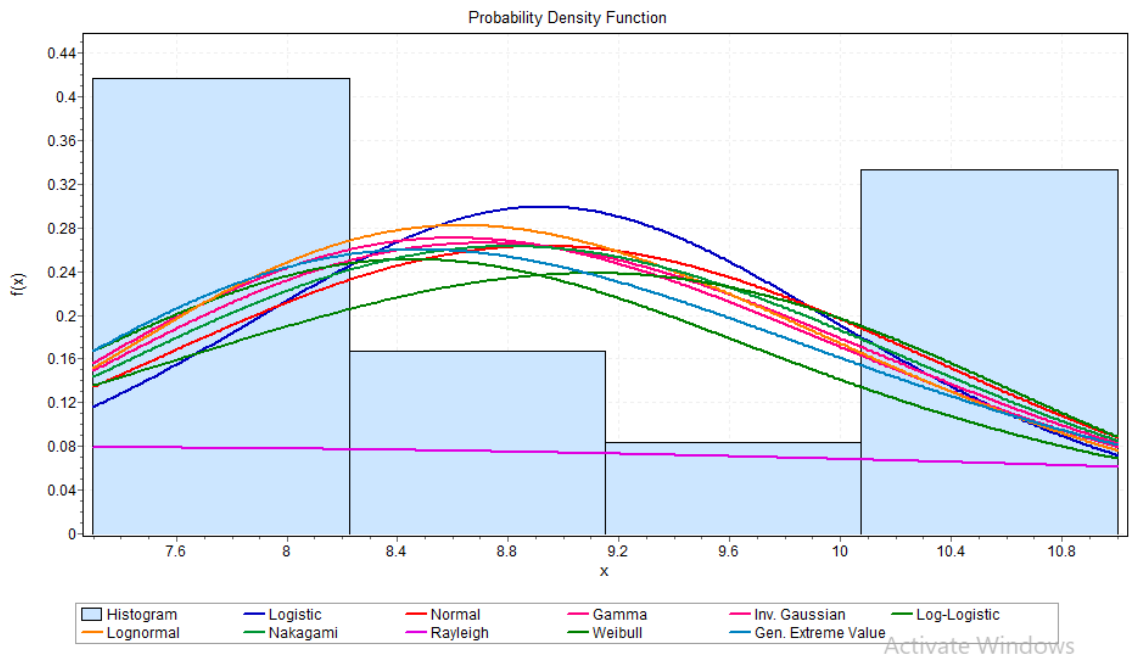

Figure 4.10: PDF-JIGAWA-2008

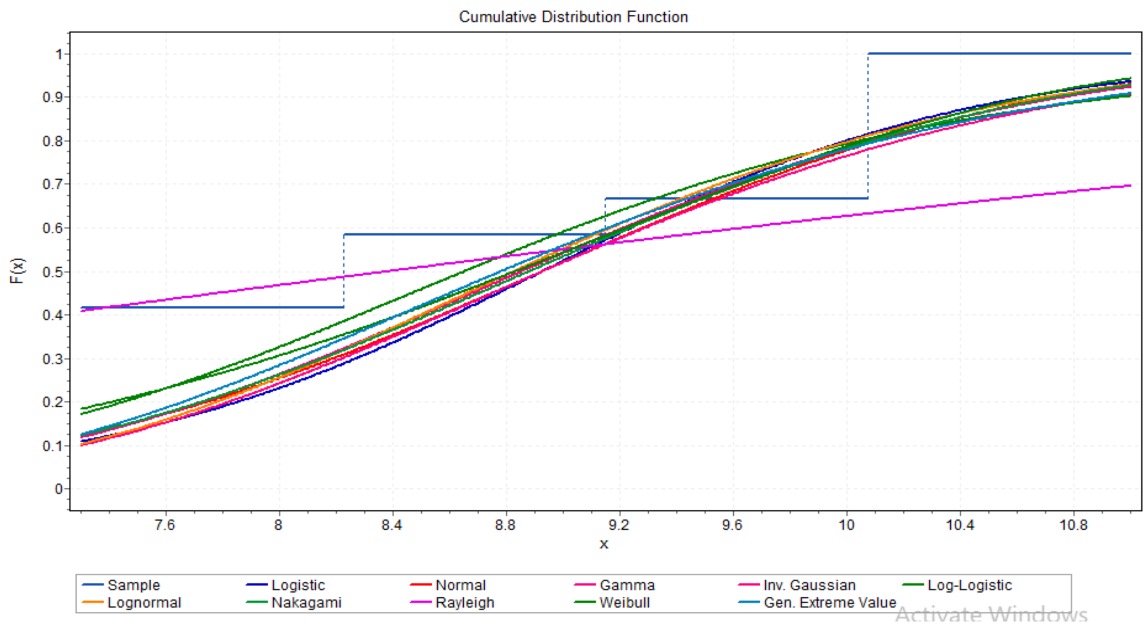

Figure 4.11: CDF-JIGAWA-2008

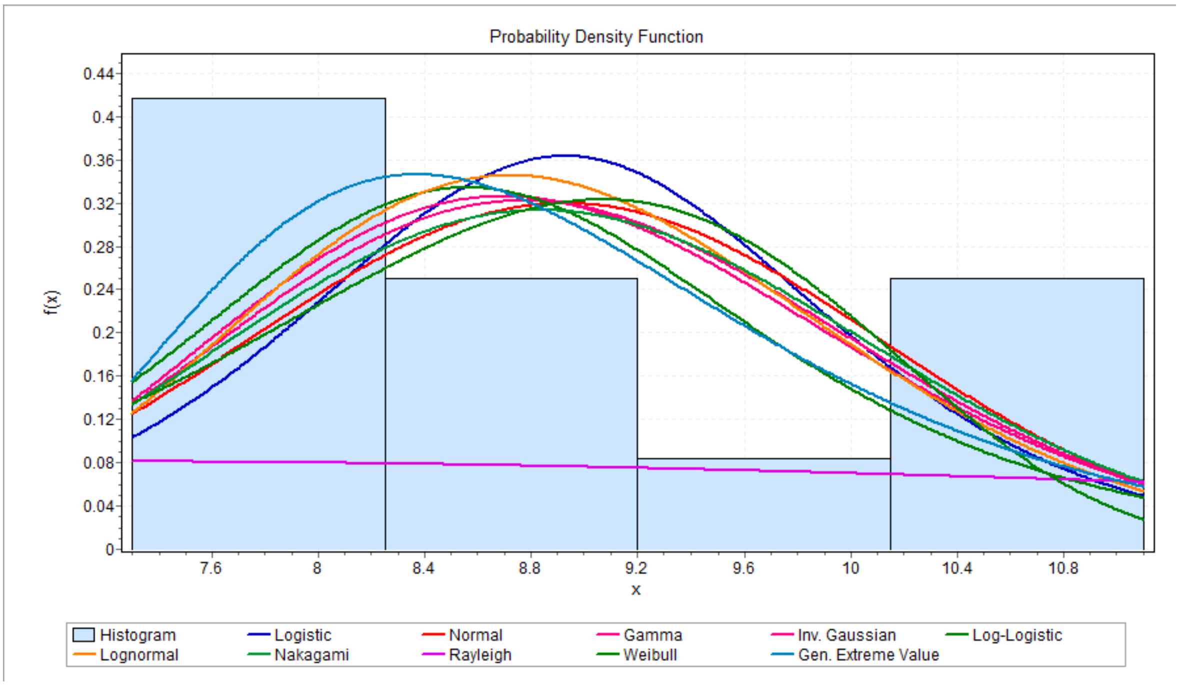

Figure 4.12: PDF-JIGAWA-2009

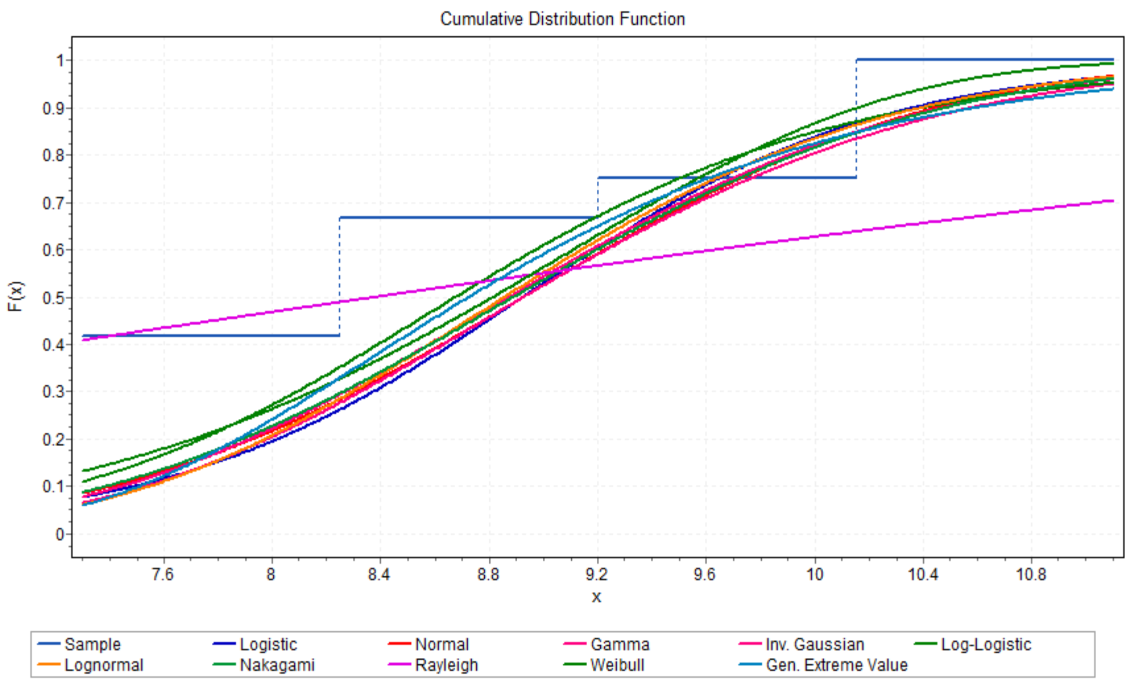

Figure 4.13: CDF-JIGAWA-2009

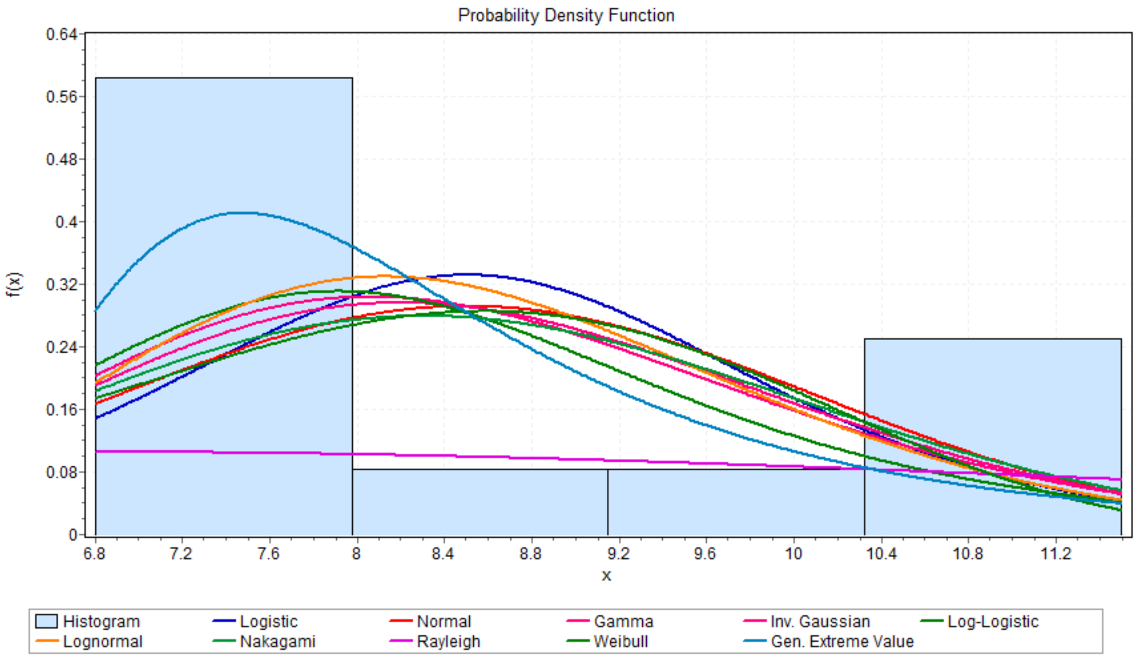

Figure 4.14: PDF-JIGAWA-2010

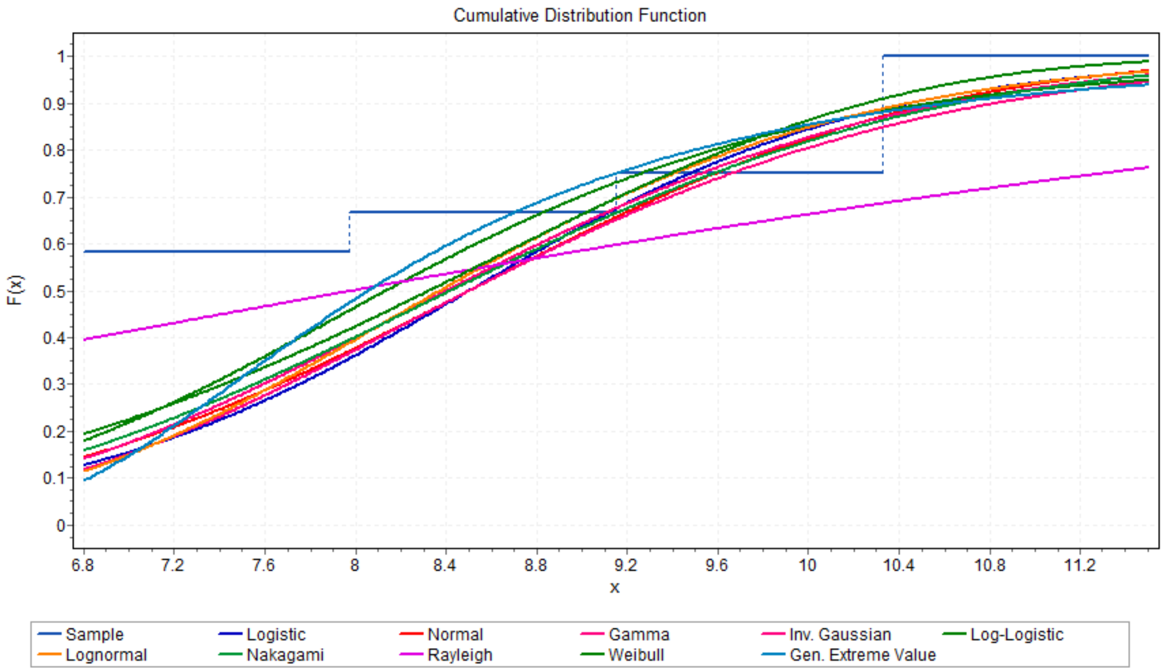

Figure 4.15: CDF-JIGAWA-2010

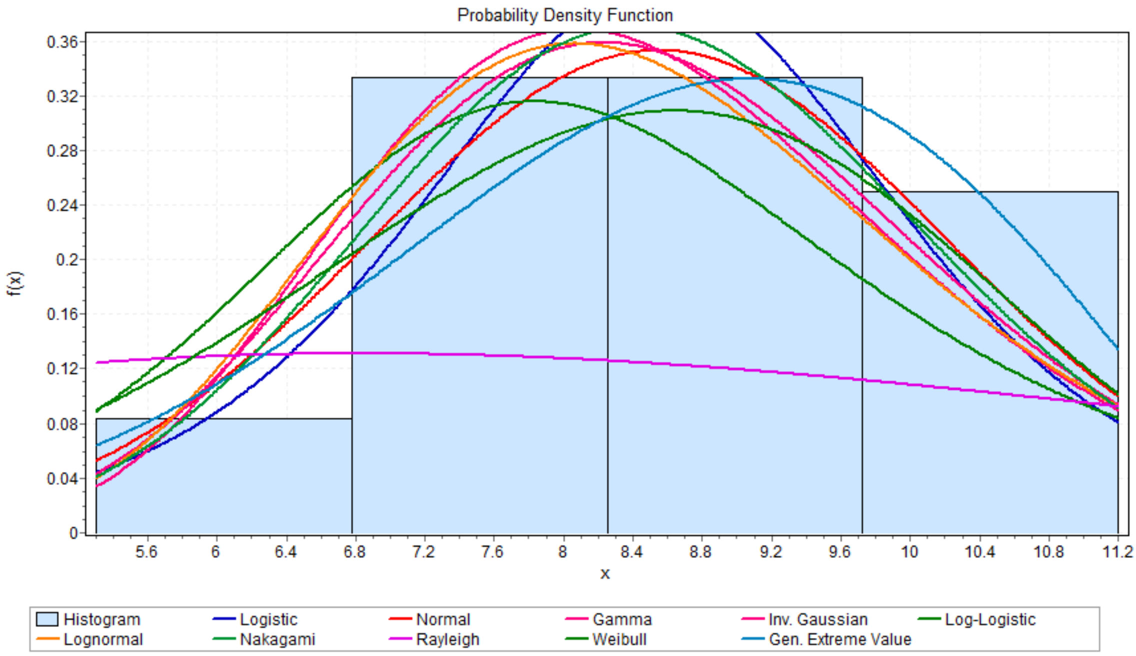

Figure 4.16: PDF-JIGAWA-2011

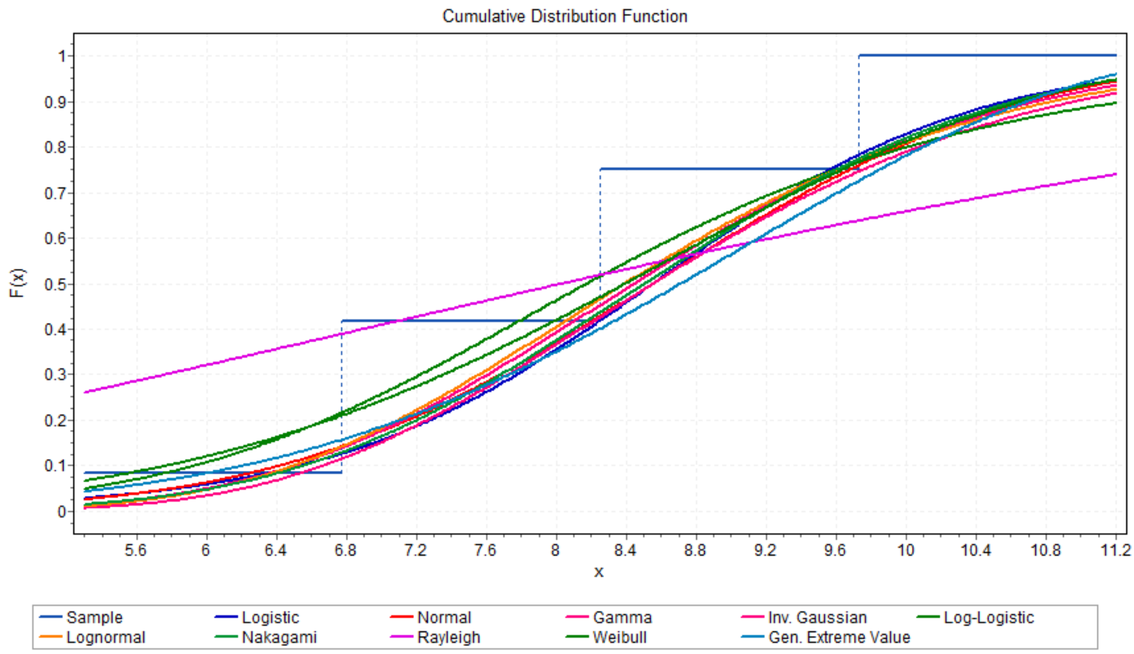

Figure 4.17: CDF-JIGAWA-2011

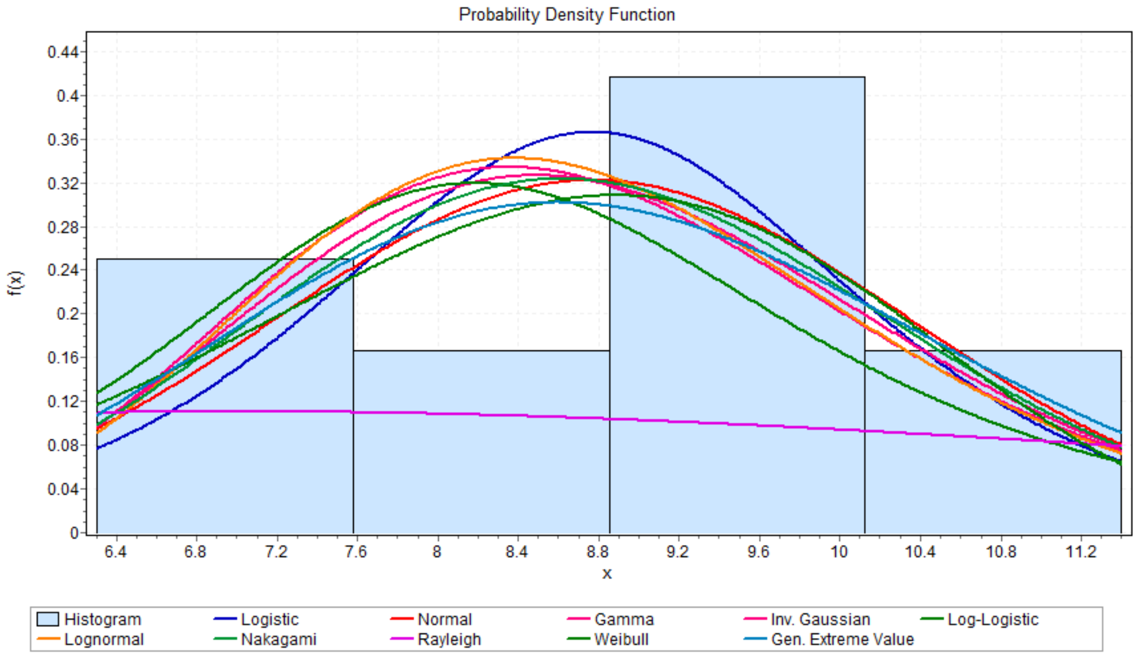

Figure 4.18: PDF-JIGAWA-2012

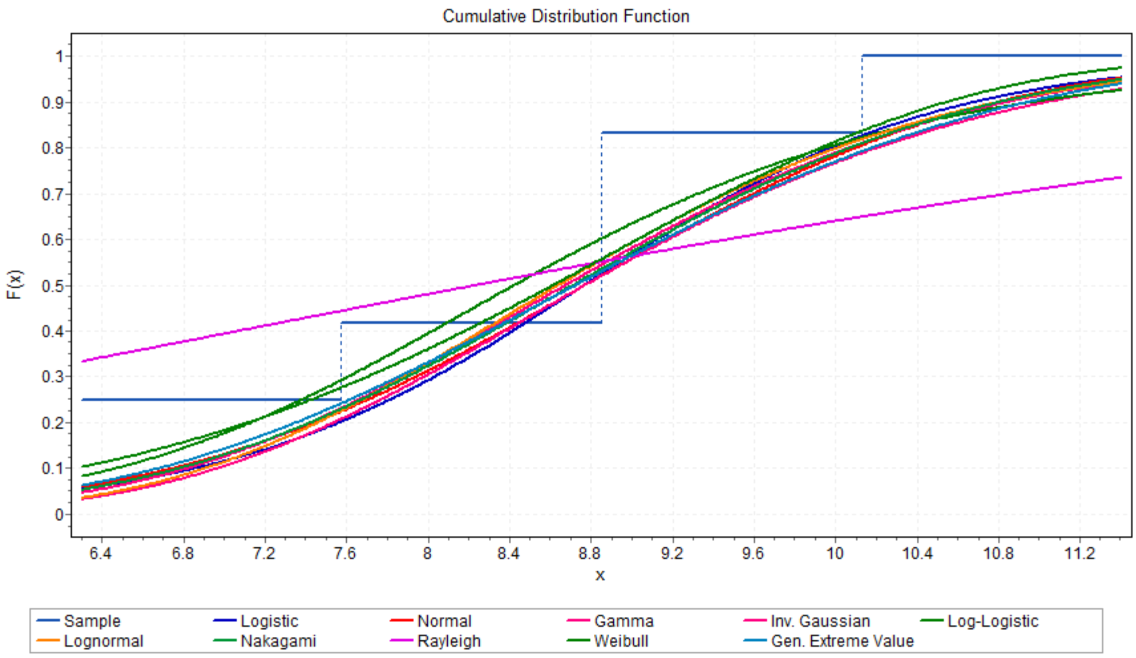

Figure 4.19: CDF-JIGAWA-2012

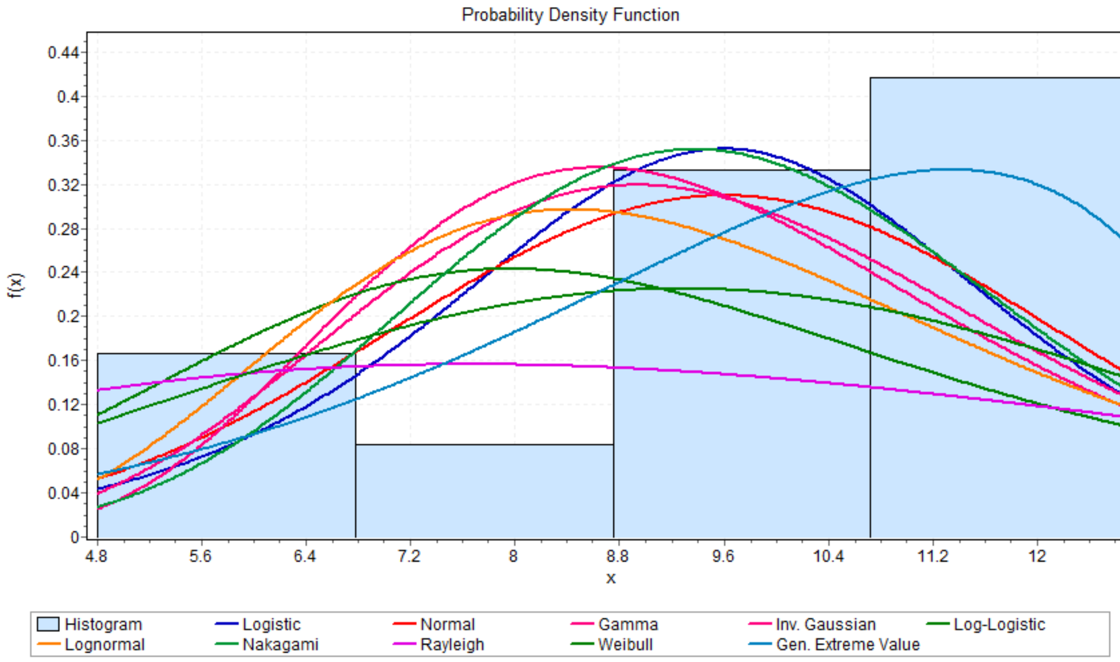

Figure 4.20: PDF-JIGAWA-2013

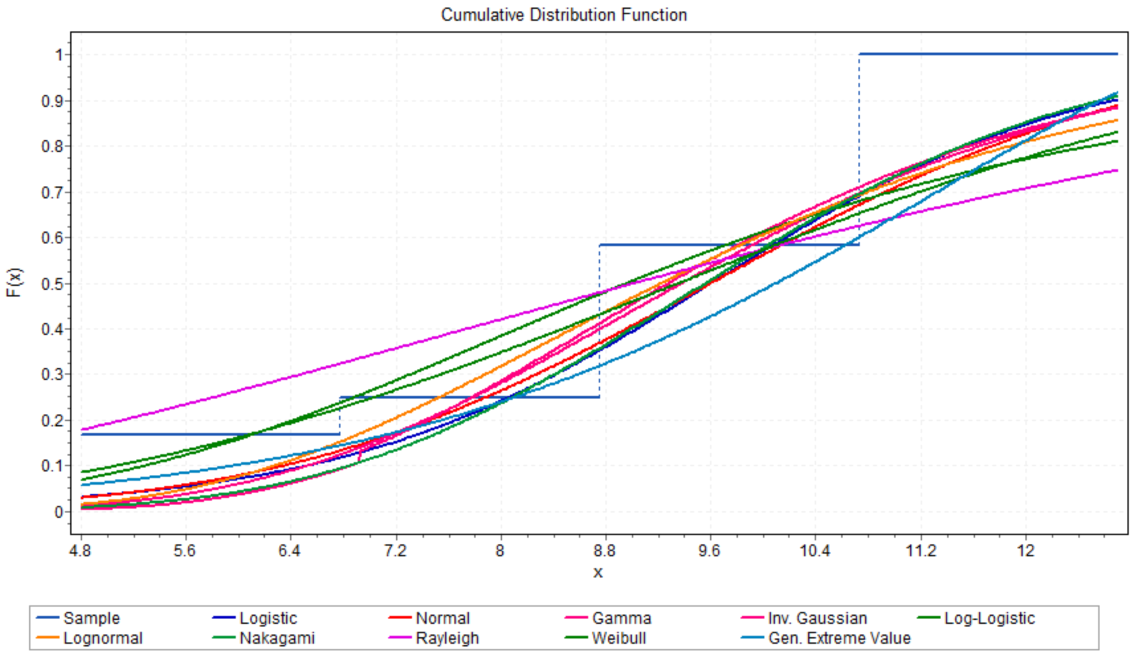

Figure 4.21: CDF-JIGAWA-2013

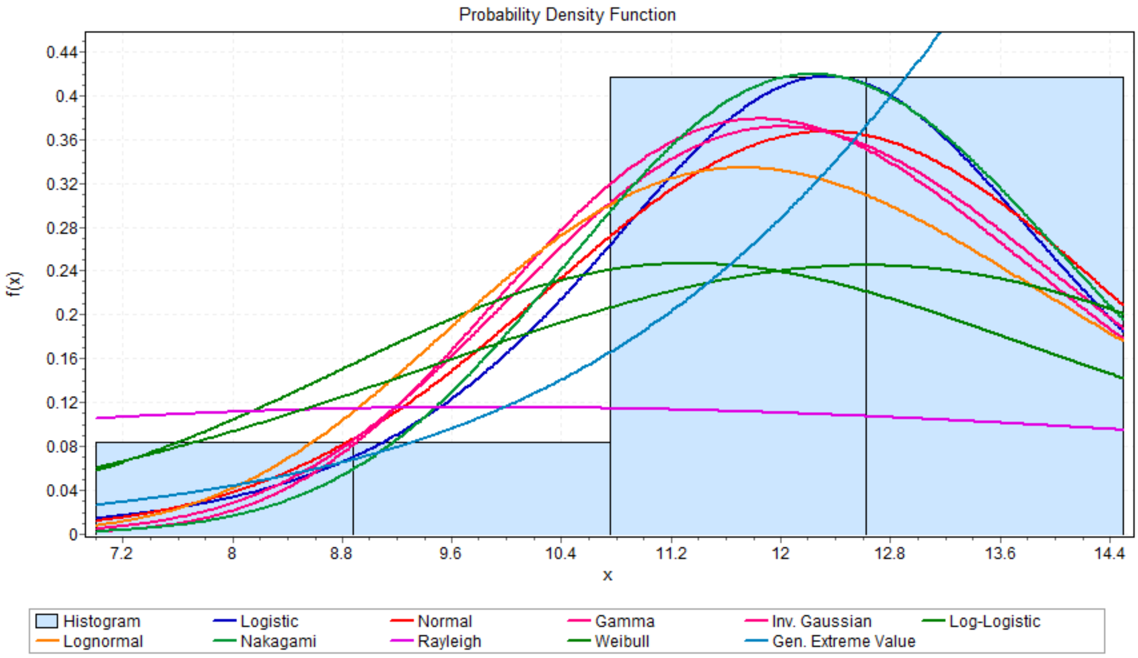

Figure 4.22: PDF-JIGAWA-2014

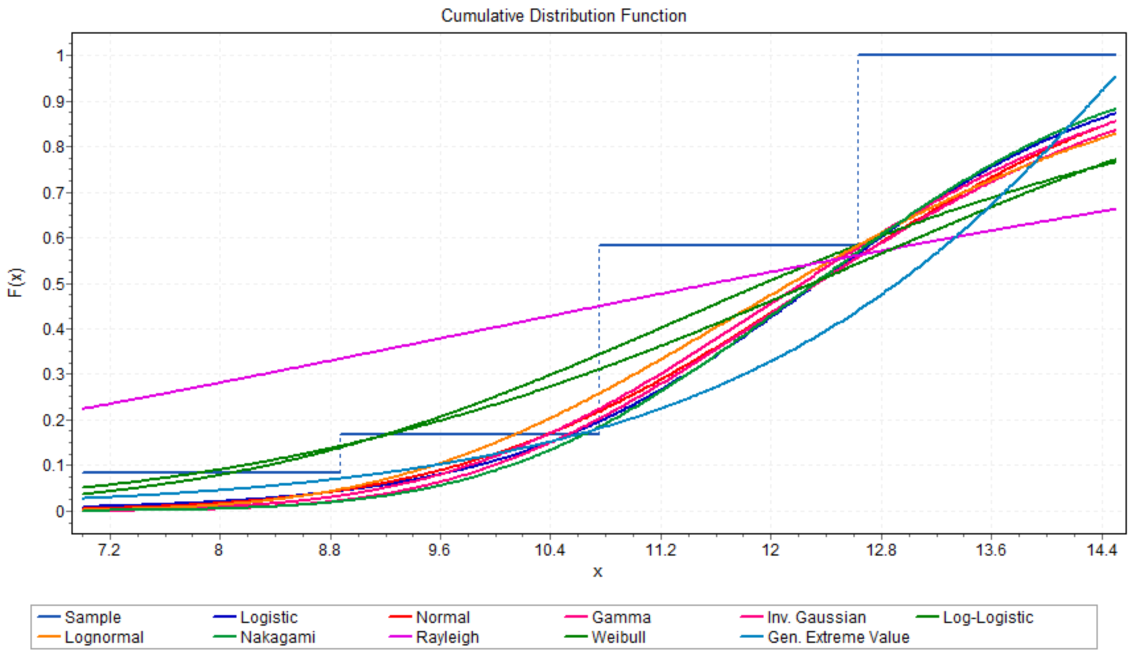

Figure 4.23: CDF-JIGAWA-2014

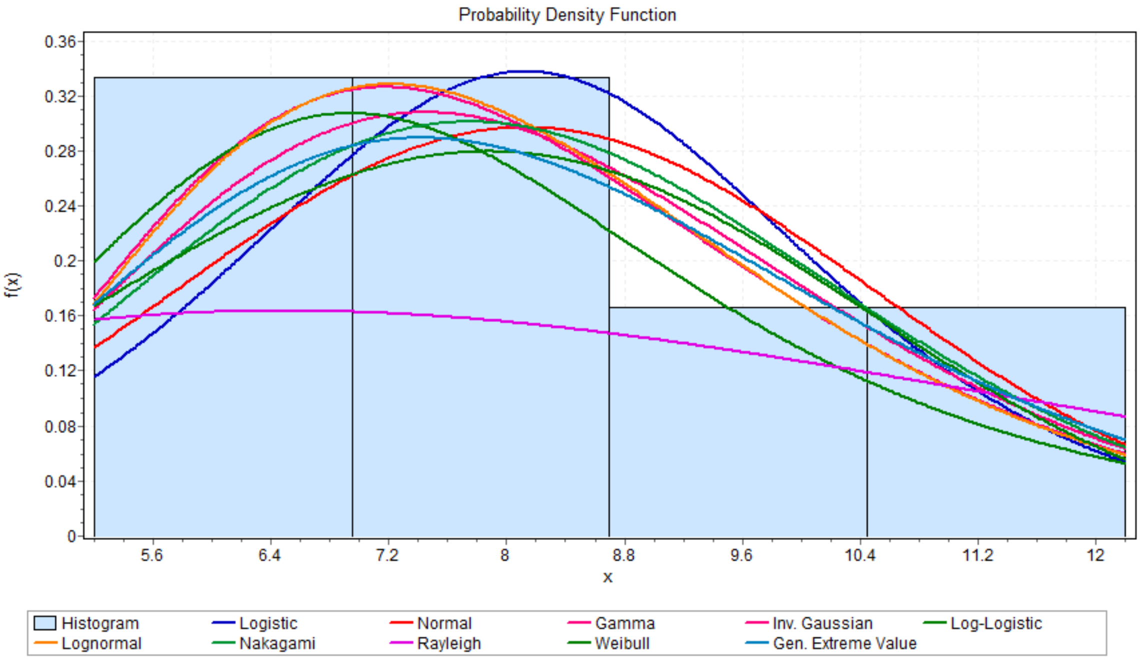

Figure 4.24: PDF-JIGAWA-2015

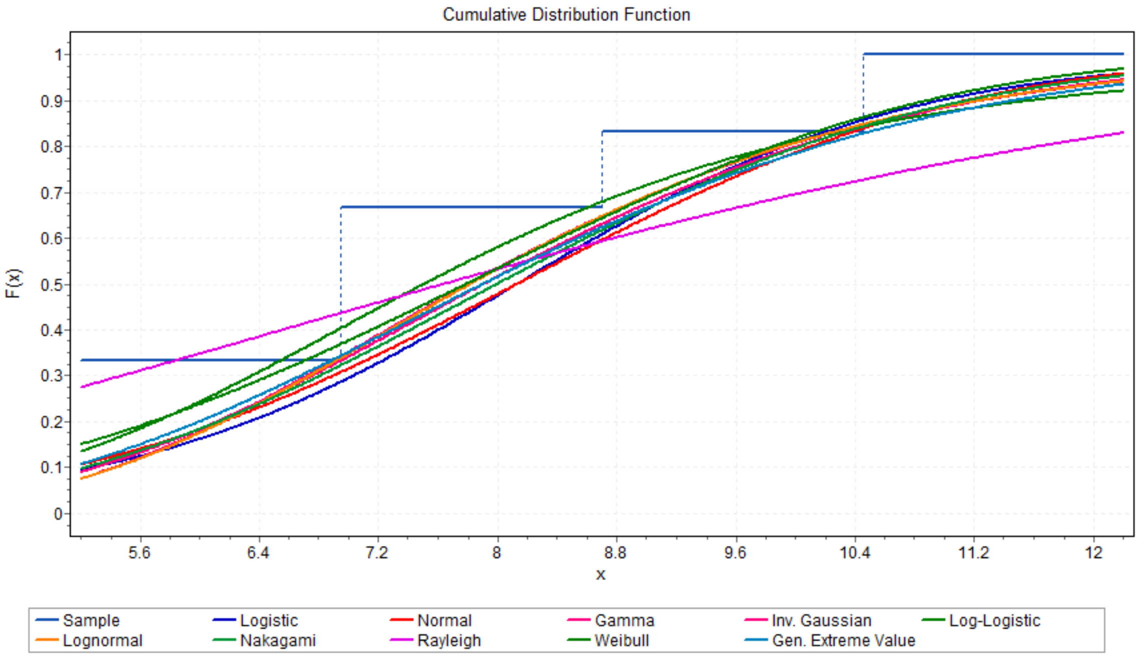

Figure 4.25: CDF-JIGAWA-2015

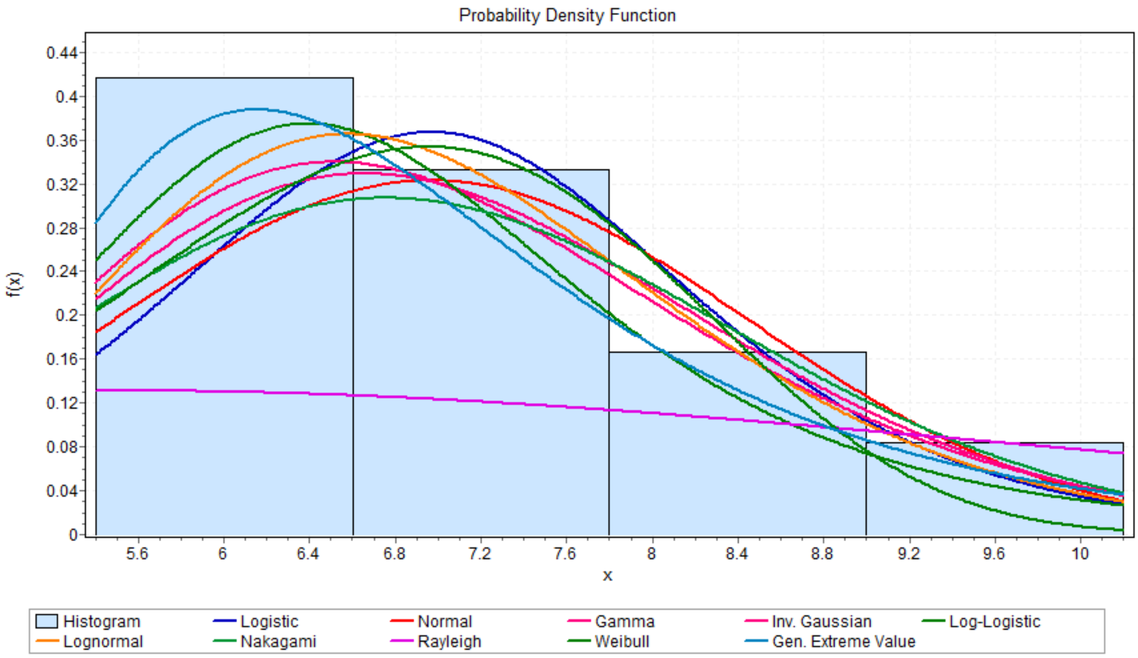

Figure 4.26: PDF-JIGAWA-2016

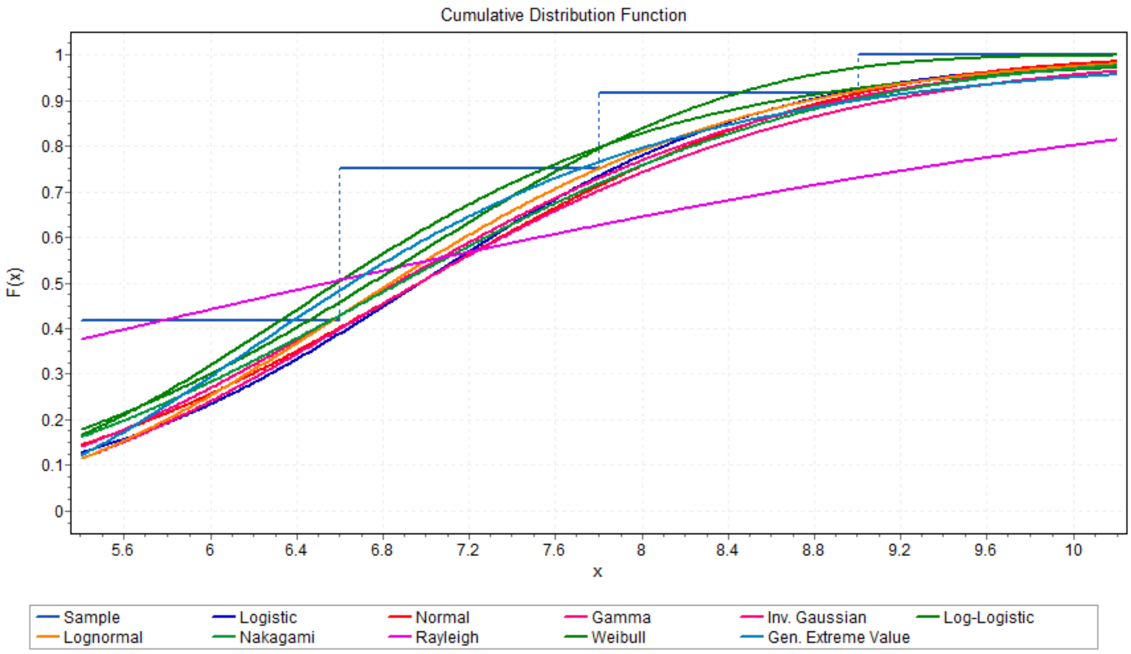

Figure 4.27: CDF-JIGAWA-2016

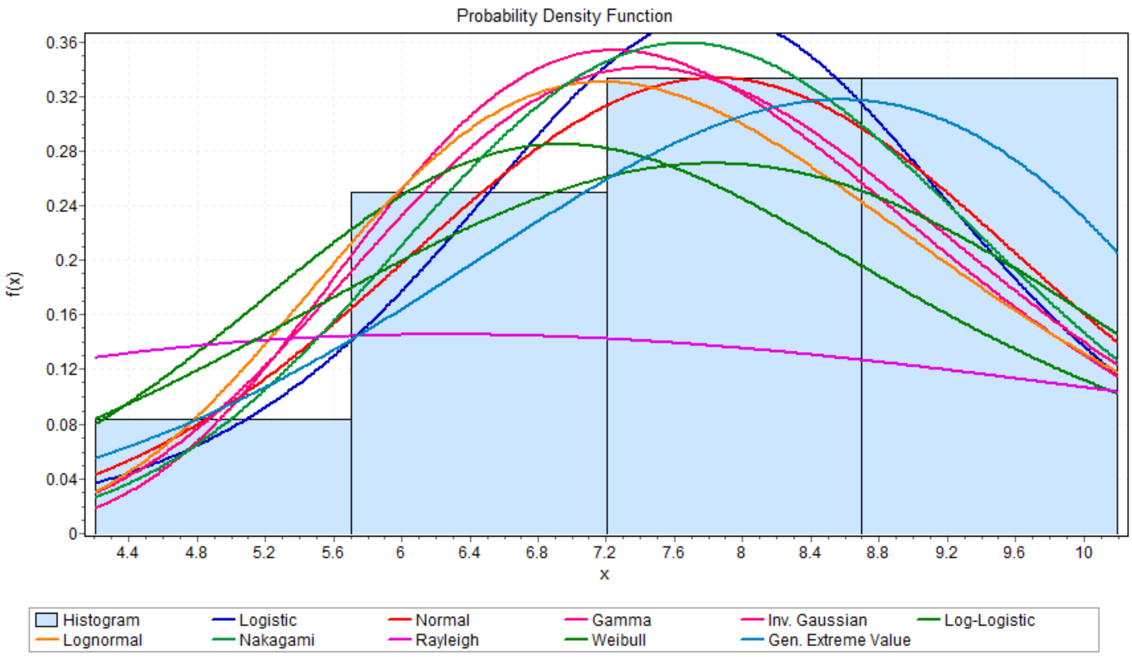

Figure 4.28: PDF-JIGAWA-2017

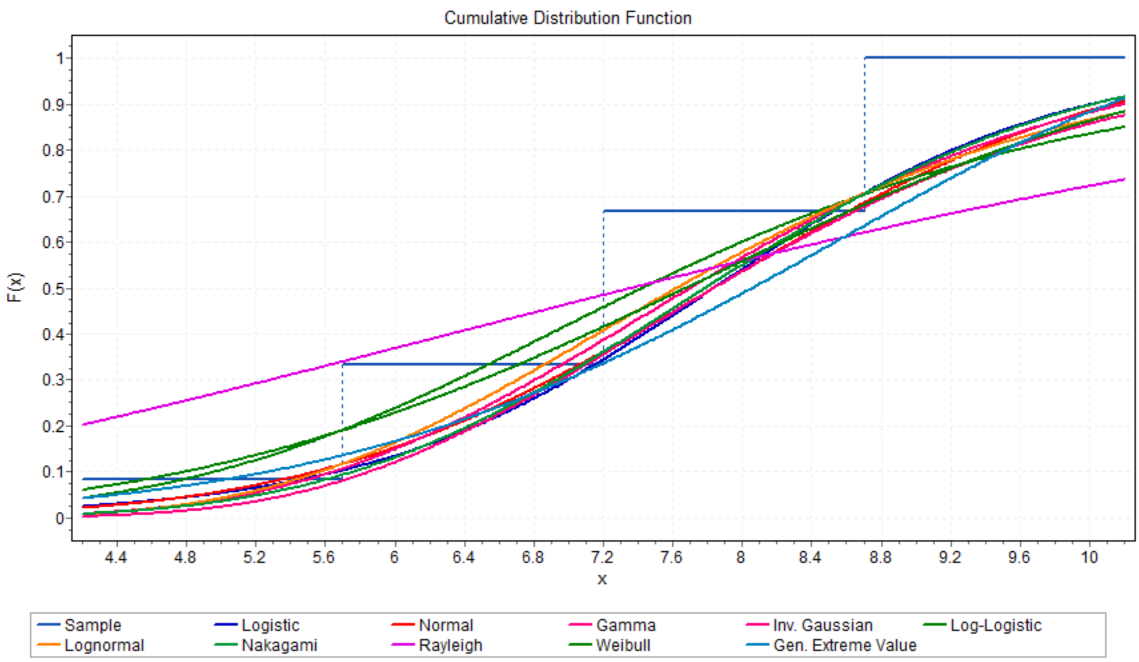

Figure 4.29: CDF-JIGAWA-2017

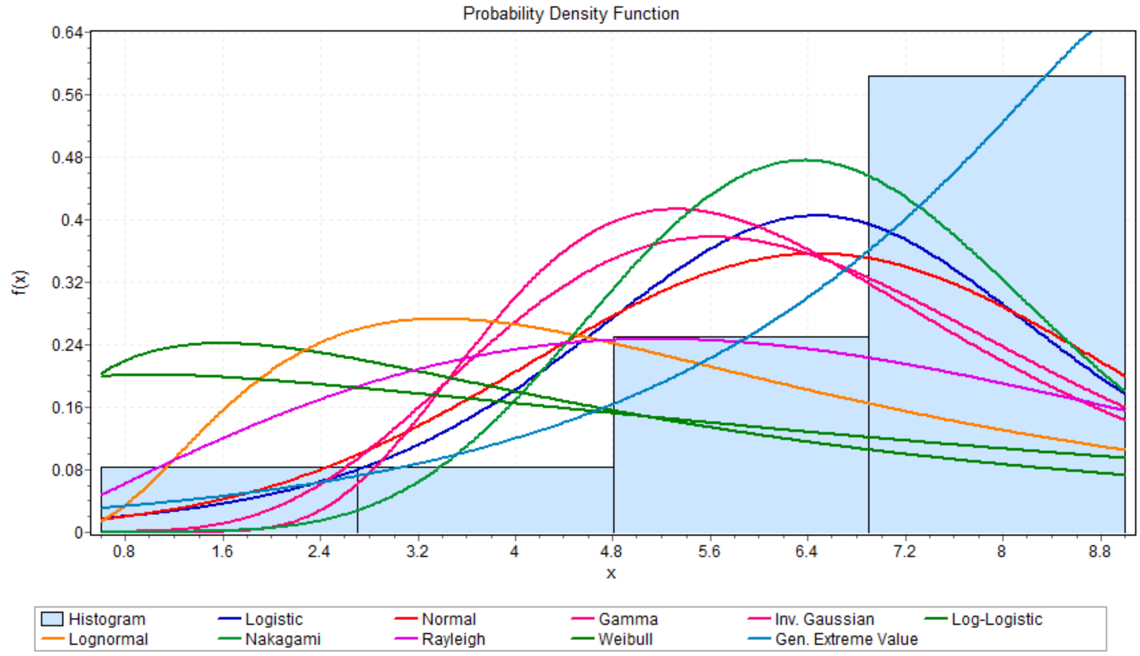

Figure 4.30: PDF-YOBE-2008

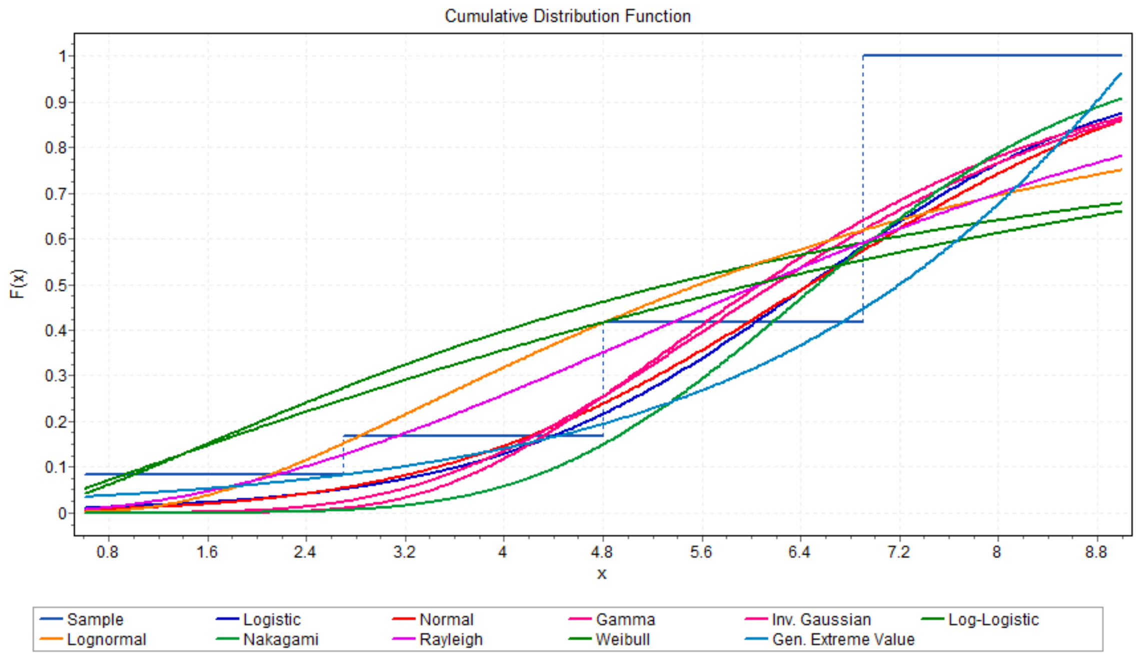

Figure 4.31: CDF-YOBE-2008

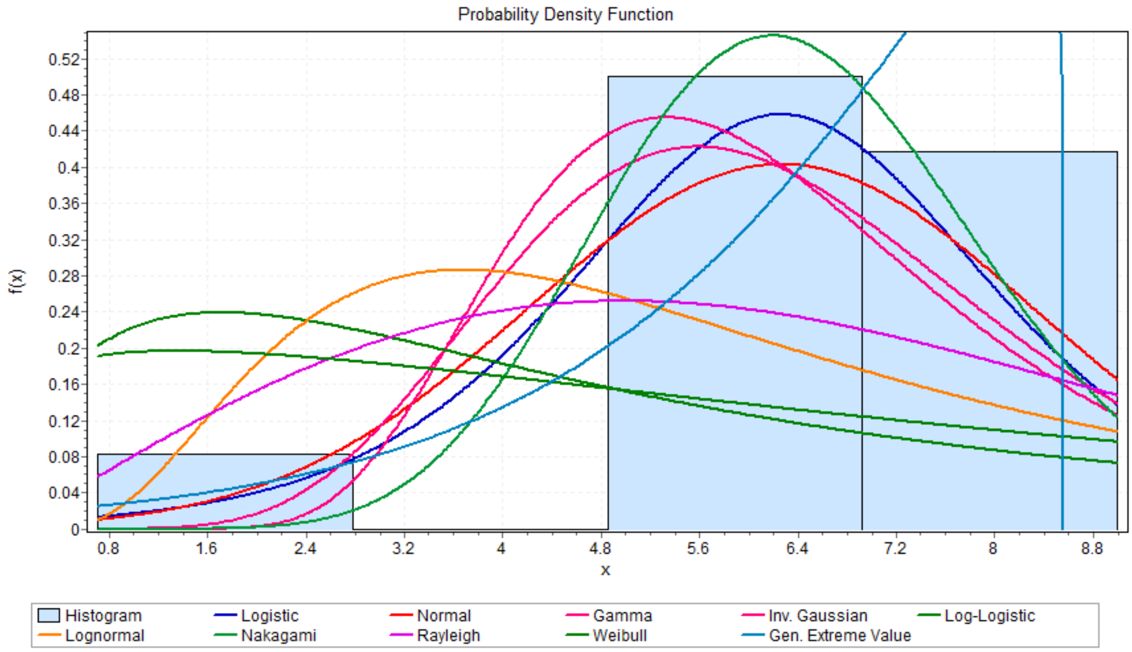

Figure 4.32: PDF-YOBE-2009

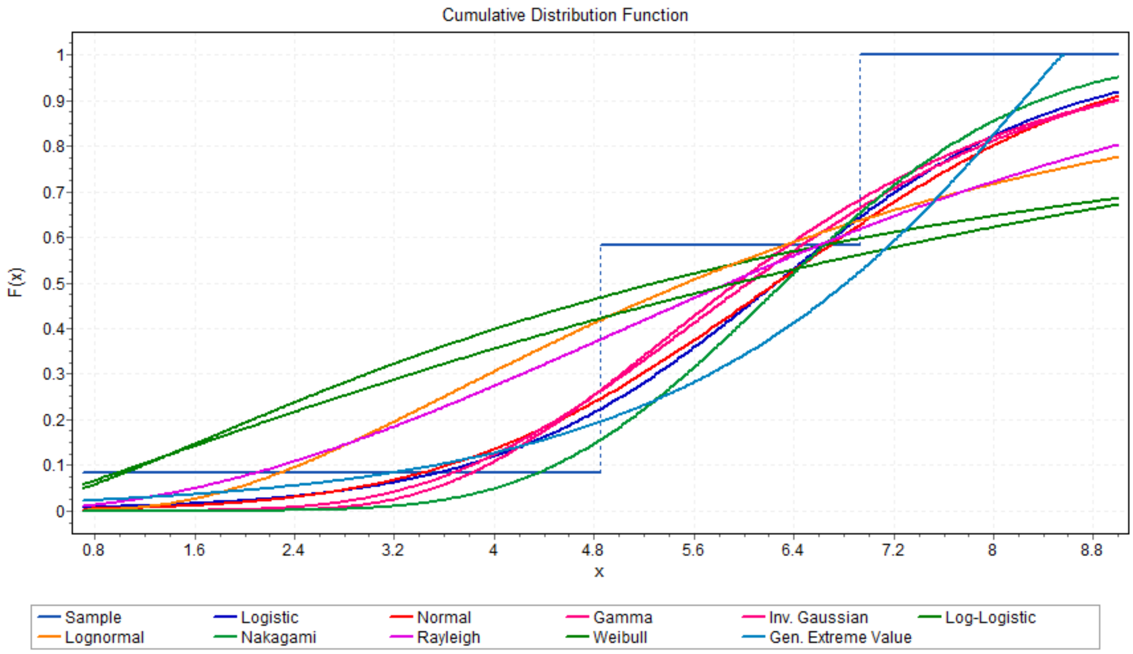

Figure 4.33: CDF-YOBE-2009

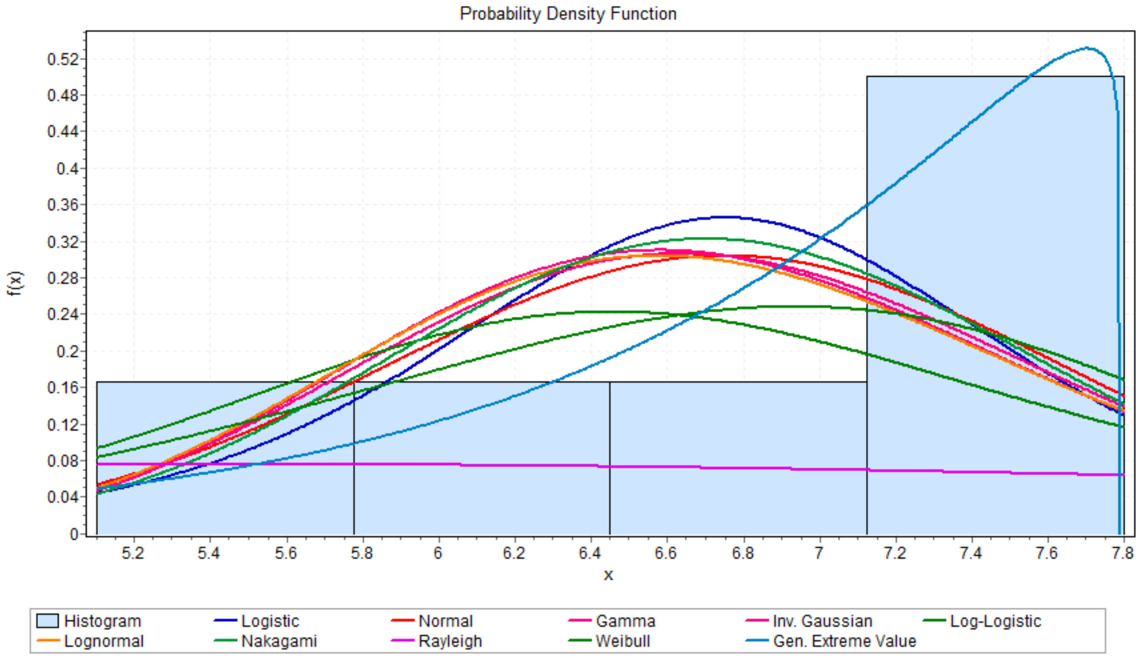

Figure 4.34: PDF-YOBE-2010

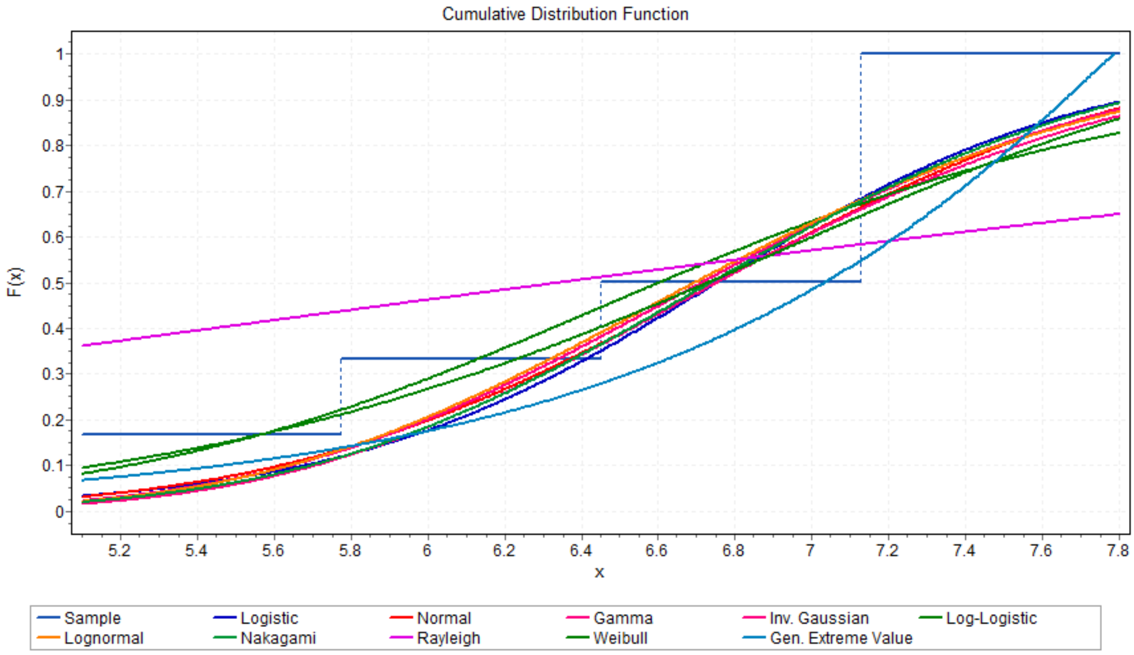

Figure 4.35: CDF-YOBE-2010

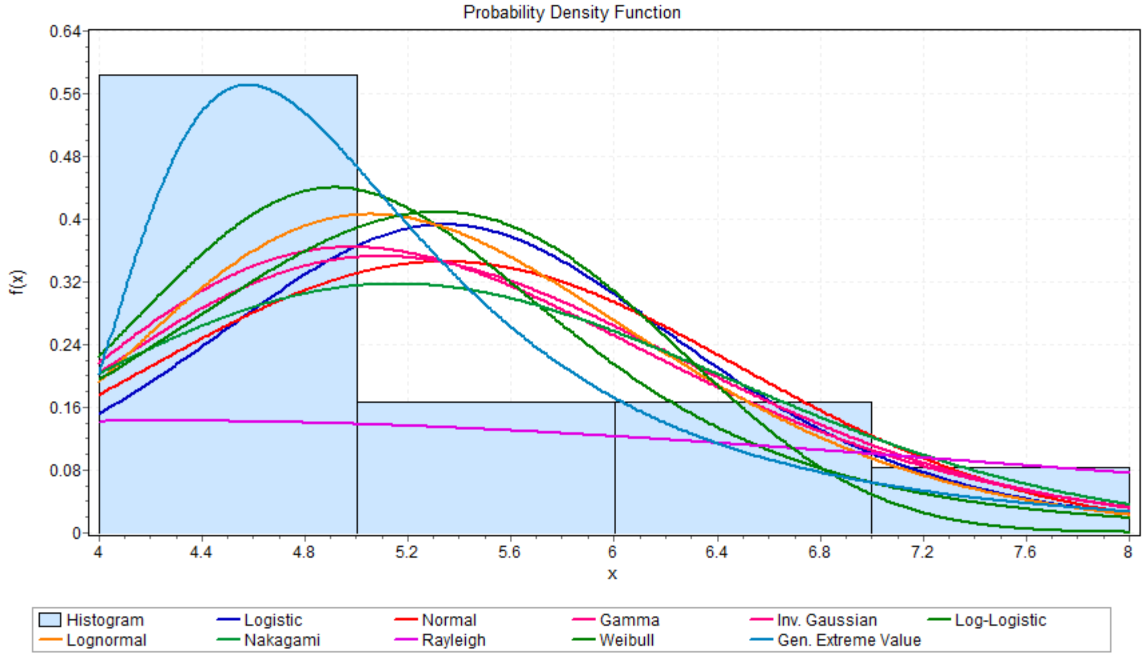

Figure 4.36: PDF-YOBE-2011

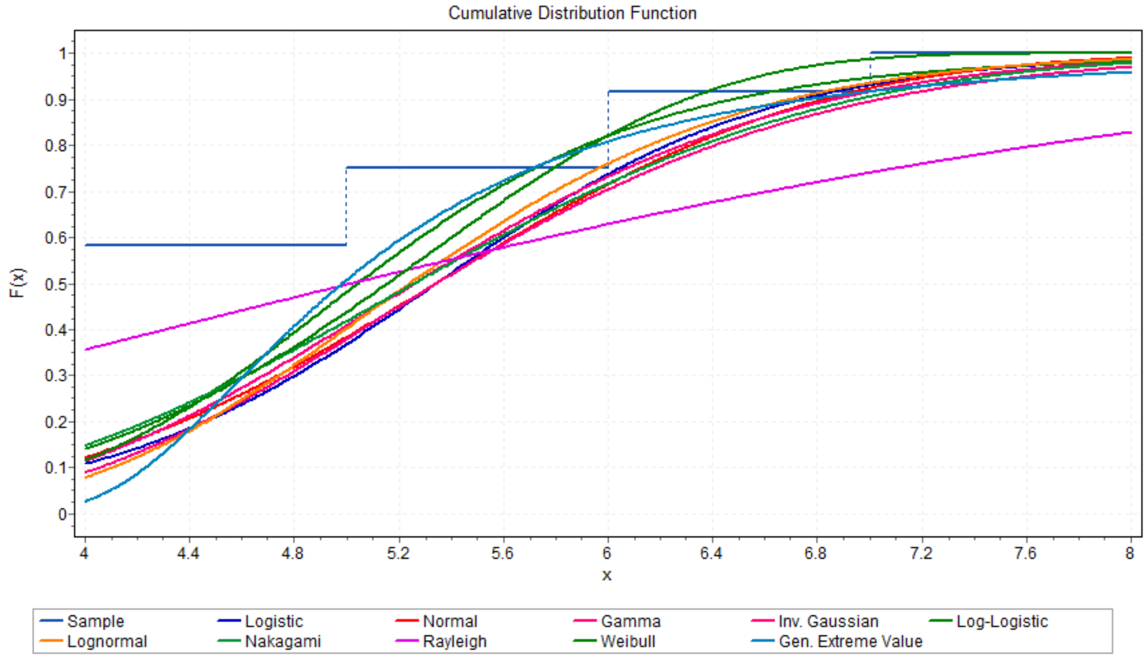

Figure 4.37: CDF-YOBE-2011

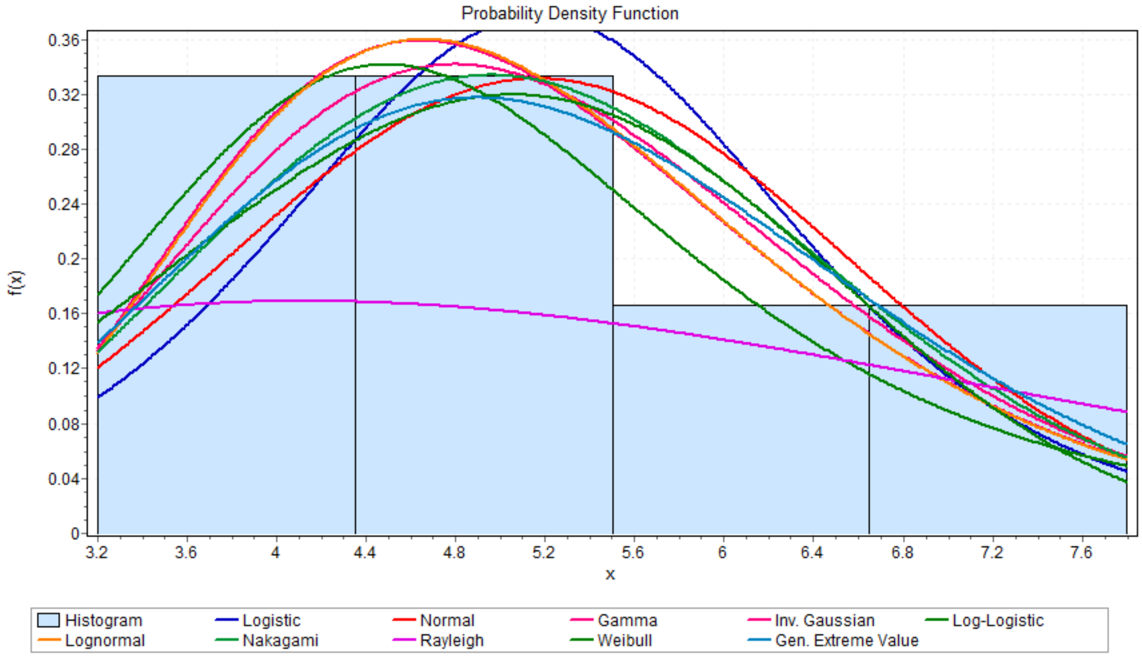

Figure 4.38: PDF-YOBE-2012

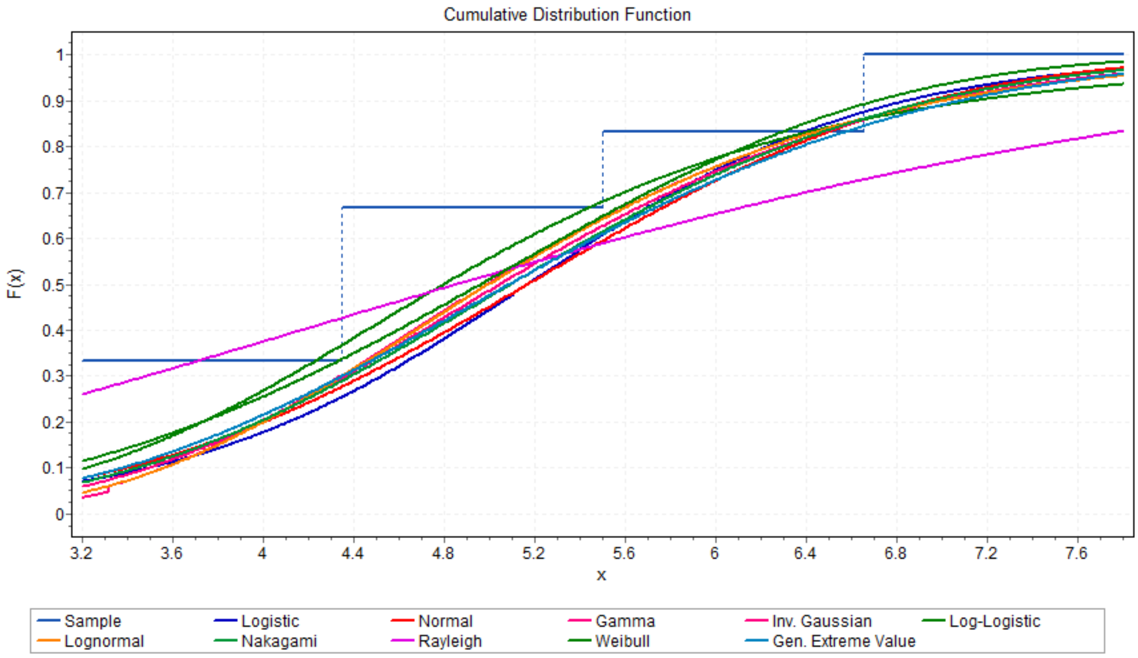

Figure 4.39: CDF-YOBE-2012

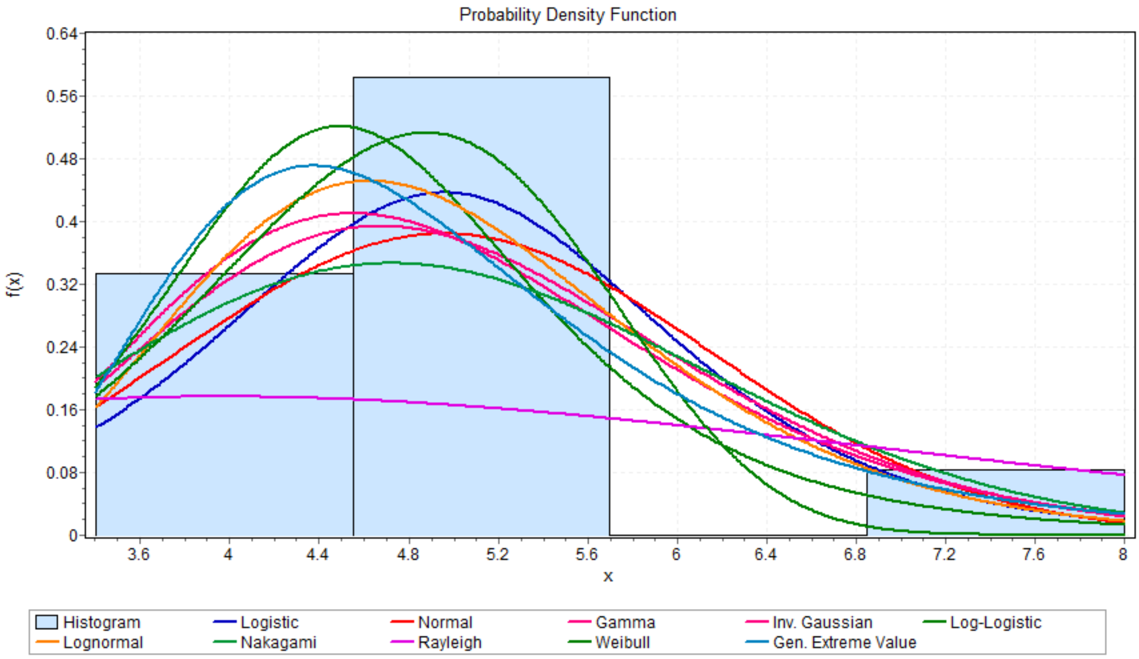

Figure 4.40: PDF-YOBE-2013

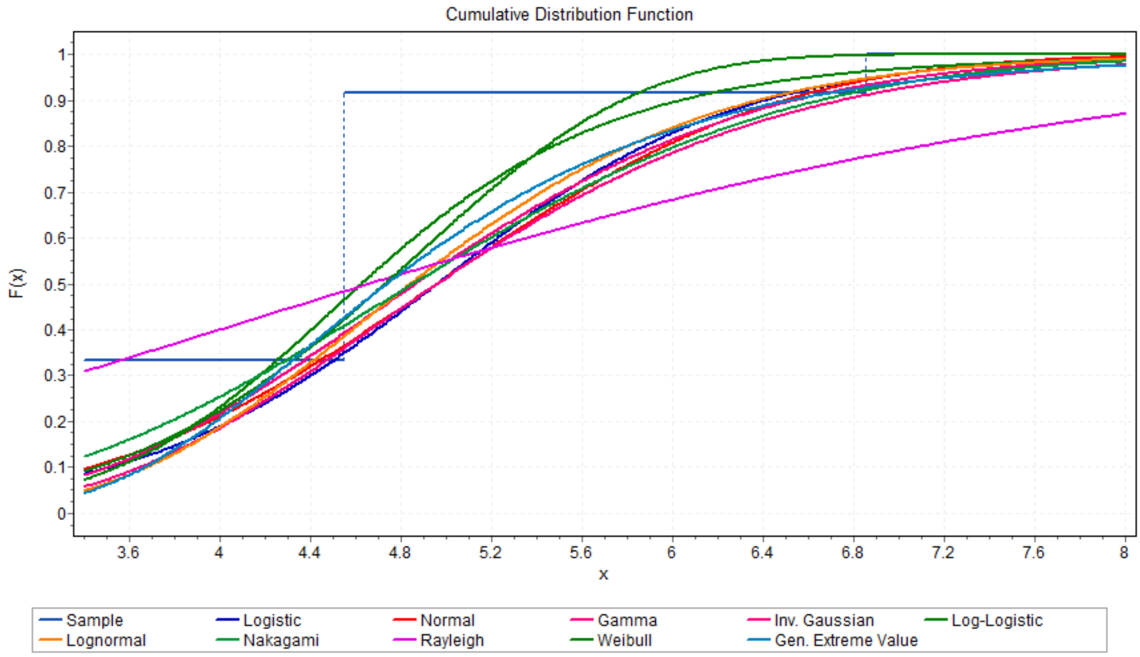

Figure 4.41: CDF-YOBE-2013

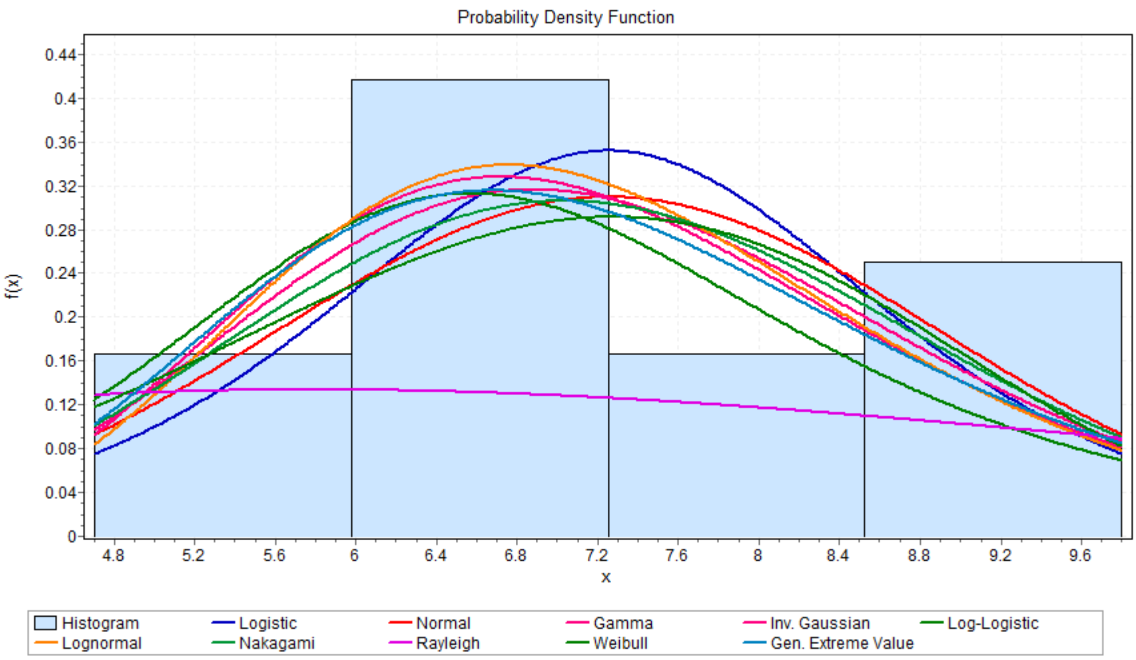

Figure 4.42: PDF-YOBE-2014

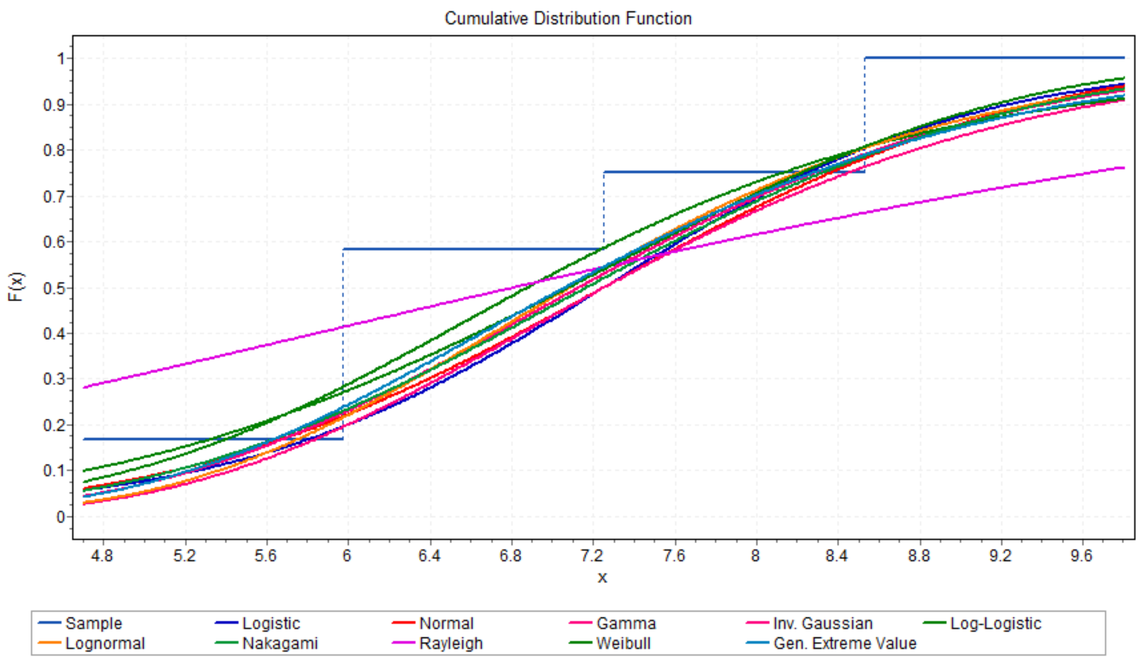

Figure 4.43: CDF-YOBE-2014

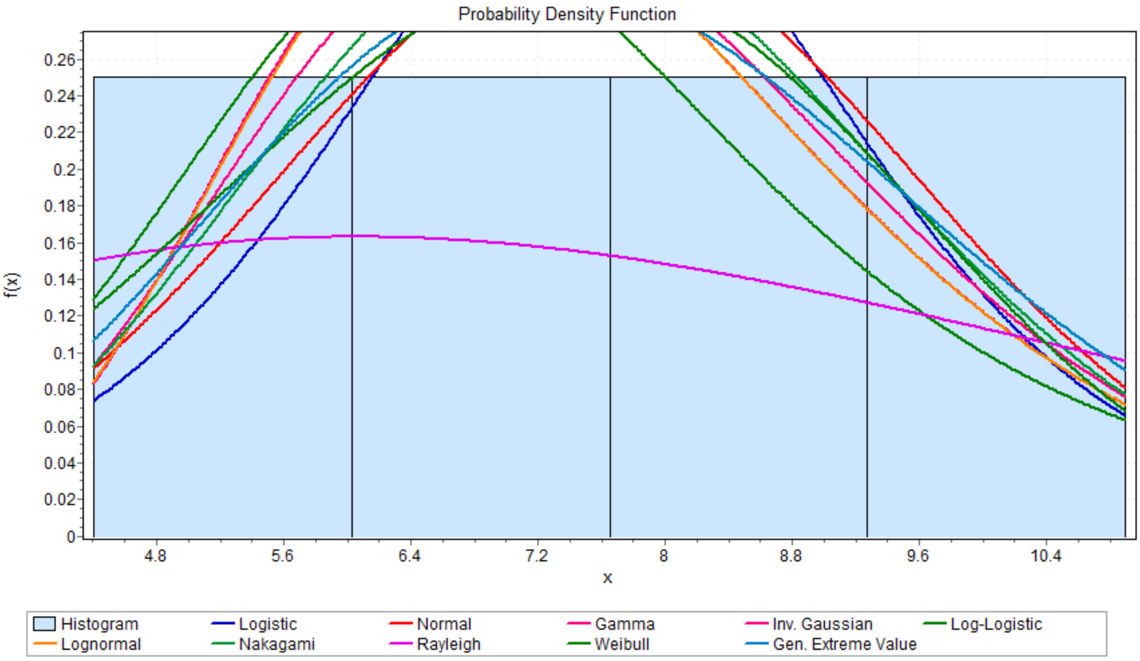

Figure 4.44: PDF-YOBE-2015

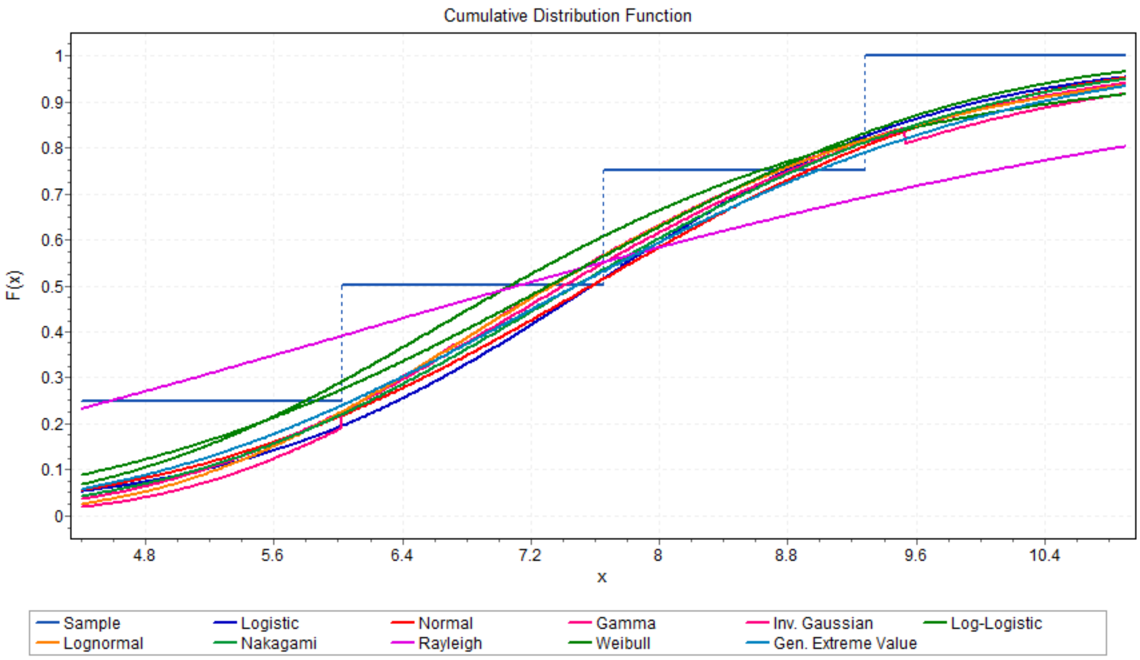

Figure 4.45: CDF-YOBE-2015

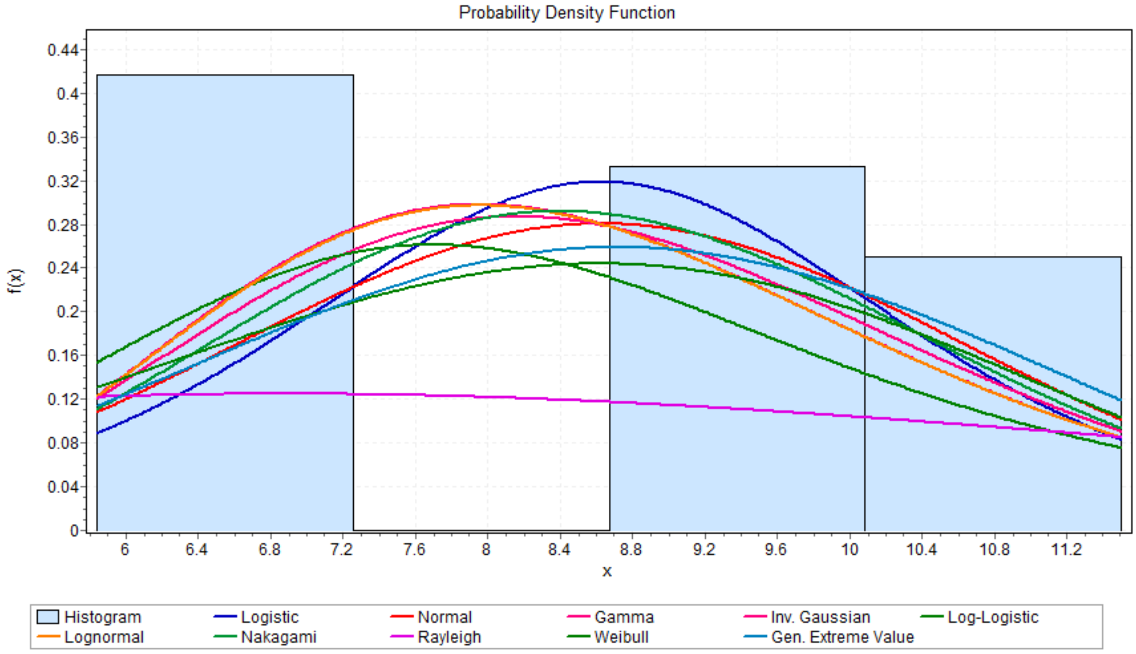

Figure 4.46: PDF-YOBE-2016

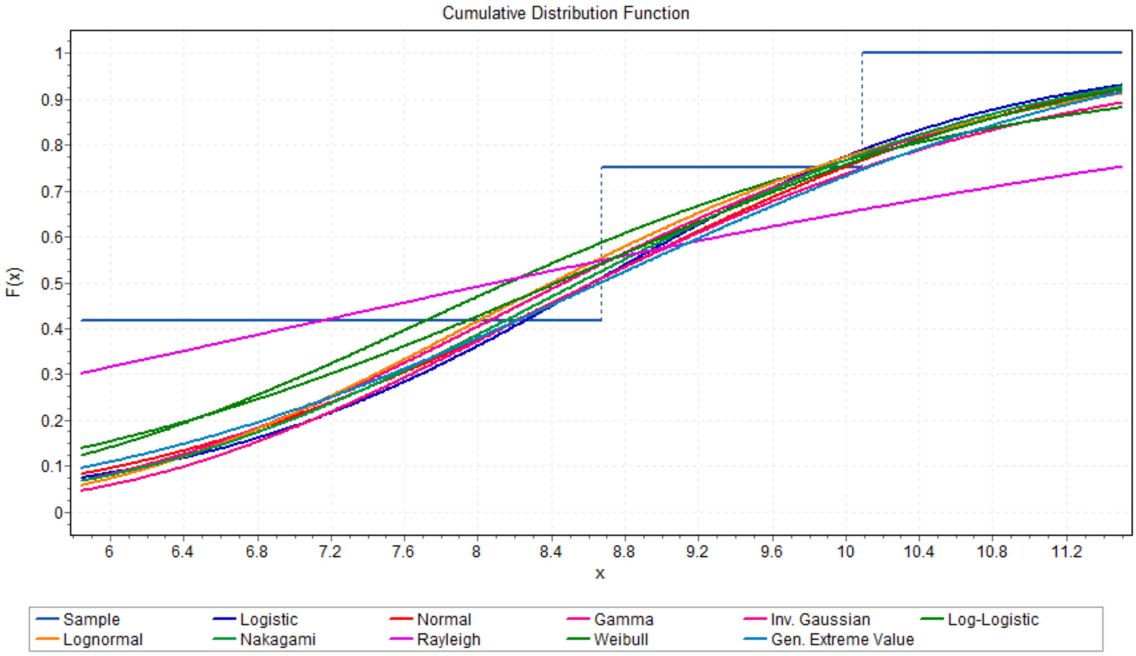

Figure 4.47: CDF-YOBE-2016

4.6 Economic Analysis of Electricity Generation Potential

In this thesis, the performance of the HAWT was evaluated. In a general case, the HAWT is used mostly for generating electricity. VAWT are usually used for low wind speeds, but HAWT are purely evaluated here because the wind speed data is relatively high. The description of the medium and large-scale wind turbines that have been evaluated in this work is presented in Table 4.11.

Table 4.11: Characteristics of the selected wind turbines

Model	Rated Power (kW)	Rated Wind Speed (m/s)	Cut-in Wind Speed (m/s)	Rotor Diameter (m)	Hub Height (m)
Bonus -33	300	14	3	33.4	30
Suzlon S52-600 kW	600	13	4	52	75
Vestas V42	600	16	4	42	53
Vestas -V47	660	15	4	47	55
Norwin 47/750	750	15	4	80	65
Vestas V52	850	14	4	52	70
Gamesa G58	850	12	3.5	58	65
Bonus -54	1000	15	3	54.2	50
Suzlon S82-1.5 MW	1500	14	4	82	78.5
YDF-1500-87	1500	10.2	3	87	75
Vestas V82	1,650	13	3.5	82	78
Vestas V80-2 MW	2000	16	4	80	67
Gamesa G128	4,500	13	4	128	140

The annual Energy production power in kWh and capacity factor were calculated with equations (2.6) and (2.8) respectively.

Table 4.12 shows the wind turbine models, their various hub heights, the annual energy production for each turbine and their capacity factor. From the table, it is observed in the Jigawa station that Bonus -33 has the smallest annual energy production with a value of 11,932.22KWh and also has the second lowest capacity factor with a value of 10.897%. The turbine with the lowest capacity factor is VESTAS V42 with a capacity factor of 9.729%. So therefore, these turbines cannot be recommended for this region.

Additionally, from the Table 4.12, the wind turbine GAMESA G128 can be observed to produce the highest annual energy production of 476,084.25 KWh and has a capacity factor with a value of 28.985%, which is good, but does not have the highest capacity factor. The turbine with the highest capacity factor is YDF-1500-87 with a value of 37.140%, but the annual energy production is less than half of GAMESA G128 with a value of 203,341.05KWh. However, the YDF-1500-87 is selected to be the appropriate recommended wind turbine for the Jigawa station, because it has the highest capacity factor.

Furthermore, the same analysis was conducted for Yobe station, and again it can be observed from the table that VESTAS V42 and VESTAS -V47 both have negative values for the annual energy production and capacity factors, therefore these wind turbines cannot be used in this station. NORWIN 47/750 has the lowest annual energy production of 535.76KWh and also a low capacity factor of 0.196% and therefore cannot be recommended. While the GAMESA G128 again produces the highest annual energy production with a value of 84,574.46KWh with a capacity factor of 5.149%. Nevertheless, the turbine with the highest capacity factor is the YDF-1500-87 with a value of 7.451% and an annual energy production value of 40,794.36 KWh. Therefore the YDF-1500-87 is the recommended wind turbine for both stations.

Table 4.12: Annual electricity production and capacity factor at the two stations

Region	Model	Hub Height [m]	Annual Energy Production [kWh]	Capacity factor [%]
Jigawa	SUZLON S52-600KW	75	42,618.39	19.460
	SUZLON S82-1.5MW	78.5	106,545.97	19.460
	NORWIN 47/750	65	35,361.81	12.918
	VESTAS V52	70	48,971.64	15.785
	GAMESA G58	65	70,542.95	22.737
	VESTAS V42	53	21,305.97	9.729
	VESTAS V82	78	128,817.61	21.389
	GAMESA G128	140	476,084.25	28.985
	BONUS -33	30	11,932.22	10.897
	BONUS -54	50	47,135.14	12.914
	VESTAS -V47	55	27,646.22	11.476
	VESTAS -80	67	83,859.22	11.488
	YDF-1500-87	75	203,341.05	37.140
Yobe	SUZLON S52-600KW	75	2,230.32	1.018
	SUZLON S82-1.5MW	78.5	5,575.79	1.018
	NORWIN 47/750	65	535.76	0.196
	VESTAS V52	70	1,709.85	0.551
	GAMESA G58	65	7,930.96	2.556
	VESTAS V42	53	-976.99	-0.446
	VESTAS V82	78	18,631.70	3.094
	GAMESA G128	140	84,574.46	5.149
	BONUS -33	30	676.44	0.618
	BONUS -54	50	6,863.79	1.880
	VESTAS -V47	55	-939.62	-0.390
	VESTAS -80	67	1,959.93	0.268
	YDF-1500-87	75	40,794.36	7.451

CHAPTER 5

CONCLUSIONS AND FUTURE WORK

5.1 Conclusions

This thesis observed the characteristics of the wind speed along the wind power potential for 2 selected stations in northern Nigeria, namely; Jigawa and Yobe, for different periods. Economic analysis of the wind turbines was conducted for each of the stations. The functionality of the turbines was also compared for use in the rural settlements where these stations can be located.

The following bullet points highlight the major conclusion that have been arrived at after carrying out the analysis.

- The yearly mean wind speed shows a range between 4.96 knots & 12.3 knots at a height of 10 meters. This validates these stations as having a high wind potential.
- It was observed from the analysis that although both stations are good harvesting stations for wind energy. The station with the better wind potential between the two selected studied stations was Jigawa.
- Gamesa G128 model with a high power rating of 4,500KW produced the higest result in annual energy production and also had one of the higest capacity factors for both stations.

5.2 Future Work

Work in this thesis, studied rural areas (selected stations). Nigeria is a very big country with a lot of untapped potential, there should be more studies carried out in other northern Nigerian states such as Borno State, Kano State, Katsina State, Zamfara State, Sokoto State and Kebbi State. This is because all these states are also exposed to the northeasterly trade wind also known as Harmattan wind which blows into Nigeria from the Sahara desert.

In addition, more studies should be carried out in urbanized areas where it would be difficult to use medium – large wind turbines. And to use smaller vertical axis wind turbines instead and also the possible use of computational fluid dynamics (CFD) to accurately predict the wind speed in the urban areas in order to install the most suitable wind turbine for such stations.

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APPENDIX

CATALOGUE OF EUROPEAN URBAN WIND TURBINE MANUFACTURERS

Catalogue of European Urban Wind Turbine Manufacturers






Supported by the
European Commission under the
Intelligent Energy - Europe
Programme



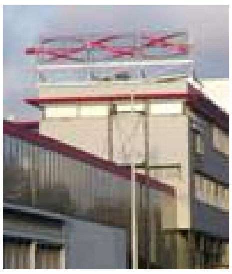



Table of contents

Aircon

HAWT - 10 kW

Contact name: Aircon GmbH & Co.KG
Address: Nessestraße 27, 26789 Leer
Telephone: +49 491 454 44 84
Country : **Germany**

Aircon 10 references

Site	Use	Country
Nordhausen	University	Germany
Bremerhaven	University	Germany
Hamburg	Greenpeace building	Germany
Warnungs	Solartechn. Hubert Kuhn	Austria
Sopelana	Zero CO2/ Environmental assoc	Spain

Technical information

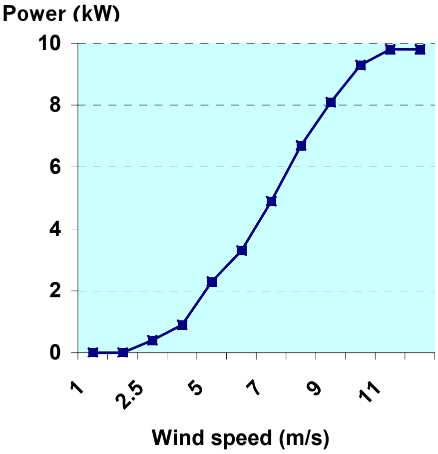
POWER		Unit
1) Rated power	10	kW
2) Rated wind speed	11	m/s
3) Cut-in wind speed	2,5	m/s
4) Cut-out wind speed	32	m/s
5) Maximum wind speed the turbine can withstand	190	Km/h
DIMENSIONS		
6) Rotor weight	144	kg
7) Rotor diameter	7,1	m
8) Rotor height (for VAWT only)		m
9) Swept area	39,6	m^2
10) Height of the mast	12/18/24/30	m
OTHER INFORMATION		
11) Maximum rpm	130	At rated wind speed
12) Gear box type	Gearless	
13) Brake system	Pitch-control + generator overload regulation	
14) Number of blades	3	
15) Blades material	Composite fibre glass	
16) Output voltage	400	V
17) Minimum operation temperature	- 20	°C
18) Maximum operation temperature	+ 40	°C
19) Acoustic levels at a distance of 20 m ? at nacelle ? (wind = 5 m/s)	< 40	DB
20) Lifetime	> 20	Years
21) Is the machine self-starting	Yes	
22) Use of an asynchronous generator	No	
23) Yaw control system	Azimut motor	
24) Upwind or downwind	Upwind turbine	

Aircon 10/ 10 kW

Calculated power curve

Wind speed (m/s)	Power (kW)
1	0
2	0
2,5	0,4
4	0,9
5	2,3
6	3,3
7	4,9
8	6,7
9	8,1
10	9,3
11	9,8
11,5- 25	9,8

Power curve:



Ampair

HAWT – 0,1 to 0,3 kW

Contact name: George Durrant
Address: The Doughty Building, Crow Arch Lane, Ringwood, Hampshire, BH24 1NZ
Telephone: +44 (0) 1425 480 780
Country: **United Kingdom**

Ampair 0,1 kW references

Site	Use	Country
Regis Road Recycling Centre, Camden, London	Electricity generation	UK

Ampair Pacific Hawk / 0,1 kW

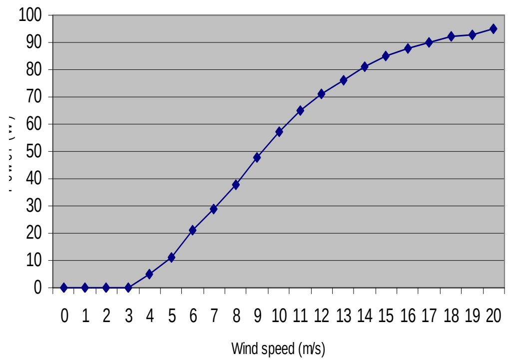
Technical information

POWER		Unit
1) Rated power	0,1	kW
2) Rated wind speed	20	m/s
3) Cut-in wind speed	3,5	m/s
4) Cut-out wind speed	None	m/s
5) Maximum wind speed the turbine can withstand	Storm-proof	km/h
DIMENSIONS		
6) Nacelle and rotor weight	12,6	kg
7) Rotor diameter	0,928	m
8) Rotor height (for VAWT only)	-	m
9) Swept area	0,68	m^2
10) Height of the mast	Variable	m
OTHER INFORMATION		
11) Maximum rpm	DK	At rated wind speed
12) Gear box type	None	
13) Brake system	Inductors	
14) Number of blades	6	
15) Blades material	Glass filled polypropylene	
16) Output voltage	12 / 24	V
17) Minimum operation temperature	- 30	°C
18) Maximum operation temperature	High temperatures not a problem	°C
19) Acoustic levels at a distance of 20 m? at nacelle? (wind = 5 m/s)	20 at nacelle in strong winds	DB
20) Lifetime	10	Years
21) Is the machine self-starting	Yes	
22) Use of an asynchronous generator	No	
23) Yaw control system	Wind vane, free yaw	
24) Upwind or downwind	Upwind	

Calculated power curve

Wind speed (m/s)	Power (W)
1	0
2	0
3	0
4	05
5	11
6	21
7	29
8	38
9	48
10	57
11	65
12	71
13	76
14	81
15	85
16	88
17	90
18	92
19	93
20	95

Power curve



Ampair

HAWT – 0,1 to 0,3 kW

Contact name: George Durrant
Address: The Doughty Building, Crow Arch Lane, Ringwood, Hampshire, BH24 1NZ
Telephone: +44 (0) 1425 480 780
Country: **United Kingdom**

Ampair 0,3 kW references

Site	Use	Country
None available yet		

Ampair Pacific Hawk / 0,3 kW

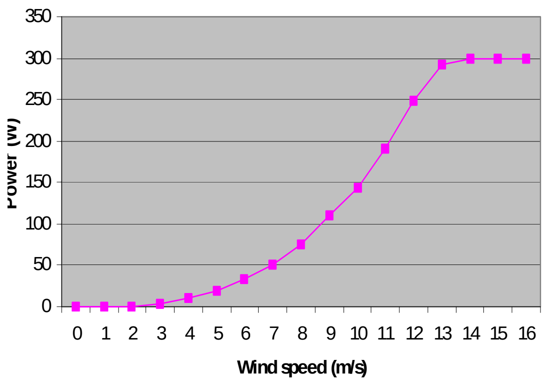
Technical information

POWER		Unit
1) Rated power	0,3	kW
2) Rated wind speed	12,6	m/s
3) Cut-in wind speed	3	m/s
4) Cut-out wind speed	None	m/s
5) Maximum wind speed the turbine can withstand	180	km/h
DIMENSIONS		
6) Nacelle and rotor weight	12	kg
7) Rotor diameter	1,2	m
8) Rotor height (for VAWT only)	-	m
9) Swept area	1.13	m²
10) Height of the mast	Variable	m
OTHER INFORMATION		
11) Maximum rpm	DK	At rated wind speed
12) Gear box type	None	
13) Brake system	Blade pitch control	
14) Number of blades	3	
15) Blades material	Glass filled polypropylene	
16) Output voltage	12 / 24, or grid-connected	V
17) Minimum operation temperature	Perhaps - 20	°C
18) Maximum operation temperature	Perhaps + 35	°C
19) Acoustic levels at a distance of 20 m? at nacelle ? (wind = 5 m/s)	Not dB tested yet	DB
20) Lifetime	10	Years
21) Is the machine self-starting	Yes	
22) Use of an asynchronous generator	No	
23) Yaw control system	Wind vane, free yaw	
24) Upwind or downwind	Upwind	

Calculated power curve

Wind speed (m/s)	Power (W)
1	0
2	0
3	4
4	10
5	20
6	34
7	51
8	76
9	110
10	144
11	192
12	248
13	293
14	300
15	300
16	300

Power curve



ATLANTIS Windkraft

HAWT from 0,3 kW to 0,6 kW.

WB 15 / 0,3 kW

Contact name: Kottwitz Raimund
Address: Holzstr. 10, 31556 Wölpinghausen
Telephone: +49 5037 988 03
Country : **Germany**

Atlantis WB 15 references

Site	Use	Country
Berlin	About 20 projects in Berlin (7 schools, 1 high school, 4 practical education centres, …).	Germany

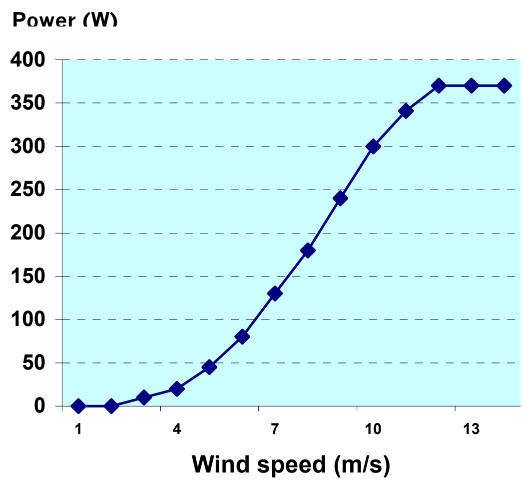
Technical information

		Unit
1) Rated power	0,3	kW
2) Rated wind speed	10	m/s
3) Cut-in wind speed	3	m/s
4) Cut-out wind speed	None	m/s
5) Maximum wind speed the turbine can withstand	No limit	Km/h
DIMENSIONS		
6) Rotor weight	23	kg
7) Rotor diameter	1,5	m
8) Rotor height (for VAWT only)		m
9) Swept area	1,8	m^2
10) Height of the mast	3/6/ 9/12	m
OTHER INFORMATION		
11) Maximum rpm		At rated wind speed
12) Gear box type		
13) Brake system		
14) Number of blades	3	
15) Blades material	Composite fibre glass	
16) Output voltage	12 – 24	V
17) Minimum operation temperature	Tested in arctic	°C
18) Maximum operation temperature	+ 90	°C
19) Acoustic levels at a distance of 20 m ? at nacelle ? (wind = 5 m/s)	78	DB
20) Lifetime	20	Years
21) Is the machine self-starting	Yes	
22) Use of an asynchronous generator	No	
23) Yaw control system	Wind vane	
24) Upwind or downwind		

Calculated power curve

Wind speed (m/s)	Power (W)
1	0
2	0
3	10
4	20
5	
6	80
7	
8	180
9	
10	300
11	
12	370
13	
14	370

Power curve:



ATLANTIS Windkraft

HAWT from 0,3 kW to 0,6 kW.

Contact name: Kottwitz Raimund
Address: Holzstr. 10, 31556 Wölpinghausen
Telephone: +49 5037 988 03
Country : **Germany**

WB 20/ 0,6 kW

Atlantis WB 20 references

Site	Use	Country
Berlin	About 20 projects in Berlin: 7 schools, 1 high school, 4 practical education centres, ...	Germany

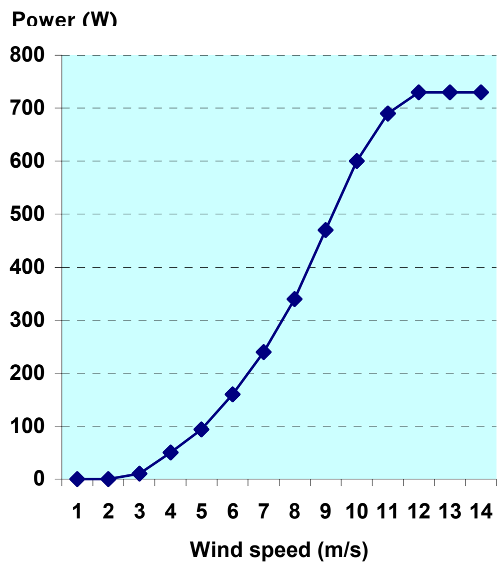
Technical information

POWER		Unit
1) Rated power	0,6	kW
2) Rated wind speed	10	m/s
3) Cut-in wind speed	3	m/s
4) Cut-out wind speed	None	m/s
5) Maximum wind speed the turbine can withstand	No limit	Km/h
DIMENSIONS		
6) Rotor weight	37	kg
7) Rotor diameter	2	m
8) Rotor height (for VAWT only)		m
9) Swept area	3,14	m^2
10) Height of the mast	3/6/ 9/12	m
OTHER INFORMATION		
11) Maximum rpm		At rated wind speed
12) Gear box type		
13) Brake system		
14) Number of blades		4
15) Blades material		Carbon fibre
16) Output voltage	24- 48	V
17) Minimum operation temperature	Tested in arctic	°C
18) Maximum operation temperature	+ 90	°C
19) Acoustic levels at a distance of 20 m ? at nacelle ? (wind = 5 m/s)	78	DB
20) Lifetime	20	Years
21) Is the machine self-starting		Yes
22) Use of an asynchronous generator		No
23) Yaw control system		Wind vane
24) Upwind or downwind		

Calculated power curve

Wind speed (m/s)	Power (W)
1	0
2	0
3	10
4	50
5	
6	160
7	
8	340
9	
10	600
11	
12	730
13	
14	730

Power curve:



Eclectic Energy

HAWT – 0,4 kW

Contact name:	Peter Anderson
Address:	Edwinstowe House, High Street, Edwinstowe, Nottinghamshire NG21 9PR
Telephone:	+44 (0) 162 382 15 35

D400 – 0,4 kW references

Site	Use	Country
Nottingham University	Testing / monitoring	UK
Building Research Establishment (BRE), Watford	Testing / Monitoring	UK

Stealth Gen D400 / 0,4 kW

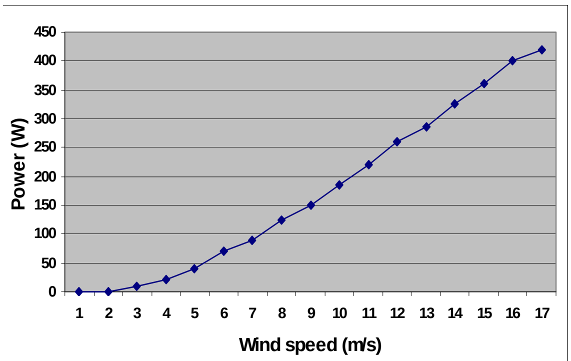
Technical information

POWER		Unit
1) Rated power	0,4	kW
2) Rated wind speed	16	m/s
3) Cut-in wind speed	2	m/s
4) Cut-out wind speed	None	m/s
5) Maximum wind speed the turbine can withstand	130	km/h
DIMENSIONS		
6) Nacelle and rotor weight	15	kg
7) Rotor diameter	1,1	m
8) Rotor height (for VAWT only)	-	m
9) Swept area	0,95	m^2
10) Height of the mast	Variable	m
OTHER INFORMATION		
11) Maximum rpm	1 200	At rated wind speed
12) Gear box type		None
13) Brake system		Electrical
14) Number of blades		5
15) Blades material		Glass reinforced nylon
16) Output voltage	12/24/48/150	V
17) Minimum operation temperature	-20	°C
18) Maximum operation temperature	120	°C
19) Acoustic levels at a distance of 20 m? at nacelle? (wind = 5 m/s)	3 above background	DB
20) Lifetime	20	Years
21) Is the machine self-starting		Yes
22) Use of an asynchronous generator		No
23) Yaw control system		Wind vane, free yaw
24) Upwind or downwind		Upwind

Calculated power curve

Wind speed (m/s)	Power (W)
1	0
2	0
3	10
4	20
5	40
6	70
7	90
8	125
9	150
10	185
11	220
12	260
13	285
14	325
15	360
16	400

Power curve:



Ecofys

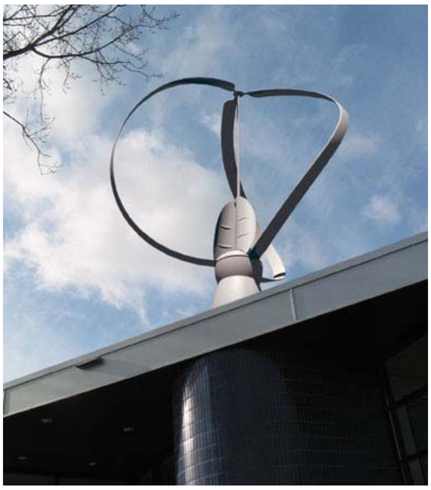
VAWT 3 kW.

Contact name:	Geert Timmers
Address:	PO Box 8408, 3503 RK Utrecht
Telephone:	+31-30 3808300
Country :	Netherlands

Neoga references: no references

Site	Use	Country

Neoga 3 kW



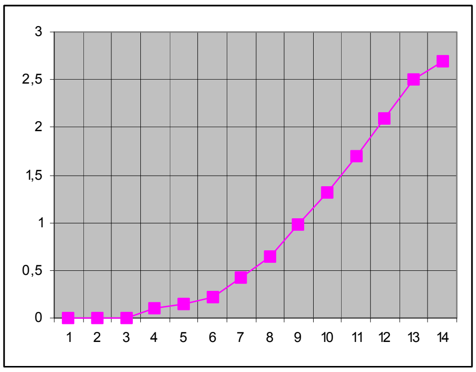
Technical information

POWER		Unit
1) Rated power	3	kW
2) Rated wind speed	14	m/s
3) Cut-in wind speed	3,5	m/s
4) Cut-out wind speed	20	m/s
5) Maximum wind speed the turbine can withstand	Not available	Km/h
DIMENSIONS		
6) Rotor weight	200	kg
7) Rotor diameter	2,8	m
8) Rotor height (for VAWT only)	4	m
9) Swept area	5,5	m^2
10) Height of the mast	Variable 1-12	m
OTHER INFORMATION		
11) Maximum rpm	300	At rated wind speed
12) Gear box type	No gear box	
13) Brake system	Electrical brake + disc brake	
14) Number of blades	5	
15) Blades material	Aluminium	
16) Output voltage	230	V
17) Minimum operation temperature	- 30	°C
18) Maximum operation temperature	+ 50	°C
19) Acoustic levels at a distance of 20 m ? at nacelle ? (wind = 5 m/s)	Not available	DB
20) Lifetime	20	Years
21) Is the machine self-starting	Yes	
22) Use of an asynchronous generator	No	
23) Yaw control system	Independent of wind direction	
24) Upwind or downwind	Not applicable	

Calculated power curve

Wind speed (m/s)	Power* (W)
1	0
2	0
3	0
4	100
5	
6	220
7	420
8	650
9	980
10	1320
11	1700
12	2100
13	2500
14	2700
15	

Power curve



Eoltec

HAWT from 6 kW to 250 kW.

Contact name: Thomas Schulthess
Address: 455, promenade des Anglais, 06299 Nice
Telephone: +33 6 85 30 35 05
Country : **France**

Sirocco/ 6 kW

Eoltec Sirocco 6 kW references

Site	Use	Country
Nice	Demonstration turbine connected to the grid	France
Orkney Island	Extreme winds test site	UK
	Hybrid electrification stand-alone or grid-tied, water pumping, heating,…	4 continents

Technical information

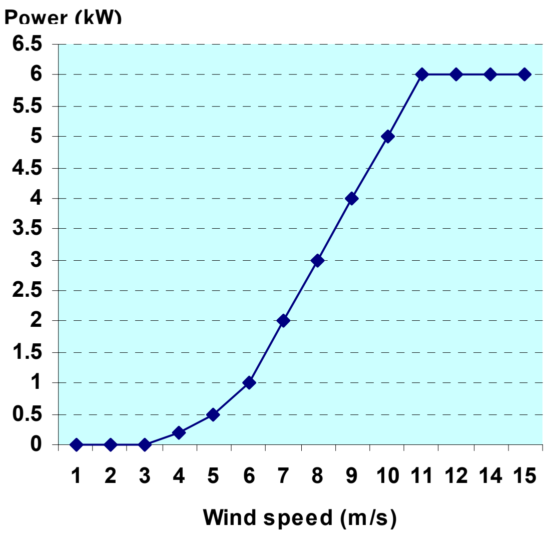
POWER		Unit
1) Rated power	6	kW
2) Rated wind speed	12	m/s
3) Cut-in wind speed	4	m/s
4) Cut-out wind speed	None	m/s
5) Maximum wind speed the turbine can withstand	216	Km/h
DIMENSIONS		
6) Rotor weight (+ generator)	202	kg
7) Rotor diameter	5,6	m
8) Rotor height (for VAWT only)		m
9) Swept area	24,7	m^2
10) Height of the mast	18/24/30	m
OTHER INFORMATION		
11) Maximum rpm	245	At rated wind speed
12) Gear box type		
13) Brake system	Optional remote control at tower base	
14) Number of blades	2	
15) Blades material	Composite fibre glass	
16) Output voltage	230	V
17) Minimum operation temperature	- 40	°C
18) Maximum operation temperature	+ 50	°C
19) Acoustic levels at a distance of 20 m ? at nacelle ? (wind = 5 m/s)	65	DB
20) Lifetime	25	Years
21) Is the machine self-starting	Yes	
22) Use of an asynchronous generator	No	
23) Yaw control system	Wind vane	
24) Upwind or downwind	Upwind turbine	

Calculated power curve

Wind speed (m/s)	Power (kW)
1	0
2	0
3	0
4	0,2
5	0.5
6	1.1
7	1.8
8	2.7
9	3.8
10	5
11	5.7
12	6
13	6
14	6
15	6

Inland site, altitude 300 m, 18 m tower
Rayleigh distribution (k= 2)
Shear ratio 0,143 / Turbulence factor 10 %

Power curve:



Eoltec

HAWT from 6 kW to 250 kW.

Contact name: Thomas Schulthess
Address: 455, promenade des Anglais, 06299 Nice
Telephone: +33 6 85 30 35 05
Country : **France**

Eoltec Wind runner 25 kW references

Site	Use	Country
Orkney Island	Prototype	UK

Wind Runner/ 25 kW

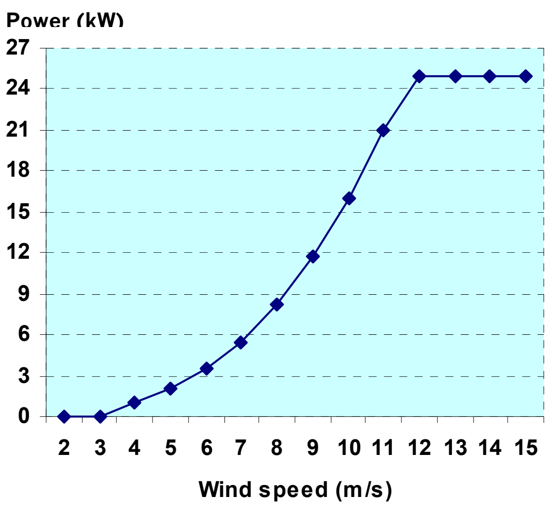
Technical information

POWER		Unit
1) Rated power	25	kW
2) Rated wind speed	12	m/s
3) Cut-in wind speed	3	m/s
4) Cut-out wind speed	None	m/s
5) Maximum wind speed the turbine can withstand	216	Km/h
DIMENSIONS		
6) Rotor weight (+ generator)	620	kg
7) Rotor diameter	10	m
8) Rotor height (for VAWT only)		m
9) Swept area	78,6	m^2
10) Height of the mast	18/24/32	m
OTHER INFORMATION		
11) Maximum rpm	140	At rated wind speed
12) Gear box type	none – direct drive	
13) Brake system	Optional remote control (blades stalling)	
14) Number of blades	2	
15) Blades material	Composite fiber glass	
16) Output voltage	400	V
17) Minimum operation temperature	- 40	°C
18) Maximum operation temperature	+ 50	°C
19) Acoustic levels at a distance of 20 m ? at nacelle ? (wind = 5 m/s)	65	DB
20) Lifetime	25	Years
21) Is the machine self-starting	Yes	
22) Use of an asynchronous generator	No	
23) Yaw control system	Wind vane	
24) Upwind or downwind	Upwind turbine	

Calculated power curve

Wind speed (m/s)	Power (kW)
1	0
2	0
3	0.5
4	1
5	2
6	3.5
7	5.5
8	8.2
9	11.7
10	16
11	21
12	25
13	25
14	25
15	25

Power curve:



Eurowind Small Turbines Ltd

VAWT – from 1,3 kW to 30 kW

Contact name: Steven Peace
Address: 38 Kings Avenue, Newhaven, East Sussex
BN9 0NA
Telephone: +44 (0) 12 73 61 23 83
Country: **United Kingdom**

Eurowind 1,3 kW references

Site	Use	Country
Unknown	Prototype	UK

Eurowind / 1,3 kW

Technical information

POWER		Unit
1) Rated power	1,3	kW
2) Rated wind speed	12	m/s
3) Cut-in wind speed	3 to 4	m/s
4) Cut-out wind speed	28 to 32	m/s
5) Maximum wind speed the turbine can withstand	255	km/h
DIMENSIONS		
6) Nacelle and rotor weight	DK	kg
7) Rotor diameter	2,25	m
8) Rotor height (for VAWT only)	2	m
9) Swept area	4,5	m^2
10) Height of the mast	Site dependent	m
OTHER INFORMATION		
11) Maximum rpm	DK	At rated wind speed
12) Gear box type		DK
13) Brake system		DK
14) Number of blades		3
15) Blades material		Composite fibre glass
16) Output voltage	24 – 240	V
17) Minimum operation temperature	Not known	°C
18) Maximum operation temperature	Not known	°C
19) Acoustic levels at a distance of 20 m ? at nacelle ? (wind = 5 m/s)	Dk	DB
20) Lifetime	20	Years
21) Is the machine self-starting		Yes
22) Use of an asynchronous generator		No
23) Yaw control system		Not necessary
24) Upwind or downwind		N/a

Calculated power curve

Not available

Wind speed (m/s)	Power (kW)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	

Power curve

Not available

Eurowind Small Turbines Ltd

VAWT – from 1,3 kW to 30 kW

Eurowind / 5 kW

Contact name: Steven Peace
Address: 38 Kings Avenue, Newhaven, East Sussex BN9 0NA
Telephone: +44 (0) 12 73 61 23 83
Country : **United Kingdom**

Eurowind 5 kW references

Site	Use	Country

Technical information

POWER		Unit
1) Rated power	5	kW
2) Rated wind speed	12	m/s
3) Cut-in wind speed	3 to 4	m/s
4) Cut-out wind speed	28 to 32	m/s
5) Maximum wind speed the turbine can withstand	255	km/h
DIMENSIONS		
6) Nacelle and rotor weight	DK	kg
7) Rotor diameter	4,25	m
8) Rotor height (for VAWT only)	4	m
9) Swept area	17	m^2
10) Height of the mast	Site dependent	m
OTHER INFORMATION		
11) Maximum rpm	DK	At rated wind speed
12) Gear box type	DK	
13) Brake system	DK	
14) Number of blades	3	
15) Blades material	Composite fibre glass	
16) Output voltage	24 – 240	V
17) Minimum operation temperature	Not known	°C
18) Maximum operation temperature	Not known	°C
19) Acoustic levels at a distance of 20 m ? at nacelle ? (wind = 5 m/s)		DB
20) Lifetime	20	Years
21) Is the machine self-starting	Yes	
22) Use of an asynchronous generator	No	
23) Yaw control system	Not necessary	
24) Upwind or downwind	N/a	

Calculated power curve

Not available

Wind speed (m/s)	Power (kW)
1	
2	
2,5	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	

Power curve

Not available

Eurowind Small Turbines Ltd

VAWT – from 1,3 kW to 30 kW

Contact name: Steven Peace
Address: 38 Kings Avenue, Newhaven, East Sussex BN9 0NA
Telephone: +44 (0) 12 73 61 23 83
Country: **United Kingdom**

Eurowind / 10,8 kW

Eurowind 10,8 kW references

Site	Use	Country

Technical information

POWER		Unit
1) Rated power	10,8	kW
2) Rated wind speed	12	m/s
3) Cut-in wind speed	3 to 4	m/s
4) Cut-out wind speed	28 to 32	m/s
5) Maximum wind speed the turbine can withstand	255	Km/h
DIMENSIONS		
6) Nacelle and rotor weight	DK	kg
7) Rotor diameter	6,26	m
8) Rotor height (for VAWT only)	5	m
9) Swept area	37	m^2
10) Height of the mast	Site dependent	m
OTHER INFORMATION		
11) Maximum rpm	DK	At rated wind speed
12) Gear box type	DK	
13) Brake system	DK	
14) Number of blades	3	
15) Blades material	Composite fibre glass	
16) Output voltage	24 – 240	V
17) Minimum operation temperature	DK	°C
18) Maximum operation temperature	DK	°C
19) Acoustic levels at a distance of 20 m ? at nacelle ? (wind = 5 m/s)	DK	DB
20) Lifetime	20	Years
21) Is the machine self-starting	Yes	
22) Use of an asynchronous generator	No	
23) Yaw control system	Not necessary	
24) Upwind or downwind	N/a	

Calculated power curve

Not available

Wind speed (m/s)	Power (kW)
1	
2	
2,5	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	

Power curve

Not available

Eurowind Small Turbines Ltd

VAWT – from 1,3 kW to 30 kW

Contact name: Steven Peace
Address: 38 Kings Avenue, Newhaven, East Sussex BN9 0NA
Telephone: +44 (0) 12 73 61 23 83
Country: **United Kingdom**

Eurowind 19 kW references

Site	Use	Country
No references available yet		

Eurowind / 19 kW

Photo Montage

Technical information

POWER		Unit
1) Rated power	19	kW
2) Rated wind speed	12	m/s
3) Cut-in wind speed	3 to 4	m/s
4) Cut-out wind speed	28 to 32	m/s
5) Maximum wind speed the turbine can withstand	255	Km/h
DIMENSIONS		
6) Nacelle and rotor weight	DK	kg
7) Rotor diameter	8,25	m
8) Rotor height (for VAWT only)	8	m
9) Swept area	66	m^2
10) Height of the mast	Site dependent	m
OTHER INFORMATION		
11) Maximum rpm	DK	At rated wind speed
12) Gear box type	DK	
13) Brake system	DK	
14) Number of blades	3	
15) Blades material	Composite fibre glass	
16) Output voltage	24 – 240	V
17) Minimum operation temperature	DK	°C
18) Maximum operation temperature	DK	°C
19) Acoustic levels at a distance of 20 m ? at nacelle ? (wind = 5 m/s)	DK	DB
20) Lifetime	20	Years
21) Is the machine self-starting	Yes	
22) Use of an asynchronous generator	No	
23) Yaw control system	Not necessary	
24) Upwind or downwind	N/a	

Calculated power curve

Not available

Wind speed (m/s)	Power (kW)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	

Power curve

Not available

Eurowind Small Turbines Ltd

VAWT – from 1,3 kW to 30 kW

Contact name: Steven Peace

Address: 38 Kings Avenue, Newhaven, East Sussex BN9 0NA

Telephone: +44 (0) 12 73 61 23 83

Country: **United Kingdom**

Eurowind 30 kW references

Site	Use	Country
No references available yet		

Eurowind / 30 kW

Photo Montage

Technical information

POWER		Unit
1) Rated power	30	kW
2) Rated wind speed	12	m/s
3) Cut-in wind speed	3 to 4	m/s
4) Cut-out wind speed	28 to 32	m/s
5) Maximum wind speed the turbine can withstand	255	Km/h
DIMENSIONS		
6) Nacelle and rotor weight	DK	kg
7) Rotor diameter	10,25	m
8) Rotor height (for VAWT only)	10	m
9) Swept area	102,5	m^2
10) Height of the mast	Site dependent	m
OTHER INFORMATION		
11) Maximum rpm	DK	At rated wind speed
12) Gear box type	DK	
13) Brake system	DK	
14) Number of blades	3	
15) Blades material	Composite fibre glass	
16) Output voltage	24 – 240	V
17) Minimum operation temperature	DK	°C
18) Maximum operation temperature	DK	°C
19) Acoustic levels at a distance of 20 m ? at nacelle ? (wind = 5 m/s)	DK	DB
20) Lifetime	20	Years
21) Is the machine self-starting	Yes	
22) Use of an asynchronous generator	No	
23) Yaw control system	Not necessary	
24) Upwind or downwind	N/a	

Calculated power curve

Not available

Wind speed (m/s)	Power (kW)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	

Power curve

Not available

Fortis Wind Energy

HAWT from 0,8 kW to 10 kW.

Contact name: Johan Kuikman
Address: Botanicuslaan 14, 9751 AC Haren
Telephone: +31 – 50 5340104
Country : **Netherlands**

Espada references

Site	Use	Country
Xingang Nat. Machinery Corp.	Technology transfer	China
Windsund, Sunderland	Offshore application	UK
Brussel	Ecole Royale Miltaire	Belgium
Galeforce	Stand alone application	UK

Espada / 0,8 kW

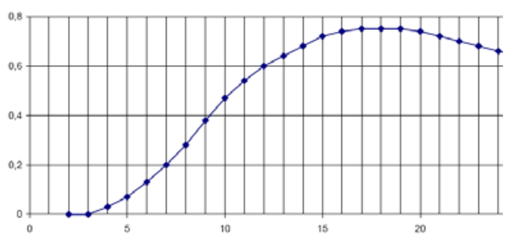
Technical information

POWER		Unit
1) Rated power	0,8	kW
2) Rated wind speed	14	m/s
3) Cut-in wind speed	3	m/s
4) Cut-out wind speed	No	m/s
5) Maximum wind speed the turbine can withstand	60	Km/h
DIMENSIONS		
6) Rotor weight	52	kg
7) Rotor diameter	2,2	m
8) Rotor height (for VAWT only)	---	m
9) Swept area	3,80	m^2
10) Height of the mast	12 – 18	m
OTHER INFORMATION		
11) Maximum rpm	1000	At rated wind speed
12) Gear box type	No brake system	
13) Brake system	Short circuit in generator	
14) Number of blades	2	
15) Blades material	Composite fibre glass	
16) Output voltage	12 - 240	V (DC)
17) Minimum operation temperature	- 30	°C
18) Maximum operation temperature	+ 50	°C
19) Acoustic levels at a distance of 20 m ? (wind = 10 m/s)	< 60	DB
20) Lifetime	20	Years
21) Is the machine self-starting	Yes	
22) Use of an asynchronous generator	No	
23) Yaw control system	Wind vane	
24) Upwind or downwind	Upwind	

Calculated power curve

Wind speed (m/s)	Power (W)
1	0
2	0
3	0
4	0,03
5	0,07
6	0,13
7	0,20
8	0,28
9	0,38
10	0,47
11	0,57
12	0,66
13	0,74
14	0,78
15	0,8

Power curve



Fortis Wind Energy

HAWT from 0,8 kW to 10 kW.

Contact name: Johan Kuikman
Address: Botanicuslaan 14, 9751 AC Haren
Telephone: +31-50 5340104
Country : Nethrelands

Passaat references

Site	Use	Country
Dieren	Stand alone electricity	Netherlands
Split	Roof university building	Croatia
Lapan	Rural electrification	Indonesia
Trontheim	Radio repeaters	Norway

Passaat 1,4 kW

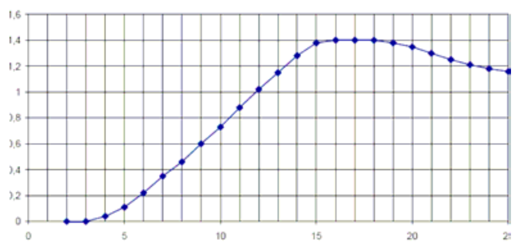
Technical information

POWER		Unit
1) Rated power	1,4	kW
2) Rated wind speed	16	m/s
3) Cut-in wind speed	2,5	m/s
4) Cut-out wind speed	None	m/s
5) Maximum wind speed the turbine can withstand	60	Km/h
DIMENSIONS		
6) Rotor weight	75	kg
7) Rotor diameter	3,12	m
8) Rotor height (for VAWT only)	---	m
9) Swept area	7,65	m^2
10) Height of the mast	12 - 24	m
OTHER INFORMATION		
11) Maximum rpm	775	At rated wind speed
12) Gear box type	No gear box	
13) Brake system	Short circuit of generator	
14) Number of blades	3	
15) Blades material	Composite fibre glass	
16) Output voltage	24-240	V (DC)
17) Minimum operation temperature	- 30	°C
18) Maximum operation temperature	+ 50	°C
19) Acoustic levels at a distance of 20 m ? (wind = 10 m/s)	< 60	DB
20) Lifetime	20	Years
21) Is the machine self-starting	Yes	
22) Use of an asynchronous generator	No	
23) Yaw control system	Wind vane	
24) Upwind or downwind	Upwind	

Calculated power curve

Wind speed (m/s)	Power* (W)
1	0
2	0
3	0,001
4	0,040
5	0,110
6	0,220
7	0,350
8	0,460
9	0,600
10	0,730
11	0,880
12	1,020
13	1,150
14	1,280
15	1,400
*power on axis, sea level, temp. 15°C	

Power curve



Fortis Montana

HAWT from 0,8 kW to 10 kW.

Contact name: Johan Kuikman
Address: Botanicuslaan 14, 9751 AC Haren
Telephone: +31 – 50 5340104
Country : Netherlands

Montana references

Site	Use	Country
Stompetoren	Demonstration at installation company	Netherlands
Waregem	On the roof of industrial building	Belgium
Perugia	Plasto Work and Wind Engineering	Italy
CREST	Stand alone electricity	Greece

Montana 5,6 kW

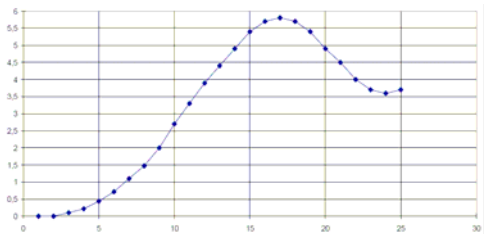
Technical information

POWER		Unit
1) Rated power	5,6	kW
2) Rated wind speed	17	m/s
3) Cut-in wind speed	2,5	m/s
4) Cut-out wind speed	No	m/s
5) Maximum wind speed the turbine can withstand	60	Km/h
DIMENSIONS		
6) Rotor weight	170	kg
7) Rotor diameter	5	m
8) Rotor height (for VAWT only)	---	m
9) Swept area	19,6	m^2
10) Height of the mast	18	m
OTHER INFORMATION		
11) Maximum rpm	450	At rated wind speed
12) Gear box type	No gear box	
13) Brake system	Short circuit at generator	
14) Number of blades	3	
15) Blades material	Composite fibre glass	
16) Output voltage	24 - 400	V (DC)
17) Minimum operation temperature	- 30	°C
18) Maximum operation temperature	+ 50	°C
19) Acoustic levels at a distance of 20 m ? (wind = 10 m/s)	< 60	DB
20) Lifetime	20	Years
21) Is the machine self-starting	Yes	
22) Use of an asynchronous generator	No	
23) Yaw control system	Wind vane	
24) Upwind or downwind	Upwind	

Calculated power curve

Wind speed (m/s)	Power (W)
1	0
2	0
3	0,10
4	0,22
5	0,44
6	0,72
7	1,10
8	1,43
9	2,00
10	2,70
11	3,30
12	3,90
13	4,40
14	4,90
15	5,40

Power curve



Fortis Wind Energy

HAWT from 0,8 kW to 10 kW.

Contact name: Johan Kuikman
Address: Botanicuslaan 14, 9751 AC Haren
Telephone: +31-50 5340104
Country : Netherlands

Alize references

Site	Use	Country
Dronrijp	Farm	Netherlands
Lutjegast	Farm	Netherlands
Opende	Farm	Netherlands
St. Cruz de la Palma	Desalination plant	Spain, Canary Islands

Alize, 10 kW

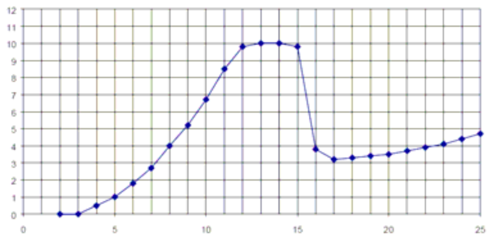
Technical information

POWER		Unit
1) Rated power	10	kW
2) Rated wind speed	12	m/s
3) Cut-in wind speed	3	m/s
4) Cut-out wind speed	No	m/s
5) Maximum wind speed the turbine can withstand	60	Km/h
DIMENSIONS		
6) Rotor weight	285	kg
7) Rotor diameter	7	m
8) Rotor height (for VAWT only)	---	m
9) Swept area	38,5	m^2
10) Height of the mast	18 – 36	m
OTHER INFORMATION		
11) Maximum rpm	300	At rated wind speed
12) Gear box type	No gear box	
13) Brake system	Short circuit of generator	
14) Number of blades	3	
15) Blades material	Composite fibre glass	
16) Output voltage	120 - 400	V (DC)
17) Minimum operation temperature	- 30	°C
18) Maximum operation temperature	+ 50	°C
19) Acoustic levels at a distance of 20 m ? (wind = 10 m/s)	< 60	DB
20) Lifetime	20	Years
21) Is the machine self-starting	Yes	
22) Use of an asynchronous generator	No	
23) Yaw control system	Wind vane	
24) Upwind or downwind	Upwind	

Calculated power curve

Wind speed (m/s)	Power* (W)
1	0
2	0
3	0
4	0,4
5	1,0
6	1,8
7	2,8
8	3,9
9	5,2
10	6,8
11	8,5
12	9,8
13	10,0
14	10,0
15	10,0

Power curve



Fuhrländer

HAWT from 30 kW to 2 700 kW.

FL 30/ 30 kW

Contact name:	Carina Demuth / A. Kloos
Address:	Auf der Höhe 4, 56477 Waigandshain
Telephone:	+49 266 49 96 60
Country :	**Germany**

Fürländer FL30 references

Site	Use	Country
Zistersdorf	Government	Austria
Cody / Wyoming	Privat Ranch	USA
Köln	Public Services	Germany

Technical information

POWER		Unit
1) Rated power	30	kW
2) Rated wind speed	12	m/s
3) Cut-in wind speed	2,5	m/s
4) Cut-out wind speed	25	m/s
5) Maximum wind speed the turbine can withstand	55	m/s
DIMENSIONS		
6) Rotor weight	640	kg
7) Rotor diameter	13	m
8) Rotor height (for VAWT only)		m
9) Swept area	133	m^2
10) Height of the mast	18/27	m
OTHER INFORMATION		
11) Maximum rpm	70	At rated wind speed
12) Gear box type	Spur gear/planet gears	
13) Brake system	Disk brake+ Mech tip brake	
14) Number of blades	3	
15) Blades material	Glass Fibre Composite	
16) Output voltage	400	V
17) Minimum operation temperature	-20°C	°C
18) Maximum operation temperature	+ 50°C	°C
19) Acoustic levels at a distance of 20 m ? at nacelle ? (wind = 5 m/s)	93	DB
20) Lifetime		Years
21) Is the machine self-starting	Yes	
22) Use of an asynchronous generator	Yes	
23) Yaw control system	1 gearbox motors	
24) Upwind or downwind		

Calculated power curve

Wind speed (m/s)	Power (W)
1	0
2	0
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	

Power curve

Fuhrländer

HAWT from 30 kW to 2 700 kW.

Contact name: Carina Demuth / A. Kloos
Address: Auf der Höhe 4, 56477 Waigandshain
Telephone: +49 266 49 96 60
Country : **Germany**

Fuhrländer FL 100 references

Site	Use	Country
Rennerod	Company " Spedition Pracht"	Germany
Iwata /Shizuoka	Iwata Factory	Japan
Vilemov	Orthodox Akademie	Czech Republic
Boston	IBEW Local	USA

FL 100/ 100 kW

Technical information

POWER		Unit
1) Rated power	100	kW
2) Rated wind speed	13	m/s
3) Cut-in wind speed	2,5	m/s
4) Cut-out wind speed	25	m/s
5) Maximum wind speed the turbine can withstand	67	m/s
DIMENSIONS		
6) Rotor weight (incl. hub)	2 300	kg
7) Rotor diameter	21	m
8) Rotor height (for VAWT only)		m
9) Swept area	346	m^2
10) Height of the mast	35	m
OTHER INFORMATION		
11) Maximum rpm	47	At rated wind speed
12) Gear box type	Combined spur gear/planet gears	
13) Brake system	Disc brake + rotor tip brake + parking brake system + aerodynamic safety system "stall"	
14) Number of blades	3	
15) Blades material	Glass Fibre Composite	
16) Output voltage	400	V
17) Minimum operation temperature	-20°C	°C
18) Maximum operation temperature	+ 50°C	°C
19) Acoustic levels at a distance of 20 m ? at nacelle ? (wind = 5 m/s)	95	DB
20) Lifetime	25	Years
21) Is the machine self-starting	Yes	
22) Use of an asynchronous generator	Yes	
23) Yaw control system	Wind vane	
24) Upwind or downwind	Upwind	

Calculated power curve

Wind speed (m/s)	Power (W)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	

Power curve

Gaia-Wind A/S

HAWT 11 kW.

Contact name: Jesper Andersen
Address: Håndværkervej 1, 8840 Rødkærsbro
Telephone: +45 87 76 22 00
Country : **Denmark**

Gaia 11 kW references: have not provided any references

Site	Use	Country

Gaia/ 11 kW

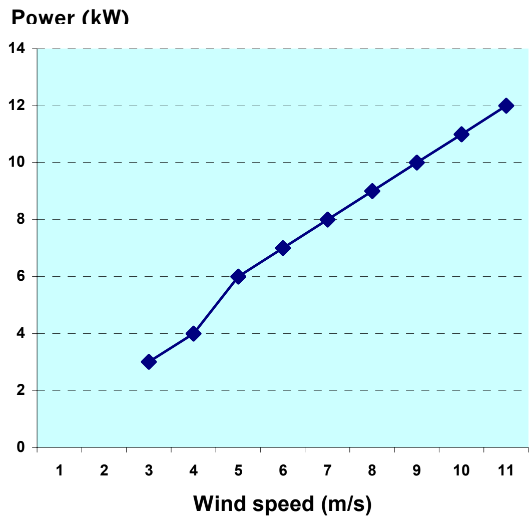
Technical information

POWER		Unit
1) Rated power	11	kW
2) Rated wind speed	10	m/s
3) Cut-in wind speed	3	m/s
4) Cut-out wind speed	25	m/s
5) Maximum wind speed the turbine can withstand	65	Km/h
DIMENSIONS		
6) Rotor weight	208-248	kg
7) Rotor diameter	13	m
8) Rotor height (for VAWT only)	Not relevant	m
9) Swept area	132	m^2
10) Height of the mast	18	m
OTHER INFORMATION		
11) Maximum rpm	56	At rated wind speed
12) Gear box type	Compact shaft mounted gear	
13) Brake system	Disc brake	
14) Number of blades	2	
15) Blades material	Composite fiber glass	
16) Output voltage	380-400	V
17) Minimum operation temperature	- 20	°C
18) Maximum operation temperature	+ 50	°C
19) Acoustic levels at a distance of 20 m ? at nacelle ? (wind = 5 m/s)	45 Db at 59 meters	DB
20) Lifetime	20	Years
21) Is the machine self-starting	Yes	
22) Use of an asynchronous generator	Yes	
23) Yaw control system	Wind vane	
24) Upwind or downwind	Downwind turbine	

Calculated power curve

Wind speed (m/s)	Power(kW)
1	
2	
3	3
4	4
5	6
6	7
7	8
8	9
9	10
10	11
11	12

Power curve:



Gazelle Wind Turbines Ltd

HAWT – 20 kW

Contact name: Ken Chaplin
Address: Stargate Ind Est, Ryton, Tyne & Wear, NE40 3 EX
Telephone: +44 (0) 191 413 00 12
Country: **United Kingdom**

Gazelle 20 kW references

Site	Use	Country
Southport Eco Centre,	Electricity generation for building	UK
Montagne Jeunesse Eco Factory, Swansea	Electricity generation for building	UK
Sunderland Enterprise Park, Sunderland	Electricity generation for building	UK

Gazelle / 20 kW

Technical information

POWER		Unit
1) Rated power	20	kW
2) Rated wind speed	13	m/s
3) Cut-in wind speed	4	m/s
4) Cut-out wind speed	20	m/s
5) Maximum wind speed the turbine can withstand	DK	km/h
DIMENSIONS		
6) Nacelle and rotor weight	1600	kg
7) Rotor diameter	11	m
8) Rotor height (for VAWT only)	-	m
9) Swept area	95	m^2
10) Height of the mast	12,5 to 20	m
OTHER INFORMATION		
11) Maximum rpm	106	At rated wind speed
12) Gear box type		None
13) Brake system		-
14) Number of blades		3
15) Blades material		Carbon fibre epoxy
16) Output voltage	400	V
17) Minimum operation temperature	DK	°C
18) Maximum operation temperature	DK	°C
19) Acoustic levels at a distance of 20 m ? at nacelle ? (wind = 5 m/s)	DK	DB
20) Lifetime	20 to 25	Years
21) Is the machine self-starting		Yes
22) Use of an asynchronous generator		Yes
23) Yaw control system		Free yaw
24) Upwind or downwind		Downwind

Calculated power curve

Not available

Wind speed (m/s)	Power (kW)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	

Power curve

Not available

Iskra Wind Turbines

HAWT – 5 kW

Contact name: John Balson
Address: 261, Woodborough Road, St Anns, Nottingham, NG3 4 JZ
Telephone: +44 (0) 115 841 32 83
Country: **United Kingdom**

Iskra 5 kW references

Site	Use	Country
The Turbine, Shireoaks Business Innovation Centre, Worksop	Electricity generation for building	UK
Westergate Business Centre, Brighton	Electricity generation for building	UK
Hockerton Housing Project, Hockerton	Electricity generation for homes and visitor centre	UK

Technical information

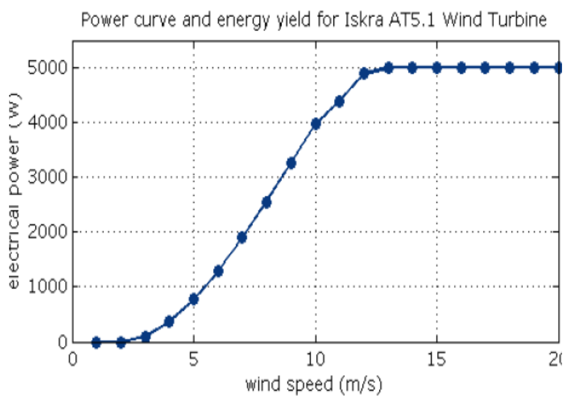
POWER		Unit
1) Rated power	5	kW
2) Rated wind speed	11	m/s
3) Cut-in wind speed	3	m/s
4) Cut-out wind speed	60	m/s
5) Maximum wind speed the turbine can withstand	216	km/h
DIMENSIONS		
6) Nacelle and rotor weight	280	kg
7) Rotor diameter	5.4	m
8) Rotor height (for VAWT only)	-	m
9) Swept area	22.9	m^2
10) Height of the mast	12 to 30	m
OTHER INFORMATION		
11) Maximum rpm	200	At rated wind speed
12) Gear box type	None	
13) Brake system	Electro-dymamic	
14) Number of blades	3	
15) Blades material	Composite fibre glass	
16) Output voltage	Variable	V
17) Minimum operation temperature	-20	°C
18) Maximum operation temperature	+50	°C
19) Acoustic levels at a distance of 20 m ? at nacelle ? (wind = 5 m/s)	DK	DB
20) Lifetime	20	Years
21) Is the machine self-starting	Yes	
22) Use of an asynchronous generator	No	
23) Yaw control system	Tail vane	
24) Upwind or downwind	Upwind	

Iskra / 5 kW

Calculated power curve

Wind speed (m/s)	Power (W)
1	0
2	0
3	96
4	367
5	771
6	1284
7	1901
8	2547
9	3253
10	3965
11	4397
12	4888
13	5000
14	5000
15	5000

Power curve:



Jonica Impianti

HAWT of 20 kW.

Contact name:	Nicola De Luca
Address:	Via Poerio 226, 74020 Lizzano
Telephone:	+39 099 955 12 08
Country :	**Italy**

Jonica Impianti/ 20 kW

Jonica Impianti 20 kW references

City (Province)	Use	Country
Lizzano (Taranto)	Jonica Impianti factory	Italy
Perarolo di Cadore (Belluno)	Industrial area	Italy
Pos al Pago (Belluno)	Industrial area	Italy
Quero (Belluno)	Industrial area	Italy
Colle Salvetti (Livorno)	AGIP Service station	Italy

Technical information

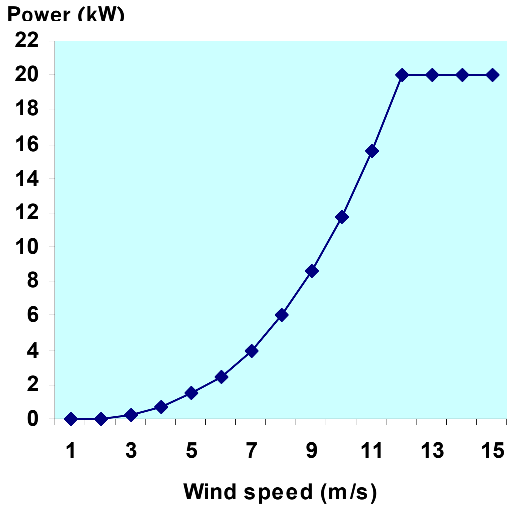
POWER		Unit
1) Rated power	20	KW
2) Rated wind speed	12,5	m/s
3) Cut-in wind speed	3,5	m/s
4) Cut-out wind speed	37,5	m/s
5) Maximum wind speed the turbine can withstand	153	Km/h
DIMENSIONS		
6) Rotor weight (blades)	100	Kg
7) Rotor diameter	8	m
8) Rotor height (for VAWT only)		m
9) Swept area	50,3	m^2
10) Height of the mast	12/18	m
OTHER INFORMATION		
11) Maximum rpm	200	At rated wind speed
12) Gear box type	Not present	
13) Brake system	Aerodynamic with pitch control	
14) Number of blades	3	
15) Blades material	Composite fiber glass	
16) Output voltage	380	V
17) Minimum operation temperature	- 20	°C
18) Maximum operation temperature	+ 50	°C
19) Acoustic levels at a distance of 50 m (wind = 9 m/s)	50	DB
20) Lifetime	20	Years
21) Is the machine self-starting	Yes	
22) Use of an asynchronous generator	No	
23) Yaw control system	Wind vane	
24) Upwind or downwind	Upwind turbine	

Calculated power curve

Wind speed (m/s)	Power (kW)
1	0
2	0
3	0,.25
4	0,.50
5	1, 5
6	2, 5
7	4
8	6
9	8, 6
10	11, 8
11	15, 6
12	20
13	20
14	20
15	20

Sea level, Raleygh distrib k = 2
Tower height= 18 m, Shear coef = 0,14
Turbulence factor = 15%

Power curve:



Marlec Engineering Co Ltd

HAWT – From 0,025 kW to 0,34 kW

Contact name: Teresa Auciello
Address: Rutland House, Trevithick Rd, Corby, Northants NN17 5XY
Telephone: +44 (0) 1536 201 588
Country: **United Kingdom**

Rutland 503 – 0,025 kW references

Site	Use	Country
Elliott Durham Comprehensive School, Nottingham	Educational	UK
Sandy Upper School and Community Sports College	Educational	UK
Cromwell Park Primary School, Huntingdon	Educational	UK

Rutland 503 / 0,025 kW

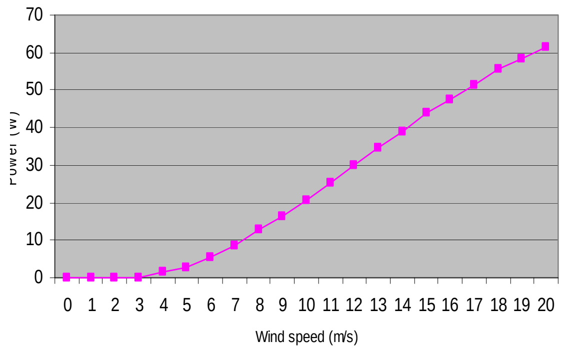
Technical information

POWER		Unit
1) Rated power	0, 025	kW
2) Rated wind speed	10	m/s
3) Cut-in wind speed	2,6	m/s
4) Cut-out wind speed	None	m/s
5) Maximum wind speed the turbine can withstand	> 137	km/h
DIMENSIONS		
6) Nacelle and rotor weight	3	kg
7) Rotor diameter	0,500	m
8) Rotor height (for VAWT only)	-	m
9) Swept area	0,196	m^2
10) Height of the mast	Variable up to 6,5	m
OTHER INFORMATION		
11) Maximum rpm	DK	At rated wind speed
12) Gear box type	None	
13) Brake system	DK	
14) Number of blades	6	
15) Blades material	Glass reinforced plastic	
16) Output voltage	12 or 24	V
17) Minimum operation temperature	-25	°C
18) Maximum operation temperature	DK	°C
19) Acoustic levels at a distance of 20 m? at nacelle? (wind = 5 m/s)	DK	DB
20) Lifetime	15	Years
21) Is the machine self-starting	Yes	
22) Use of an asynchronous generator	No	
23) Yaw control system	Wind vane	
24) Upwind or downwind	Upwind	

Calculated power curve

Wind speed (m/s)	Power (W)
1	0
2	0
3	1
4	2
5	4
6	6
7	10
8	14
9	20
10	26
11	28
12	36
13	39
14	44
15	56

Power curve:



Marlec Engineering Co Ltd

HAWT – From 0,025 kW to 0,34 kW

Contact name: Teresa Auciello
Address: Rutland House, Trevithick Rd, Corby, Northants NN17 5XY
Telephone: +44 (0) 1536 201 588
Country : **United Kingdom**

Rutland 910-3 – 0,09 kW references

Site	Use	Country
Hagbourne Primary School, Oxon	Educational and Electricity generation	UK
A43 roadside	Traffic signals	UK
Tokyo	Street lighting	Japan

Rutland 910-3 / 0,09 kW

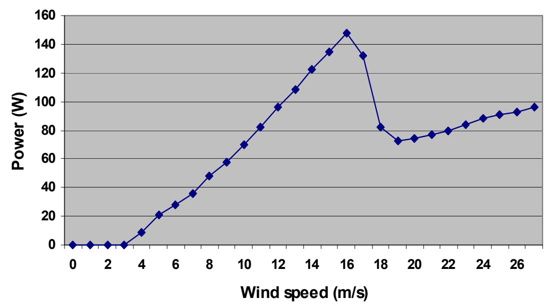
Technical information

POWER		Unit
1) Rated power	0,09	kW
2) Rated wind speed	10	m/s
3) Cut-in wind speed	2,6	m/s
4) Cut-out wind speed	It furls at 15 m/s but no real cut out	m/s
5) Maximum wind speed the turbine can withstand	> 137	km/h
DIMENSIONS		
6) Nacelle and rotor weight	17	kg
7) Rotor diameter	0,910	m
8) Rotor height (for VAWT only)	-	m
9) Swept area	0,655	m^2
10) Height of the mast	Up to 6,5	m
OTHER INFORMATION		
11) Maximum rpm	DK	At rated wind speed
12) Gear box type	None	
13) Brake system	DK	
14) Number of blades	6	
15) Blades material	Glass reinforced plastic	
16) Output voltage	12 or 24	V
17) Minimum operation temperature	Artic	°C
18) Maximum operation temperature	Sahara	°C
19) Acoustic levels at a distance of 20 m? at nacelle? (wind = 5 m/s)	DK	DB
20) Lifetime	15	Years
21) Is the machine self-starting	Yes	
22) Use of an asynchronous generator	No	
23) Yaw control system	Wind vane	
24) Upwind or downwind	Upwind	

Calculated power curve

Wind speed (m/s)	Power (W)
1	0
2	0
3	2
4	14
5	21
6	28
7	44
8	50
9	66
10	83
11	87
12	92
13	121
14	138
15	159

Power curve:



Marlec Engineering Co Ltd

HAWT – From 0,025 kW to 0,34 kW

Contact name:	Teresa Auciello
Address:	Rutland House, Trevithick Rd, Corby, Northants NN17 5XY
Telephone:	+44 (0) 1536 201 588
Country :	**United Kingdom**

Rutland 913 – 0,09 kW references

Site	Use	Country
Rutland Water	Water level monitoring	UK
Southampton	Sailing boat	UK
	Street lighting	Taiwan
A6006 road sign	Safety sign	UK

Rutland 913/ 0,09 kW

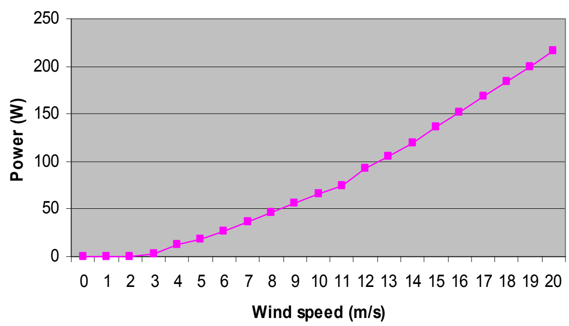
Technical information

POWER		Unit
1) Rated power	0,09	kW
2) Rated wind speed	10	m/s
3) Cut-in wind speed	2,6	m/s
4) Cut-out wind speed	None	m/s
5) Maximum wind speed the turbine can withstand	> 137	Km/h
DIMENSIONS		
6) Nacelle and rotor weight	13	Kg
7) Rotor diameter	0,913	m
8) Rotor height (for VAWT only)	-	m
9) Swept area	0,655	m^2
10) Height of the mast	Variable up to 6,5	m
OTHER INFORMATION		
11) Maximum rpm	DK	At rated wind speed
12) Gear box type	None	
13) Brake system	DK	
14) Number of blades	6	
15) Blades material	Glass reinforced plastic	
16) Output voltage	12 or 24	V
17) Minimum operation temperature	-25	°C
18) Maximum operation temperature	DK	°C
19) Acoustic levels at a distance of 20 m? at nacelle? (wind = 5 m/s)	DK	DB
20) Lifetime	15	Years
21) Is the machine self-starting	Yes	
22) Use of an asynchronous generator	No	
23) Yaw control system	Wind vane	
24) Upwind or downwind	Upwind	

Calculated power curve

Wind speed (m/s)	Power (W)
1	0
2	0
3	2
4	14
5	21
6	28
7	44
8	50
9	66
10	83
11	87
12	92
13	121
14	138
15	159

Power curve:



OY Windside Production Ltd

VAWT from 1 kW to 8 kW.

WS-4B & 4C/ 1-2 kW

Contact name: Risto Joutsiniemi
Address: Niemenharjuntie 85, 44800 Pihtipudas
Telephone: +358 208 350 700
Country : **Finland**

Oy Windside WS-4B/4C references

Site	Use	Country
Doncaster	Earth Centre	England
Helsinki	Arabianranta	Finland
Chicago	Millenium Park	U.S.A
Yurigaoka, Fukuoka	Sports centre	Japan
Oulu	In a Park wind art work Synergia	Finland

Technical information

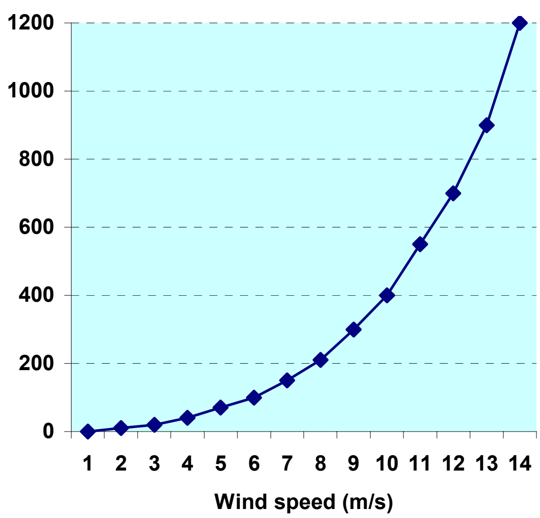
POWER		Unit
1) Rated power	1	KW
2) Rated wind speed	18	m/s
3) Cut-in wind speed	2	m/s
4) Cut-out wind speed	None	m/s
5) Maximum wind speed the turbine can withstand	144	Km/h
DIMENSIONS		
6) Rotor weight	400	Kg
7) Rotor diameter	1	m
8) Rotor height (for VAWT only)	4	m
9) Swept area	4	m^2
10) Height of the mast	Not relevant	m
OTHER INFORMATION		
11) Maximum rpm	170 - 400	At rated wind speed
12) Gear box type	No gear box	
13) Brake system	Disk brake	
14) Number of blades	2	
15) Blades material	Composite fibre glass	
16) Output voltage	0 - 200	V
17) Minimum operation temperature	- 60	°C
18) Maximum operation temperature	+ 80	°C
19) Acoustic levels at a distance of 20 m ? at nacelle ? (wind = 5 m/s)	0	DB
20) Lifetime	100	Years
21) Is the machine self-starting	Yes	
22) Use of an asynchronous generator	Yes	
23) Yaw control system	Not needed	
24) Upwind or downwind		

Calculated power curve

Wind speed (m/s)	Power (W)
1	0
2	10
3	20
4	40
5	70
6	100
7	150
8	210
9	300
10	400
11	550
12	700
13	900
14	1 200

In battery charging the electricity production will be changing according to the voltage level chosen by the client. 3-phase Generator 25 Ampers

Power curve



OY Windside Production Ltd

VAWT from 1 kW to 8 kW.

Contact name:	Risto Joutsiniemi
Address:	Niemenharjuntie 85, 44800 Pihtipudas
Telephone:	+358 208 350 700
Country :	**Finland**

Oy Windside WS-12 references

Site	Use	Country
Raisio	Shopping centre	Finland

WS-12/ 8 kW

Technical information

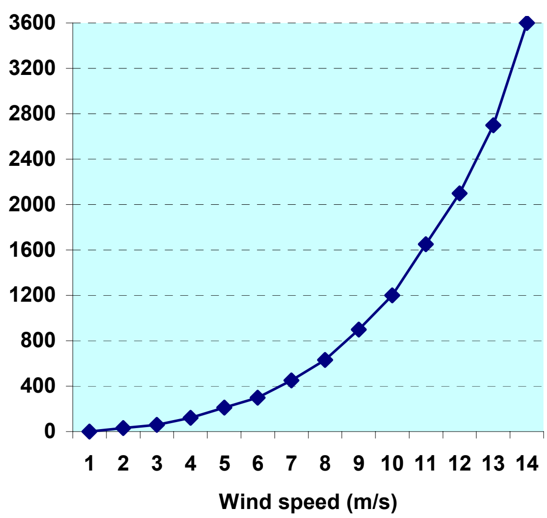
POWER		Unit
1) Rated power	8	kW
2) Rated wind speed	20	m/s
3) Cut-in wind speed	2	m/s
4) Cut-out wind speed	None	m/s
5) Maximum wind speed the turbine can withstand	216	Km/h
DIMENSIONS		
6) Rotor weight	3000	kg
7) Rotor diameter	2	m
8) Rotor height (for VAWT only)	6	m
9) Swept area	12	m^2
10) Height of the mast	Not relevant	m
OTHER INFORMATION		
11) Maximum rpm	100 - 300	At rated wind speed
12) Gear box type		No gear box
13) Brake system		Disk brake
14) Number of blades		2
15) Blades material		Aluminium
16) Output voltage	0 - 200	V
17) Minimum operation temperature	- 60	°C
18) Maximum operation temperature	+ 80	°C
19) Acoustic levels at a distance of 20 m ? at nacelle ? (wind = 5 m/s)	0	DB
20) Lifetime	100	Years
21) Is the machine self-starting		Yes
22) Use of an asynchronous generator		Yes
23) Yaw control system		Not needed
24) Upwind or downwind		

Calculated power curve

Wind speed (m/s)	Power (W)
1	0
2	30
3	60
4	120
5	211
6	300
7	450
8	630
9	900
10	1 200
11	1 650
12	2 100
13	2 700
14	3 600

In battery charging the electricity production will be changing according to the voltage level chosen by the client.

Power curve



Pitchwind Systems AB

HAWT from 20 kW to 30 kW

Contact name:	Lars Akeson
Address:	PO Box 89, 44 322 Lerum
Telephone:	+46 708 237 219
Country :	**Sweden**

Pitchwind/ 30 kW Grid

Pitchwind 30 kW Grid connected references

Site	Use	Country

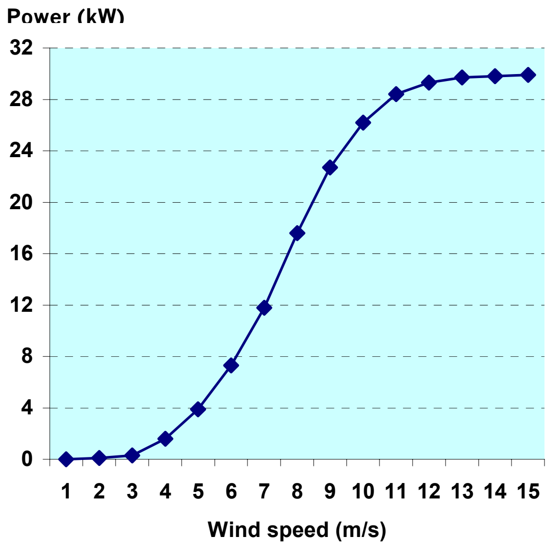
Technical information

POWER		Unit
1) Rated power	30	kW
2) Rated wind speed	15	m/s
3) Cut-in wind speed	2	m/s
4) Cut-out wind speed	None	m/s
5) Maximum wind speed the turbine can withstand	250	Km/h
DIMENSIONS		
6) Rotor weight	550	kg
7) Rotor diameter	14	m
8) Rotor height (for VAWT only)		m
9) Swept area	154	m^2
10) Height of the mast	20 / 62	m
OTHER INFORMATION		
11) Maximum rpm	81	At rated wind speed
12) Gear box type	None	
13) Brake system	Pitch by electrical actuator at service parking brake	
14) Number of blades	2	
15) Blades material	Steel polyster	
16) Output voltage	380 – 500	V
17) Minimum operation temperature	- 40	°C
18) Maximum operation temperature	+ 40	°C
19) Acoustic levels at a distance of 30m from tower base (wind speed 5 m/s & rotor speed = 48 rpm)	50	DB
20) Lifetime	20	Years
21) Is the machine self-starting	Yes	
22) Use of an asynchronous generator	No	
23) Yaw control system	Wind wheels	
24) Upwind or downwind	Upwind	

Calculated power curve

Wind speed (m/s)	Power (kW)
1	0
2	0,1
3	0,3
4	1,6
5	3,9
6	7,3
7	11,8
8	17,6
9	22,7
10	26,2
11	28,4
12	29,3
13	29,7
14	29,8
15	29,9

Power curve:



Proven Energy Products Ltd

HAWT – From 0,6 kW to 15 kW

Contact name: David Watson
Address: Wardhead Park, Stewarton, Ayrshire, KA3 5 LH, Scotland
Telephone: +44 (0) 1560 485 570
Country : **United Kingdom**

Proven WT 600 references

Site	Use	Country

Proven WT 600/ 0,6 kW

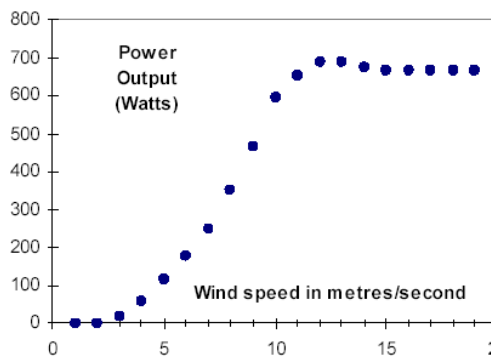
Technical information

POWER		Unit
1) Rated power	0,6	KW
2) Rated wind speed	10	m/s
3) Cut-in wind speed	2,5	m/s
4) Cut-out wind speed	None	m/s
5) Maximum wind speed the turbine can withstand	234	Km/h
DIMENSIONS		
6) Rotor weight	70	Kg
7) Rotor diameter	2,55	m
8) Rotor height (for VAWT only)		m
9) Swept area	5,11	m^2
10) Height of the mast	5,5	m
OTHER INFORMATION		
11) Maximum rpm		At rated wind speed
12) Gear box type		
13) Brake system		
14) Number of blades		3
15) Blades material		Polypropylene / P.U.
16) Output voltage	14 / 24/ 48	V
17) Minimum operation temperature	Artic circle	°C
18) Maximum operation temperature	South America	°C
19) Acoustic levels at a distance of 20 m ? at nacelle ? (wind = 5 m/s)	21 at 20 m 35 at mast	DB
20) Lifetime	20-25	Years
21) Is the machine self-starting		Yes
22) Use of an asynchronous generator		No
23) Yaw control system		
24) Upwind or downwind		Downwind

Calculated power curve

Wind speed (m/s)	Power (W)
1	0
2	0
3	15
4	60
5	110
6	190
7	260
8	350
9	480
10	600
11	660
12	700
13	700
14	700

Power curve:



Proven Energy Products Ltd

HAWT – From 0,6 kW to 15 kW

Contact name: David Watson
Address: Wardhead Park, Stewarton, Ayrshire, KA3 5 LH, Scotland
Telephone: +44 (0) 1560 485 570
Country : **United Kingdom**

Proven WT 6 000 references

Site	Use	Country

Proven WT 6 000/ 6 kW

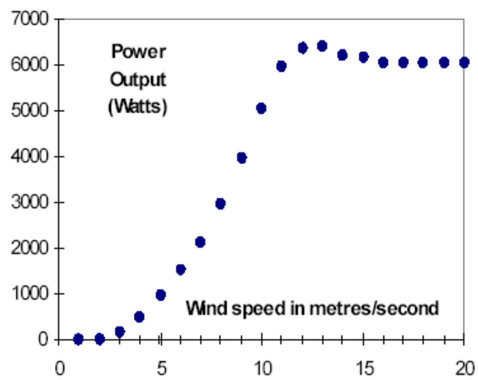
Technical information

POWER		Unit
1) Rated power	6	KW
2) Rated wind speed	12	m/s
3) Cut-in wind speed	2,5	m/s
4) Cut-out wind speed	None	m/s
5) Maximum wind speed the turbine can withstand	234	Km/h
DIMENSIONS		
6) Rotor weight	539	Kg
7) Rotor diameter	5,5	m
8) Rotor height (for VAWT only)		m
9) Swept area	23,76	m^2
10) Height of the mast	9 / 15	m
OTHER INFORMATION		
11) Maximum rpm		At rated wind speed
12) Gear box type		
13) Brake system		
14) Number of blades		3
15) Blades material		Wood/ Epoxy / P.U.
16) Output voltage	48 to 300	V
17) Minimum operation temperature	Artic circle	°C
18) Maximum operation temperature	South America	°C
19) Acoustic levels at a distance of 20 m ? at nacelle ? (wind = 5 m/s)	45 dB at mast 36 dB at 20 m	DB
20) Lifetime	20-25	Years
21) Is the machine self-starting		Yes
22) Use of an asynchronous generator		No
23) Yaw control system		
24) Upwind or downwind		Downwind

Calculated power curve

Wind speed (m/s)	Power (W)
1	0
2	0
3	100
4	450
5	1 000
6	1 500
7	2 050
8	3 000
9	4 000
10	5 000
11	6 000
12	6 200
13	6 250
14	6 150

Power curve:



Proven Energy Products Ltd

HAWT – From 0,6 kW to 15 kW

Contact name: David Watson
Address: Wardhead Park, Stewarton, Ayrshire, KA3 5 LH, Scotland
Telephone: +44 (0) 1560 485 570
Country : **United Kingdom**

Proven WT 15 000 references

Site	Use	Country

Proven WT 15 000/ 15 kW

Technical information

POWER		Unit
1) Rated power	15	KW
2) Rated wind speed	12	m/s
3) Cut-in wind speed	2,5	m/s
4) Cut-out wind speed	None	m/s
5) Maximum wind speed the turbine can withstand	234	Km/h
DIMENSIONS		
6) Rotor weight	1 100	Kg
7) Rotor diameter	9	m
8) Rotor height (for VAWT only)		m
9) Swept area	63,62	m^2
10) Height of the mast	15 /20	m
OTHER INFORMATION		
11) Maximum rpm		At rated wind speed
12) Gear box type		
13) Brake system		
14) Number of blades	3	
15) Blades material	Glass Epoxy	
16) Output voltage	48 DC or 230 AC or 240 AC	V
17) Minimum operation temperature	Artic circle	°C
18) Maximum operation temperature	South America	°C
19) Acoustic levels at a distance of 20 m ? at nacelle ? (wind = 5 m/s)	65 dB at mast 48 dB at 20 m	DB
20) Lifetime	20-25	Years
21) Is the machine self-starting	Yes	
22) Use of an asynchronous generator	No	
23) Yaw control system		
24) Upwind or downwind	Downwind	

Calculated power curve

Wind speed (m/s)	Power (W)
1	0
2	0
3	300
4	1 200
5	2 200
6	4 000
7	5 500
8	7 500
9	10 000
10	12 500
11	15 000
12	16 000
13	16 000
14	16 500

Power curve:

Renewable Devices Swift Turbines

HAWT – 1,5 kW

Contact name:
Address: Bush Estate, Edinburgh, EH26 OPH
Telephone: +44 (0) 131 535 33 01
Country : **United Kingdom**

Swift Rooftop/ 1,5 kW

Swift Rooftop 1,5 kW references

Site	Use	Country
Fife School / Collidean	Primary school (rooftop)	England

Technical information

POWER		Unit
1) Rated power	1,5	KW
2) Rated wind speed	12	m/s
3) Cut-in wind speed	4	m/s
4) Cut-out wind speed	17	m/s
5) Maximum wind speed the turbine can withstand	223	Km/h
DIMENSIONS		
6) Rotor weight	15	Kg
7) Rotor diameter	2	m
8) Rotor height (for VAWT only)		m
9) Swept area	3,14	m^2
10) Height of the mast	5	m
OTHER INFORMATION		
11) Maximum rpm		At rated wind speed
12) Gear box type		
13) Brake system		
14) Number of blades	5	
15) Blades material	Moulded carbon fibre	
16) Output voltage	60 DC	V
17) Minimum operation temperature	DK	°C
18) Maximum operation temperature	DK	°C
19) Acoustic levels at a distance of 20 m ? at nacelle ? (wind = 5 m/s)	DK	DB
20) Lifetime	20	Years
21) Is the machine self-starting	Yes	
22) Use of an asynchronous generator	No	
23) Yaw control system	Wind vane	
24) Upwind or downwind	Upwind	

Calculated power curve

Wind speed (m/s)	Power (W)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	

Power curve:

Ropatec S.p.a.

VAWT from 0,75 kW to 6 kW.

Contact name: Hannes Riegler
Address: Via Siemens 19
Telephone: +39 0471 568 180
Country : **Italy**

WRE.007 / 0,75 kW

Ropatec WRE.007 references

Site	Use	Country
Near Bristol	Battery charging for a LNG-station	England
	Demonstration unit on a rooftop	Korea
Ihoshy	Energy supply for a radio station	Madagascar
Hammerfest	Battery charging	Norway

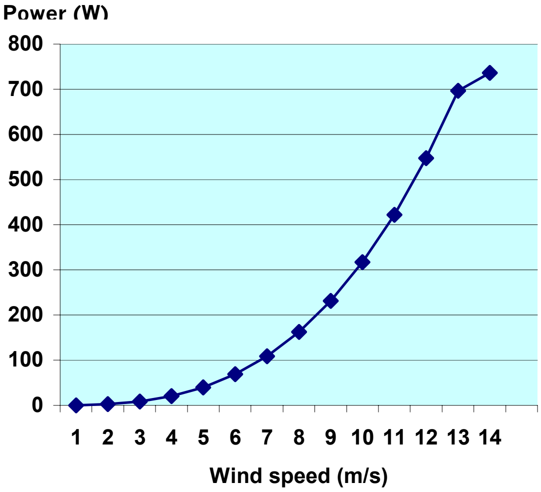
Technical information

		Unit
1) Rated power	0,75	kW
2) Rated wind speed	14	m/s
3) Cut-in wind speed	2	m/s
4) Cut-out wind speed	None	m/s
5) Maximum wind speed the turbine can withstand	> 150	Km/h
DIMENSIONS		
6) Rotor weight	150	kg
7) Rotor diameter	1,5	m
8) Rotor height (for VAWT only)	1,5	m
9) Swept area	2,25	m^2
10) Height of the mast	Not relevant	m
OTHER INFORMATION		
11) Maximum rpm	350	At rated wind speed
12) Gear box type	No gear box – direct driven	
13) Brake system	None	
14) Number of blades	2	
15) Blades material	Aluminium	
16) Output voltage	200	V
17) Minimum operation temperature	- 30	°C
18) Maximum operation temperature	+ 50	°C
19) Acoustic levels at a distance of 20 m ? at nacelle ? (wind = 5 m/s)	Not audible	DB
20) Lifetime	15/20	Years
21) Is the machine self-starting	Yes	
22) Use of an asynchronous generator	No	
23) Yaw control system	Independent of wind direction	
24) Upwind or downwind	Upwind turbine	

Calculated power curve

Wind speed (m/s)	Power* (W)
1	0,32
2	2,54
3	8,56
4	20,28
5	39,62
6	68,46
7	108,71
8	162,28
9	231,05
10	316,94
11	421,85
12	547,68
13	696,33
14	736,27
15	
*power on axis, sea level, temp. 15°C	

Power curve:



Ropatec S.p.a.

VAWT from 0,75 kW to 6 kW.

Contact name: Hannes Riegler
Address: Via Siemens 19
Telephone: +39 0471 568 180
Country : **Italy**

WRE.030 / 3 kW

Ropatec WRE.30 references

Site	Use	Country
Monte Cimone	Research station	Italy
Foggia	Support for electrical pumps	Italy
Sennes	Refuge	Italy
Marchetti	Refuge	Italy

Technical information

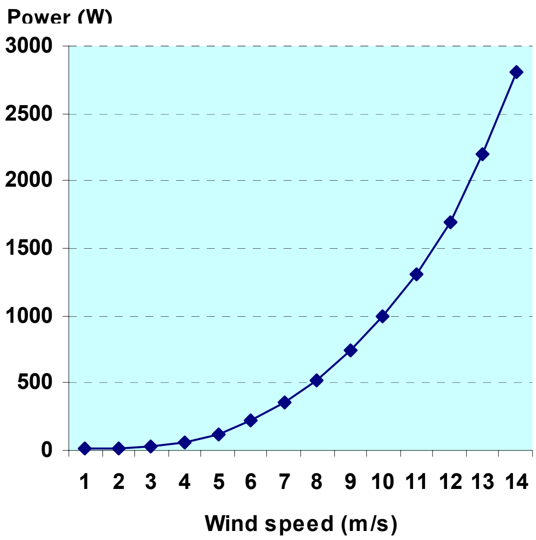
POWER		Unit
1) Rated power	3	kW
2) Rated wind speed	14	m/s
3) Cut-in wind speed	2	m/s
4) Cut-out wind speed	None	m/s
5) Maximum wind speed the turbine can withstand	> 150	Km/h
DIMENSIONS		
6) Rotor weight	~430	kg
7) Rotor diameter	3,3	m
8) Rotor height (for VAWT only)	2,2	m
9) Swept area	7,26	m^2
10) Height of the mast	Not relevant	m
OTHER INFORMATION		
11) Maximum rpm	100 to 120	At rated wind speed
12) Gear box type	No gear box – direct driven	
13) Brake system	Not required	
14) Number of blades	2	
15) Blades material	Aluminium	
16) Output voltage	0 - 220	V
17) Minimum operation temperature	- 30	°C
18) Maximum operation temperature	+ 50	°C
19) Acoustic levels at a distance of 20 m ? at nacelle ? (wind = 5 m/s)	Not audible	DB
20) Lifetime	15/20	Years
21) Is the machine self-starting	Yes	
22) Use of an asynchronous generator	No	
23) Yaw control system	Independent of wind direction	
24) Upwind or downwind	Upwind turbine	

Calculated power curve

Wind speed (m/s)	Power* (kW)
1	0,01
2	0,02
3	0,03
4	0,06
5	0,12
6	0,22
7	0,35
8	0,52
9	0,74
10	1
11	1,3
12	1,7
13	2,2
14	2,8
15	

* electrical output, sea level, temp. 15°C

Power curve:



Ropatec S.p.a.

VAWT from 0,75 kW to 6 kW.

Contact name: Hannes Riegler
Address: Via Siemens 19
Telephone: +39 0471 568 180
Country : **Italy**

WRE.060 / 6 kW

Ropatec WRE.060 references

Site	Use	Country
Valley of Aoste	Water heating system	Italy
Hallau	On-grid system	Switzerland
Townsville	Demonstration unit	Australia

Technical information

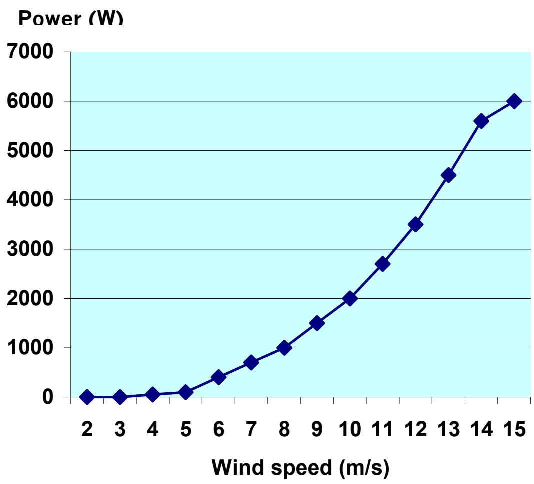
POWER		Unit
1) Rated power	6	kW
2) Rated wind speed	14	m/s
3) Cut-in wind speed	2	m/s
4) Cut-out wind speed	None	m/s
5) Maximum wind speed the turbine can withstand	> 150	Km/h
DIMENSIONS		
6) Rotor weight	750	kg
7) Rotor diameter	3,3	m
8) Rotor height (for VAWT only)	4,4	m
9) Swept area	14,52	m^2
10) Height of the mast	Not relevant	m
OTHER INFORMATION		
11) Maximum rpm	110	At rated wind speed
12) Gear box type	No gear box – direct driven	
13) Brake system	None	
14) Number of blades	2	
15) Blades material	Aluminium	
16) Output voltage	220	V
17) Minimum operation temperature	- 30	°C
18) Maximum operation temperature	+ 50	°C
19) Acoustic levels at a distance of 20 m ? at nacelle ? (wind = 5 m/s)	Not audible	DB
20) Lifetime	15/20	Years
21) Is the machine self-starting	Yes	
22) Use of an asynchronous generator	No	
23) Yaw control system	Independent of wind direction	
24) Upwind or downwind	Upwind turbine	

Calculated power curve

Wind speed (m/s)	Power*(kW)
1	0
2	0
3	0.05
4	0.10
5	0.25
6	0.40
7	0.70
8	1
9	1.5
10	2
11	2.7
12	3.5
13	4.5
14	5.6
15	6

* electrical output, sea level, temp. 15°C

Power curve:



Rugged renewables

VAWT – 0,4 kW

Contact name: Ken England
Address: Gear House, unit 3, Saltmeadows road, Gateshead, NE8 3 AH
Telephone: +44 (0) 191 478 51 11
Country : **England**

EMAT references

Site	Use	Country

0,4 kW

Technical information

POWER		Unit
1) Rated power	0,4	kW
2) Rated wind speed	12	m/s
3) Cut-in wind speed	~4,5	m/s
4) Cut-out wind speed	DK	m/s
5) Maximum wind speed the turbine can withstand	170	Km/h
DIMENSIONS		
6) Rotor weight	50	kg
7) Rotor diameter	0,8	m
8) Rotor height (for VAWT only)	2,5	m
9) Swept area	n/a	m^2
10) Height of the mast		m
OTHER INFORMATION		
11) Maximum rpm		At rated wind speed
12) Gear box type		
13) Brake system		
14) Number of blades		2
15) Blades material		Aluminium
16) Output voltage		V
17) Minimum operation temperature	- 40	°C
18) Maximum operation temperature	+ 100	°C
19) Acoustic levels at a distance of 20 m ? at nacelle ? (wind = 5 m/s)	Silent	DB
20) Lifetime	20 to 30	Years
21) Is the machine self-starting		Yes
22) Use of an asynchronous generator		No
23) Yaw control system		n/a
24) Upwind or downwind		n/a

Calculated power curve

Wind speed (m/s)	Power (kW)
1	
2	
2,5	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	

Power curve

Surface Power Technologies

HAWT – 0,46 kW

Contact name: John Quinn
Address: Castlebar, Co.Mayo
Telephone: +353 (0) 8795 45117
Country: **Ireland**

SP 460W / 0,46 kW

SP 460 – 0,46 kW references

Site	Use	Country
Dorset	Home Electricity	England
Cork	Home Electricity	Ireland
Orkney Island	Home Electricity	Scotland
Donegal	Home Electricity	Ireland

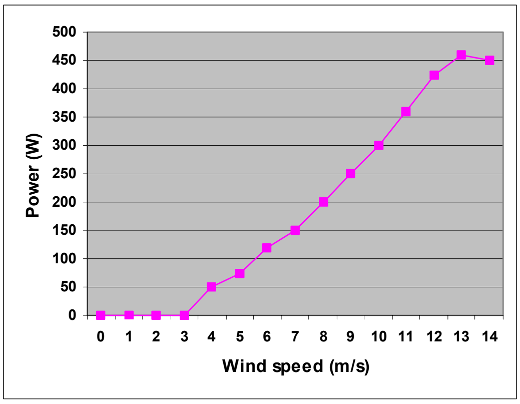
Technical information

POWER		Unit
1) Rated power	0,46	kW
2) Rated wind speed	12,5	m/s
3) Cut-in wind speed	3	m/s
4) Cut-out wind speed	None	m/s
5) Maximum wind speed the turbine can withstand	216	km/h
DIMENSIONS		
6) Nacelle and rotor weight	17	kg
7) Rotor diameter	1,4	m
8) Rotor height (for VAWT only)	-	m
9) Swept area	1,96	m^2
10) Height of the mast	7+	m
OTHER INFORMATION		
11) Maximum rpm	DK	At rated wind speed
12) Gear box type	None	
13) Brake system	Electromagnetic	
14) Number of blades	3	
15) Blades material	Composite fibre glass	
16) Output voltage	12	V
17) Minimum operation temperature	DK	°C
18) Maximum operation temperature	DK	°C
19) Acoustic levels at a distance of 20 m ? at nacelle ? (wind = 5 m/s)	Silent	DB
20) Lifetime	30	Years
21) Is the machine self-starting	Yes	
22) Use of an asynchronous generator	No	
23) Yaw control system	Wind vane	
24) Upwind or downwind	Upwind	

Calculated power curve

Wind speed (m/s)	Power (W)
1	0
2	0
3	0
4	50
5	75
6	120
7	150
8	200
9	250
10	300
11	360
12	425
13	460
14	450

Power curve:



Sviab

HAWT of 0,75 kW

Contact name: Lars Wikberg
Address: Vettershaga, 76010 Bergshamra
Telephone: +46 176 26 42 24
Country : **Sweden**

Sviab VK 240 references

Site	Use	Country
Orraids Ltd	Radio communication	Canada
Phuket	Test station	Thaïland
National Swedish Building Research	Test station	Antarctic
ASEA/ABB	Test station	New Zealand

Sviab VK 240 / 0,75 kW

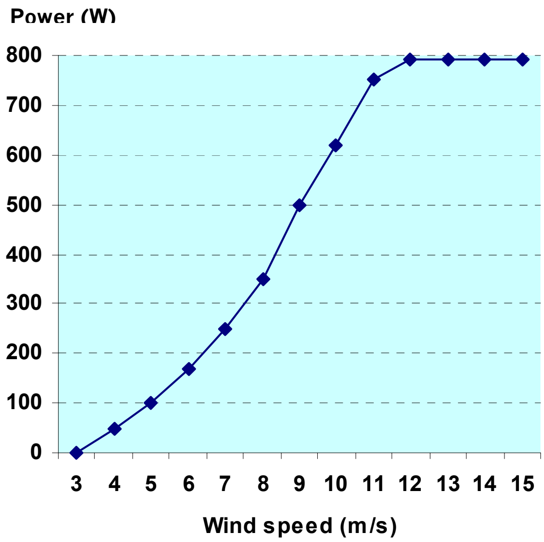
Technical information

POWER		Unit
1) Rated power	0,75	kW
2) Rated wind speed	12	m/s
3) Cut-in wind speed	2,5	m/s
4) Cut-out wind speed	None	m/s
5) Maximum wind speed the turbine can withstand	216	Km/h
DIMENSIONS		
6) Rotor weight	18	kg
7) Rotor diameter	2,4	m
8) Rotor height (for VAWT only)		m
9) Swept area	4,91	m^2
10) Height of the mast	7 / 11	m
OTHER INFORMATION		
11) Maximum rpm	270-1000	At rated wind speed
12) Gear box type	Answer not provided	
13) Brake system	Answer not provided	
14) Number of blades	3	
15) Blades material	Polyuréthane	
16) Output voltage	12 – 24	V
17) Minimum operation temperature	- 40	°C
18) Maximum operation temperature	+ 50	°C
19) Acoustic levels at a distance of 20 m ? at nacelle ? (wind = 5 m/s)	Answer not provided	DB
20) Lifetime	Answer not provided	Years
21) Is the machine self-starting	Yes	
22) Use of an asynchronous generator	No	
23) Yaw control system	Answer not provided	
24) Upwind or downwind	Answer not provided	

Calculated power curve

Wind speed (m/s)	Power (W)
1	0
2	0
3	0
4	50
5	100
6	170
7	250
8	350
9	500
10	620
11	750
12	790
13	790
14	790
15	790

Power curve:



TH Rijswijk, University of Applied Sciences

HAWT 5 – 5,5 kW

Contact name:	Eize de Vries
Address:	Lange Kleiweg 80, 2288 GK Rijswijk
Telephone:	+31- 70 3401516
Country :	Netherlands

No references

Site	Use	Country

TH Rijswijk / 5 kW

Technical information

POWER		Unit
1) Rated power	5	kW
2) Rated wind speed	10,5	m/s
3) Cut-in wind speed	2,75	m/s
4) Cut-out wind speed	>10,5	m/s
5) Maximum wind speed the turbine can withstand	Not available	Km/h
DIMENSIONS		
6) Rotor weight	175	kg
7) Rotor diameter	5	m
8) Rotor height (for VAWT only)	---	m
9) Swept area	19,6	m^2
10) Height of the mast	6 – 18	m
OTHER INFORMATION		
11) Maximum rpm	Not available	At rated wind speed
12) Gear box type	No gear box	
13) Brake system	Not available	
14) Number of blades	3	
15) Blades material	Glass fibre reinforced epoxy composite	
16) Output voltage	400	V
17) Minimum operation temperature	- 20	°C
18) Maximum operation temperature	+ 50	°C
19) Acoustic levels at a distance of 20 m ? at nacelle ? (wind = 5 m/s)	Not available	DB
20) Lifetime	20	Years
21) Is the machine self-starting	Yes	
22) Use of an asynchronous generator	Yes	
23) Yaw control system	Wind vane	
24) Upwind or downwind	Upwind	

Calculated power curve n.a.

Wind speed (m/s)	Power* (W)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	

Power curve

Travere Industries

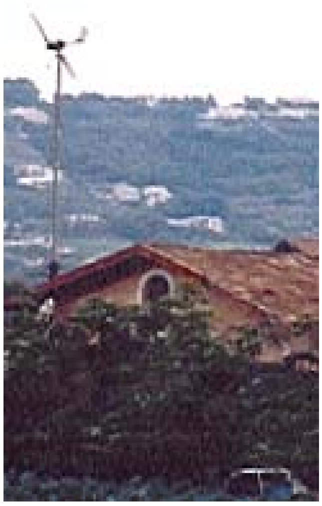
HAWT from 0,9 kW to 50 kW.

Contact name:	Adrien Orieux
Address:	27 bis imp. Pichon, 83 140 Six Fours
Telephone:	+33 4 94 10 10 29
Country :	**France**

Travere 0,9 kW references

Site	Use	Country
Corsica	Radio station	France
Guadeloupe	Dwelling	Overseas Departments
South of France	Dwelling	France
	Dwelling	Morocco

TI/2.4/0.9 (*0.9Kw/h*)



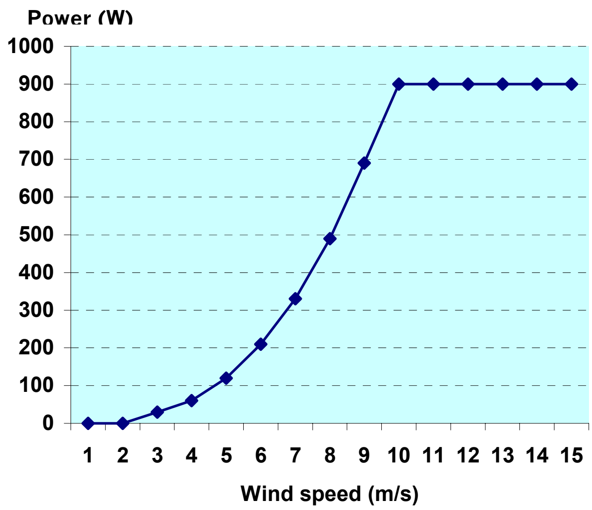
Technical information

POWER		Unit
1) Rated power	0.9	kW
2) Rated wind speed	10	m/s
3) Cut-in wind speed	2.3	m/s
4) Cut-out wind speed	60	m/s
5) Maximum wind speed the turbine can withstand	216	Km/h
DIMENSIONS		
6) Rotor weight (+ generator)	50	kg
7) Rotor diameter	2.4	m
8) Rotor height (for VAWT only)	0.2	m
9) Swept area	4.52	m^2
10) Height of the mast	12	m
OTHER INFORMATION		
11) Maximum rpm	750	At rated wind speed
12) Gear box type	None	
13) Brake system	Electronic	
14) Number of blades	2	
15) Blades material	Carbon composite	
16) Output voltage	55	V
17) Minimum operation temperature	-20	°C
18) Maximum operation temperature	80	°C
19) Acoustic levels at a distance of 20 m ? at nacelle ? (wind = 5 m/s)	<40	DB
20) Lifetime	25	Years
21) Is the machine self-starting	Yes	
22) Use of an asynchronous generator	Yes	
23) Yaw control system	*"Variable stall"* commanded centrifugal system / Rudder	
24) Upwind or downwind	Upwind	

Calculated power curve

Wind speed (m/s)	Power (kW)
1	0
2	0
3	0,03
4	0.60
5	0,12
6	0,21
7	0,33
8	0,49
9	0,69
10	0,90
11	0,90
12	0,90
13	0,90
14	0,90
15	0,90
Altitude 300 m, Tower height = 10 m Shear coeff = 0,11 ; Weibull K = 2 Turbulence factor = 10 %	

Power curve:



Travere Industries

HAWT from 0,9 kW to 50 kW.

Contact name: Adrien Orieux
Address: 27 bis imp. Pichon, 83 140 Six Fours
Telephone: +33 4 94 10 10 29
Country : **France**

Travere 1.6 kW references

Site	Use	Country
Ciotat	University	France
	University	India
South of France	Dwellings + pumping	France
South Pacific	Dwellings	Overseas Departments

TI/3.2/1.6 (*1.6Kw/h*)

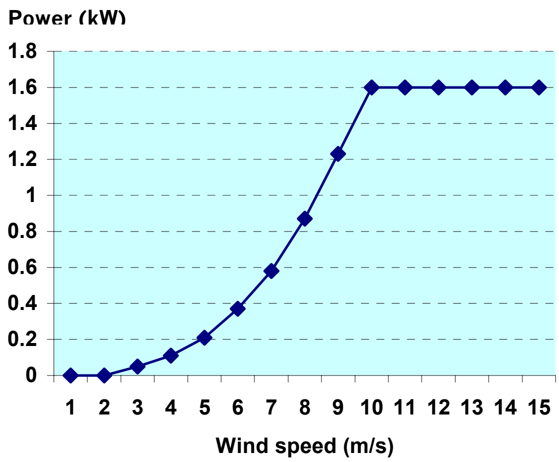
Technical information

POWER		Unit
1) Rated power	1.6	kW
2) Rated wind speed	10	m/s
3) Cut-in wind speed	2.5	m/s
4) Cut-out wind speed	60	m/s
5) Maximum wind speed the turbine can withstand	216	Km/h
DIMENSIONS		
6) Rotor weight (+ generator)	60	kg
7) Rotor diameter	3.2	m
8) Rotor height (for VAWT only)	0.3	m
9) Swept area	8.04	m^2
10) Height of the mast	12	m
OTHER INFORMATION		
11) Maximum rpm	600	At rated wind speed
12) Gear box type		No
13) Brake system		Electronic
14) Number of blades		2
15) Blades material		Carbon composit
16) Output voltage	220 to 380	V
17) Minimum operation temperature	-20	°C
18) Maximum operation temperature	80	°C
19) Acoustic levels at a distance of 20 m ? at nacelle ? (wind = 5 m/s)	<40	DB
20) Lifetime	25	Years
21) Is the machine self-starting		Yes
22) Use of an asynchronous generator		Yes
23) Yaw control system		*"Variable stall"* commanded centrifugal system / Rudder
24) Upwind or downwind		Upwind

Calculated power curve

Wind speed (m/s)	Power (kW)
1	0
2	0
3	0,05
4	0,11
5	0,21
6	0,37
7	0,58
8	0,87
9	1,23
10	1,60
11	1,60
12	1,60
13	1,60
14	1,60
15	1,60
Altitude 300 m ; Tower height = 10 m	
Shear coeff = 0,11 ; Weibull K = 2	
Turbulence factor = 10 %	

Power curve:



Travere Industries

HAWT from 0,9 kW to 50 kW.

Contact name:	Adrien Orieux
Address:	27 bis imp. Pichon, 83 140 Six Fours
Telephone:	+33 4 94 10 10 29
Country :	**France**

Travere 3 kW references

Site	Use	Country
North	Grid connection	France
	Direct heating	Turkey
North	Grid connection	France
North	Grid connection	France

TI/3.6/3 *(3Kw/h)*

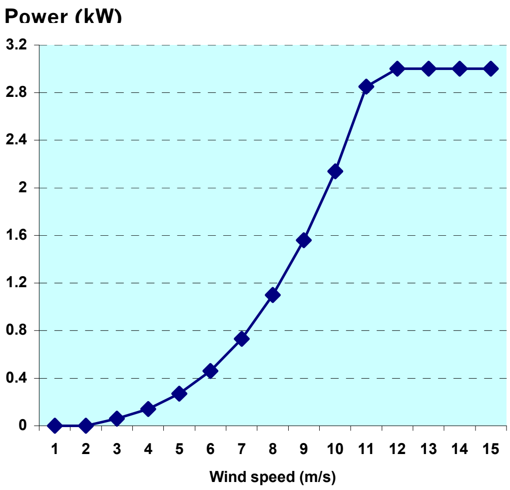
Technical information

POWER		Unit
1) Rated power	3	kW
2) Rated wind speed	12	m/s
3) Cut-in wind speed	2.8	m/s
4) Cut-out wind speed	60	m/s
5) Maximum wind speed the turbine can withstand	216	Km/h
DIMENSIONS		
6) Rotor weight (+ generator)	60	kg
7) Rotor diameter	3.6	m
8) Rotor height (for VAWT only)	0.6	m
9) Swept area	10.18	m^2
10) Height of the mast	12	m
OTHER INFORMATION		
11) Maximum rpm	550	At rated wind speed
12) Gear box type		No
13) Brake system		Electronic
14) Number of blades		2
15) Blades material		Carbon composit
16) Output voltage	220 to 380	V
17) Minimum operation temperature	-20	°C
18) Maximum operation temperature	80	°C
19) Acoustic levels at a distance of 20 m ? at nacelle ? (wind = 5 m/s)	<40	DB
20) Lifetime	25	Years
21) Is the machine self-starting		Yes
22) Use of an asynchronous generator		Yes
23) Yaw control system		*"Variable stall"* commanded centrifugal system / Rudder
24) Upwind or downwind		Upwind

Calculated power curve

Wind speed (m/s)	Power (kW)
1	0
2	0
3	0.06
4	0.14
5	0.27
6	0.46
7	0.73
8	1.10
9	1.56
10	2.14
11	2.85
12	3.00
13	3.00
14	3.00
15	3.00
Altitude = 300 m ; Tower height = 10 m	
Shear coeff = 0,11 ; Weibull K = 2	
Turbulence factor = 10 %	

Power curve:



Travere Industries

HAWT from 0,9 kW to 50 kW.

Contact name: Adrien Orieux
Address: 27 bis imp. Pichon, 83 140 Six Fours
Telephone: +33 4 94 10 10 29
Country : **France**

TI/6/2.1 *(2.1Kw/h)*

Travere 2.1 kW references

Site	Use	Country
Off shore	Platform Total Energie	Nigeria
Center	Habitation	France
South	Pumping + Dwelling	France
Center	Grid connexion	France

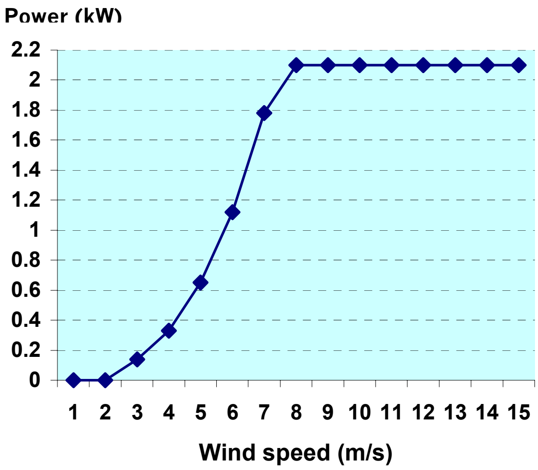
Technical information

POWER		Unit
1) Rated power	2.1	kW
2) Rated wind speed	8	m/s
3) Cut-in wind speed	2.5	m/s
4) Cut-out wind speed	60	m/s
5) Maximum wind speed the turbine can withstand	216	Km/h
DIMENSIONS		
6) Rotor weight (+ generator)	60	kg
7) Rotor diameter	6	m
8) Rotor height (for VAWT only)	0.9	m
9) Swept area	28.27	m^2
10) Height of the mast	12	m
OTHER INFORMATION		
11) Maximum rpm	440	At rated wind speed
12) Gear box type	No	
13) Brake system	Electronic	
14) Number of blades	2	
15) Blades material	Carbon composite	
16) Output voltage	220 to 380	V
17) Minimum operation temperature	-20	°C
18) Maximum operation temperature	80	°C
19) Acoustic levels at a distance of 20 m ? at nacelle ? (wind = 5 m/s)	<40	DB
20) Lifetime	25	Years
21) Is the machine self-starting	Yes	
22) Use of an asynchronous generator	Yes	
23) Yaw control system	*"Variable stall"* commanded centrifugal system / Rudder	
24) Upwind or downwind	Upwind	

Calculated power curve

Wind speed (m/s)	Power (kW)
1	0
2	0
3	0,14
4	0,33
5	0,65
6	1,12
7	1,78
8	2,10
9	2,10
10	2,10
11	2,10
12	2,10
13	2,10
14	2,10
15	2,10
Altitude = 300 m ; Tower height = 10 m	
Shear coeff = 0,11 ; Weibull K = 2	
Turbulence factor = 10 %	

Power curve:



Travere Industries

HAWT from 0,9 kW to 50 kW.

Contact name:	Adrien Orieux
Address:	27 bis imp. Pichon, 83 140 Six Fours
Telephone:	+33 4 94 10 10 29
Country :	**France**

Travere 5.5 kW references

Site	Use	Country
Aude	EDF-GDF	France
Pacific	Dwelling	Overseas Departments
	CETMEF/ Ligth House	France
South/Addrar	Pumping	Algéria

TI/6/5.5 *(5.5Kw/h)*

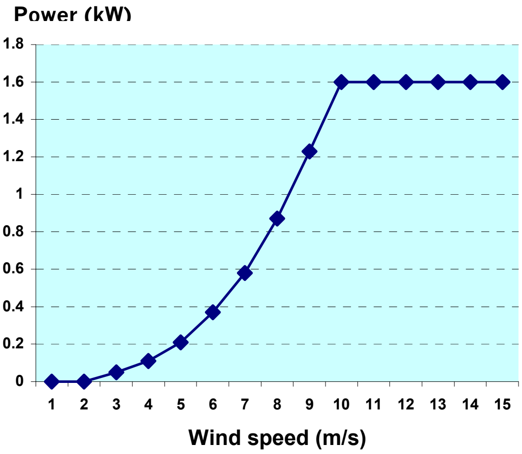
Technical information

POWER		Unit
1) Rated power	5.5	kW
2) Rated wind speed	10	m/s
3) Cut-in wind speed	3	m/s
4) Cut-out wind speed	60	m/s
5) Maximum wind speed the turbine can withstand	216	Km/h
DIMENSIONS		
6) Rotor weight (+ generator)	60	kg
7) Rotor diameter	6	m
8) Rotor height (for VAWT only)	0.9	m
9) Swept area	28.27	m^2
10) Height of the mast	12	m
OTHER INFORMATION		
11) Maximum rpm	240	At rated wind speed
12) Gear box type		No
13) Brake system		Electronic
14) Number of blades		2
15) Blades material		Carbon composite
16) Output voltage	220 to 380	V
17) Minimum operation temperature	-30	°C
18) Maximum operation temperature	80	°C
19) Acoustic levels at a distance of 20 m ? at nacelle ? (wind = 5 m/s)	<40	DB
20) Lifetime	25	Years
21) Is the machine self-starting		Yes
22) Use of an asynchronous generator		Yes
23) Yaw control system		*"Variable stall"* commanded centrifugal system / Rudder
24) Upwind or downwind		Upwind

Calculated power curve

Wind speed (m/s)	Power (W)
1	0
2	0
3	0.16
4	0.38
5	0.74
6	1.29
7	2.04
8	3.05
9	4.34
10	5.50
11	5.50
12	5.50
13	5.50
14	5.50
15	5.50
Altitude = 300 m ; Tower height = 10 m ; Shear coeff = 0,11 ; Weibull K = 2 ; Turbulence factor = 10 %.	

Power curve:



Tulipower

HAWT 2,5 kW

Contact name: Hans Duivenvoorden
Address: Van der Palmkade 44, 1051 RE Amsterdam
Telephone: +31 – 6 19618369
Country : Netherlands

Tulipower references

Site	Use	Country
Boxtel	Environmental Information Centre	Netherlands
Elst	Installer company, demonstration	Netherlands
Zevenbergen	Turbine distributor, demonstration	Netherlands

Tulipower / 2,5 kW

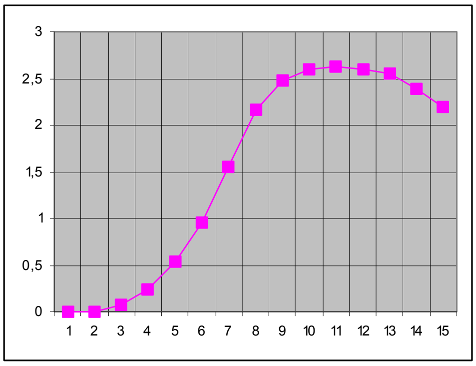
Technical information

POWER		Unit
1) Rated power	2,5	KW
2) Rated wind speed	10	m/s
3) Cut-in wind speed	3	m/s
4) Cut-out wind speed	18	m/s
5) Maximum wind speed the turbine can withstand	42,5	m/s
DIMENSIONS		
6) Total weight	200	Kg
7) Rotor diameter	5	M
8) Rotor height (for VAWT only)	---	M
9) Swept area	19,6	m^2
10) Height of the mast	12,5	M
OTHER INFORMATION		
11) Maximum rpm	140	At rated wind speed
12) Gear box type	No gear box	
13) Brake system	spring powered electro magnetic brake	
14) Number of blades	3	
15) Blades material	Composite fibre glass	
16) Output voltage	230	V
17) Minimum operation temperature	- 20	°C
18) Maximum operation temperature	+ 40	°C
19) Acoustic levels at a distance of 20 m ? (wind = 5 m/s)	< 35	DB
20) Lifetime	15	Years
21) Is the machine self-starting	Yes	
22) Use of an asynchronous generator	Yes	
23) Yaw control system	Independent of wind direction	
24) Upwind or downwind	Upwind	

Calculated power curve

Wind speed (m/s)	Power* (W)
1	0
2	0
3	68
4	243
5	530
6	958
7	1553
8	2159
9	2474
10	2595
11	2625
12	2598
13	2552
14	2382
15	2192

Power curve



Turby B.V.

VAWT 2,5 kW

Contact name:	Dick Sidler
Address:	Heuvelenweg 18, 7241 HZ Lochem
Telephone:	+31 - 6-55822169
Country :	Netherlands

Turby 2,5 kW references

Site	Use	Country
Amsterdam	Proof public building (former school)	Netherlands
Tlburg	Roof flat building	Netherlands
Den Haag	Roof town hall	Netherlands
Delft	Technical University	Netherlands

Turby 2,5 kW

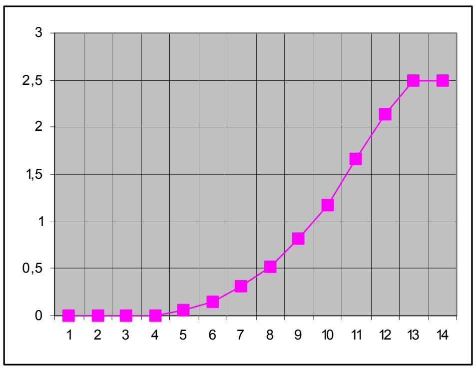
Technical information

POWER		Unit
1) Rated power	2,5	kW
2) Rated wind speed	14	m/s
3) Cut-in wind speed	4	m/s
4) Cut-out wind speed	14	m/s
5) Maximum wind speed the turbine can withstand	55	m/s
DIMENSIONS		
6) Rotor weight	135	kg
7) Rotor diameter	1,99	m
8) Rotor height (for VAWT only)	2,88	m
9) Swept area	5,3	m^2
10) Height of the mast	6 – 7,5	m
OTHER INFORMATION		
11) Maximum rpm	400	At rated wind speed
12) Gear box type	No gears	
13) Brake system	Electrical brake system	
14) Number of blades	3	
15) Blades material	Carbon epoxy composite	
16) Output voltage	230	V
17) Minimum operation temperature	- 20	°C
18) Maximum operation temperature	+ 40	°C
19) Acoustic levels at a distance of 20 m ? wind = 10 m/s)	45	DB
20) Lifetime	20	Years
21) Is the machine self-starting	No	
22) Use of an asynchronous generator	No	
23) Yaw control system	Independent	
24) Upwind or downwind	Both	

Calculated power curve

Wind speed (m/s)	Power (W)
1	0
2	0
3	0
4	6
5	56
6	155
7	310
8	527
9	812
10	1171
11	1659
12	2136
13	2500
14	2500
15	--

Power curve



Venturi Wind b.v.(i.o.)

VAWT from 0,11 kW to 0,50 k W

Contact name: D.P. Elzinga
Address: Stationsweg 18–7429 AD Deventer-Colmschate
Telephone: +31 0570-510246
Country : Netherlands

Venturi 110-500 references

Site	Use	Country
Waalwijk	Test battery charging	Netherlands
Beek & Donk	Test battery charging	Netherlands
Deventer	Test battery charging + grid con.	Netherlands

Venturi 110-500

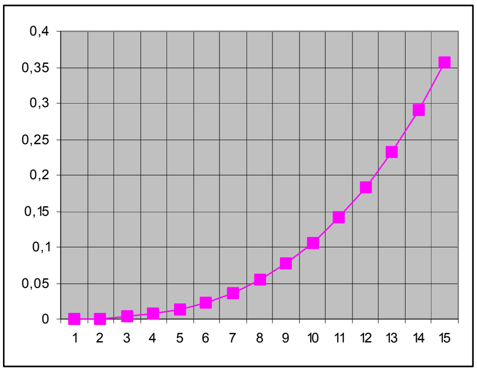
Technical information

POWER		Unit
1) Rated power	0,5	kW
2) Rated wind speed	17	m/s
3) Cut-in wind speed	2	m/s
4) Cut-out wind speed	None	m/s
5) Maximum wind speed the turbine can withstand	>145	km/h
DIMENSIONS		
6) Rotor weight	30	Kg
7) Rotor diameter	1,1	m
8) Rotor height (for VAWT only)	1,3	m
9) Swept area	1	m^2
10) Height of the mast	11	m
OTHER INFORMATION		
11) Maximum rpm	803	At rated wind speed
12) Gear box type	None	
13) Brake system	Electrical	
14) Number of blades	6	
15) Blades material	Flat blade polyester	
16) Output voltage	100	V
17) Minimum operation temperature	-25	-°C
18) Maximum operation temperature	50	°C
19) Acoustic levels at a distance of 20 m ? at nacelle ? (wind = 5 m/s)	Not audible	DB
20) Lifetime	15	Years
21) Is the machine self-starting	Yes	
22) Use of an asynchronous generator	No	
23) Yaw control system	Vane	
24) Upwind or downwind	Upwind	

Calculated power curve

Wind speed (m/s)	Power* (W)
1	0
2	0,7
3	3
4	7
5	13
6	23
7	36
8	54
9	77
10	106
11	141
12	183
13	232
14	290
15	357

Power curve



VR & Tech

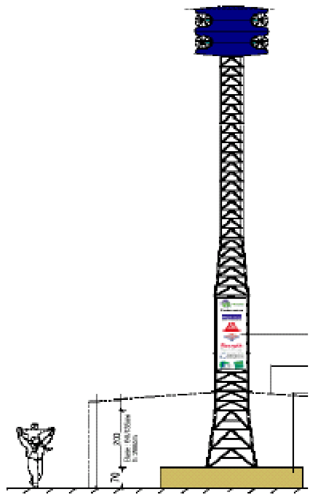
VAWT from 2,5 kW to 100 kW.

Contact name: Alain Van Ranst
Address: Rue Trou du Sart 5 C-D 5 380 Fernelmont
Telephone: +32 (0) 81 22 42 14
Country : **Belgium**

VR & Tech Telecom tower / 2 m references

Site	Use	Country
Namur	Industrial use in the field of telecom	Belgium

Telecom Tower / 2 m



Technical information

POWER		Unit
1) Rated power	Minimum 2,5*	kW
2) Rated wind speed	8	m/s
3) Cut-in wind speed	4	m/s
4) Cut-out wind speed	None	m/s
5) Maximum wind speed the turbine can withstand	No limit	Km/h
DIMENSIONS		
6) Rotor weight (+ generator)	Variable *	kg
7) Rotor diameter	2	m
8) Rotor height (for VAWT only)	~2 or 3	m
9) Swept area	Variable *	m^2
10) Height of the mast	Not relevant	m
OTHER INFORMATION		
11) Maximum rpm	800	At rated wind speed
12) Gear box type	Direct drive	
13) Brake system	Electronic constant braking	
14) Number of blades	9	
15) Blades material	Fibre glass and Epoxy	
16) Output voltage	400	V
17) Minimum operation temperature	n.a	°C
18) Maximum operation temperature	100	°C
19) Acoustic levels at a distance of 20 m ? at nacelle ? (wind = 5 m/s)	40	DB
20) Lifetime	15	Years
21) Is the machine self-starting	Yes	
22) Use of an asynchronous generator	No	
23) Yaw control system	None	
24) Upwind or downwind	Not applicable	

Calculated power curve

Wind speed (m/s)	Power (W)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	

Each project is different because the manufacturer stick several TARP to create a single WARP tower and integrate a mix of renewable energies (solar, CHP) in the same WARP tower.

Power curve :

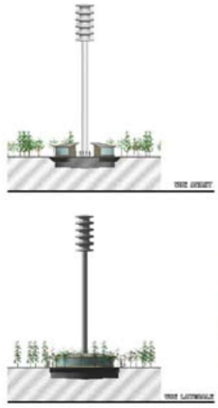
* The rated power and the rotor weight vary accordingly with the number of stacked “TARP” modules vertically piled along the tower. 1 TARP corresponds to ~2,5 kW and a same tower can be designed with more than 10 TARPS depending on the energy needs.

VR & Tech

VAWT from 2,5 kW to 100 kW.

Contact name: Alain Van Ranst
Address: Rue Trou du Sart 5 C-D 5 380 Fernelmont
Telephone: +32 (0) 81 22 42 14
Country : **Belgium**

House tower / 4 m



VR & Tech House tower/ 4 m references

Site	Use	Country
Bastogne	Training centre in renewable energies	Belgium

Technical information

POWER		Unit
1) Rated power	Minimum 10*	kW
2) Rated wind speed	8	m/s
3) Cut-in wind speed	4	m/s
4) Cut-out wind speed	None	m/s
5) Maximum wind speed the turbine can withstand	No limit	Km/h
DIMENSIONS		
6) Rotor weight (+ generator)	Variable *	kg
7) Rotor diameter	4	m
8) Rotor height (for VAWT only)	~4 or 5	m
9) Swept area	Variable	m^2
10) Height of the mast		m
OTHER INFORMATION		
11) Maximum rpm	800	At rated wind speed
12) Gear box type		Direct drive
13) Brake system		Electronic constant braking
14) Number of blades		9
15) Blades material		Fibre glass and Epoxy
16) Output voltage	400	V
17) Minimum operation temperature	n.a	°C
18) Maximum operation temperature	100	°C
19) Acoustic levels at a distance of 20 m ? at nacelle ? (wind = 5 m/s)	40	DB
20) Lifetime	15	Years
21) Is the machine self-starting		Yes
22) Use of an asynchronous generator		No
23) Yaw control system		None
24) Upwind or downwind		Not applicable

Calculated power curve

Wind speed (m/s)	Power (W)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	

Each project is different because the manufacturer stick several TARP to create a single WARP tower and integrate a mix of renewable energies (solar, CHP) in the same WARP tower.

Power curve:

* The rated power and the rotor weight vary accordingly with the number of stacked "TARP" modules vertically piled along the tower.

VR & Tech

VAWT from 2,5 kW to 100 kW.

Contact name: Alain Van Ranst
Address: Rue Trou du Sart 5 C-D 5 380 Fernelmont
Telephone: +32 (0) 81 22 42 14
Country : **Belgium**

VR & Tech House tower/6 m references

Site	Use	Country
Andenne	Food industry (Interagri)	Belgium

House tower / 6 m

Technical information

POWER		Unit
1) Rated power	Minimum 25*	kW
2) Rated wind speed	8	m/s
3) Cut-in wind speed	4	m/s
4) Cut-out wind speed	None	m/s
5) Maximum wind speed the turbine can withstand	No limit	Km/h
DIMENSIONS		
6) Rotor weight (+ generator)	Variable*	kg
7) Rotor diameter	6	m
8) Rotor height (for VAWT only)	Minimum 6	m
9) Swept area	Variable*	m^2
10) Height of the mast		m
OTHER INFORMATION		
11) Maximum rpm	800	At rated wind speed
12) Gear box type	Direct drive	
13) Brake system	Electronic constant braking	
14) Number of blades	9	
15) Blades material	Fibre glass and epoxy	
16) Output voltage	400	V
17) Minimum operation temperature	n.a	°C
18) Maximum operation temperature	100	°C
19) Acoustic levels at a distance of 20 m ? at nacelle ? (wind = 5 m/s)	40	DB
20) Lifetime	15	Years
21) Is the machine self-starting	Yes	
22) Use of an asynchronous generator	No	
23) Yaw control system	None	
24) Upwind or downwind	Not applicable	

Calculated power curve

Wind speed (m/s)	Power (W)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
Each project is different because the manufacturer stick several TARP to create a single WARP tower and integrate a mix of renewable energies (solar, CHP) in the same WARP tower.	

Power curve :

* The rated power and the rotor weight vary accordingly with the number of stacked "TARP" modules vertically piled along the tower.

Wind Energy Solutions (WES)

HAWT from 2 kW to 250 kW

Contact name: Marcel Kloesmeijer
Address: De Weel, 1736 KB Zijdewind
Telephone: +31 – 226 425150
Country : Netherlands

WES⁵ Tulipo references

Site	Use	Country
Elst	Installer company, demonstration	Netherlands
Zevenbergen	Turbine distributor, demonstration	Netherlands

WES⁵ Tulipo / 2,5 kW

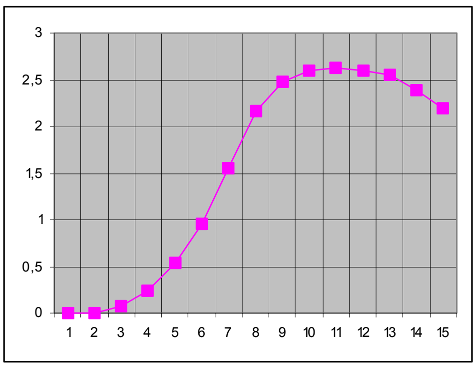
Technical information

POWER		Unit
1) Rated power	2,5	kW
2) Rated wind speed	8,5	m/s
3) Cut-in wind speed	3	m/s
4) Cut-out wind speed	20	m/s
5) Maximum wind speed the turbine can withstand	35	m/s
DIMENSIONS		
6) Total weight	200	kg
7) Rotor diameter	5	m
8) Rotor height (for VAWT only)	---	m
9) Swept area	19,6	m^2
10) Height of the mast	6 or 12	m
OTHER INFORMATION		
11) Maximum rpm	140	At rated wind speed
12) Gear box type	No gear box	
13) Brake system	spring powered electro magnetic brake	
14) Number of blades	3	
15) Blades material	Glass reinforced epoxy	
16) Output voltage	400	V
17) Minimum operation temperature	- 20	°C
18) Maximum operation temperature	+ 40	°C
19) Acoustic levels at a distance of 20 m ? (wind = 5 m/s)	< 35	DB
20) Lifetime	20	Years
21) Is the machine self-starting	Y	
22) Use of an asynchronous generator	Y	
23) Yaw control system	Active yaw control	
24) Upwind or downwind	Upwind	

Calculated power curve

Wind speed (m/s)	Power* (W)
1	0
2	0
3	68
4	243
5	530
6	958
7	1553
8	2159
9	2474
10	2595
11	2625
12	2598
13	2552
14	2382
15	2192

Power curve



Winddam

VAWT – 2 kW

AWT(1)2000/ 2 kW

Contact name:	Julie Trevithick
Address:	1 Riverside House, Heron Way, Truro,TR1 2 XN
Telephone:	+44 (0) 180 387 39 56
Country:	**United Kingdom**

Winddam 2 kW references

Site	Use	Country
Moss Side Industrial Estate	Testing	UK

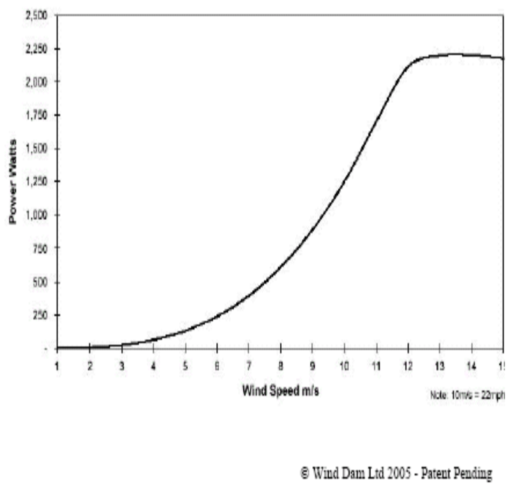
Technical information

POWER		Unit
1) Rated power	2	kW
2) Rated wind speed	12	m/s
3) Cut-in wind speed	2	m/s
4) Cut-out wind speed	None	m/s
5) Maximum wind speed the turbine can withstand	234	Km/h
DIMENSIONS		
6) Nacelle and Rotor weight	DK	Kg
7) Rotor diameter	2.56	m
8) Rotor height (for VAWT only)	2	m
9) Swept area	5.12	m^2
10) Height of the mast	DK	m
OTHER INFORMATION		
11) Maximum rpm	108	At rated wind speed
12) Gear box type	None	
13) Brake system	Mechanical	
14) Number of blades	5	
15) Blades material	Resin Composite	
16) Output voltage	12/24/48/120/ 240	V
17) Minimum operation temperature	DK	°C
18) Maximum operation temperature	DK	°C
19) Acoustic levels at a distance of 20 m ? at nacelle ? (wind = 5 m/s)	Silent	DB
20) Lifetime	25+	Years
21) Is the machine self-starting	DK	
22) Use of an asynchronous generator	No	
23) Yaw control system	N/A	
24) Upwind or downwind	N/A	

Calculated power curve

Wind speed (m/s)	Power (W)
1	0
2	0
3	35
4	75
5	110
6	250
7	400
8	600
9	850
10	1250
11	1750
12	2100
13	2200
14	2200
15	2150

Power curve:



Winddam

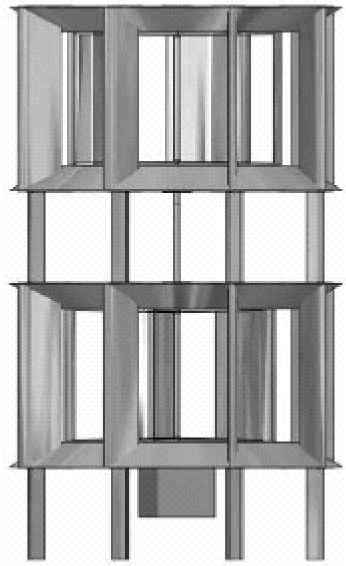
VAWT – 4 kW

Contact name:	Julie Trevithick
Address:	1 Riverside House, Heron Way, Truro,TR1 2 XN
Telephone:	+44 (0) 180 387 39 56
Country:	**United Kingdom**

Winddam 2 kW references

Site	Use	Country
DK		

AWT(2)2x2000/ 4 kW



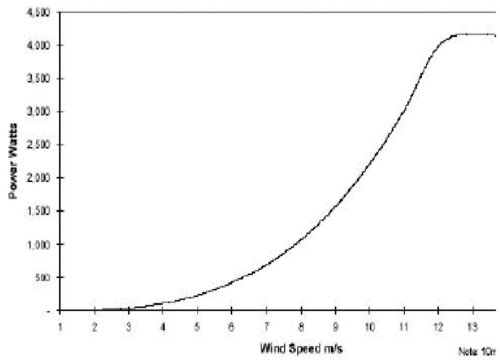
Technical information

POWER		Unit
1) Rated power	4	kW
2) Rated wind speed	12	m/s
3) Cut-in wind speed	2.5	m/s
4) Cut-out wind speed	None	m/s
5) Maximum wind speed the turbine can withstand	234	Km/h
DIMENSIONS		
6) Nacelle and Rotor weight	DK	Kg
7) Rotor diameter	2.56	m
8) Rotor height (for VAWT only)	2 x 2	m
9) Swept area	2 x 5.12	m^2
10) Height of the mast	DK	m
OTHER INFORMATION		
11) Maximum rpm	200	At rated wind speed
12) Gear box type	None	
13) Brake system	Mechanical	
14) Number of blades	2 x 3	
15) Blades material	Resin Composite	
16) Output voltage	12/24/48/120/240	V
17) Minimum operation temperature	DK	°C
18) Maximum operation temperature	DK	°C
19) Acoustic levels at a distance of 20 m ? at nacelle ? (wind = 5 m/s)	Whisper	DB
20) Lifetime	25+	Years
21) Is the machine self-starting	DK	
22) Use of an asynchronous generator	No	
23) Yaw control system	N/A	
24) Upwind or downwind	N/A	

Calculated power curve

Wind speed (m/s)	Power (W)
1	0
2	0
3	Tiny
4	100
5	205
6	400
7	665
8	1000
9	1540
10	2205
11	3000
12	4000
13	4150
14	4110
15	4000

Power curve:



Windsave

HAWT – 1 kW

Contact name: Graham Reed
Address: 27 Woodside place, Glasgow G3 7QL
Telephone: +44 (0) 141 353 68 41
Country : **United Kingdom**

WS 1000 1 kW references

Site	Use	Country
Burbank		England
Livingston		England
Teesside		England
Glasgow		Scotland

WS 1000/ 1 kW

Technical information

POWER		Unit
1) Rated power	1	KW
2) Rated wind speed	12	m/s
3) Cut-in wind speed	2,9	m/s
4) Cut-out wind speed	15	m/s
5) Maximum wind speed the turbine can withstand	216	Km/h
DIMENSIONS		
6) Rotor weight		Kg
7) Rotor diameter	1,75	m
8) Rotor height (for VAWT only)		m
9) Swept area	2,41	m^2
10) Height of the mast		m
OTHER INFORMATION		
11) Maximum rpm		At rated wind speed
12) Gear box type		
13) Brake system		
14) Number of blades	3	
15) Blades material	Polyamide Glass Reinforced	
16) Output voltage	240	V
17) Minimum operation temperature	Not tested	°C
18) Maximum operation temperature	Not tested	°C
19) Acoustic levels at a distance of 20 m ? at nacelle ? (wind = 5 m/s)	30 DB at 4m/s	DB
20) Lifetime	10	Years
21) Is the machine self-starting	Yes	
22) Use of an asynchronous generator	No	
23) Yaw control system	Wind vane	
24) Upwind or downwind	Upwind	

Calculated power curve

Wind speed (m/s)	Power (W)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	1 000
13	
14	
15	

Power curve:

WindWall B.V.

VAWT from 2,9 kW to 60 kW.

Contact name: Rob Roelofs
Address: De Eiken 5D, 7491 HP Delden
Telephone: +31 – 74 2434885
Country : Netherlands

WW2000 / 2,9 kW

WW2000 references

Site	Use	Country
Zwolle	Roof high school	Netherlands
Den Haag	Office building (Siemens)	Netherlands
Den Haag	Office building (government)	Netherlands
Rotterdam	Erasmus MC (University Medical Centre)	Netherlands

Technical information

POWER		Unit
1) Rated power	2,9	kW
2) Rated wind speed	10,5	m/s
3) Cut-in wind speed	4	m/s
4) Cut-out wind speed	20	m/s
5) Maximum wind speed the turbine can withstand	55	m/s
DIMENSIONS		
6) Rotor weight	3000	kg
7) Rotor diameter	2	m
8) Rotor height (for VAWT only)	5 (horizontal) – 15 (vertical)	m
9) Swept area	10	m^2
10) Height of the mast	n.a.	m
OTHER INFORMATION		
11) Maximum rpm	500	At rated wind speed
12) Gear box type	No gears	
13) Brake system	Electrical + disc brake system	
14) Number of blades	6	
15) Blades material	Aluminium	
16) Output voltage	400	V
17) Minimum operation temperature	- 20	°C
18) Maximum operation temperature	+ 40	°C
19) Acoustic levels at nacelle ? (wind = 5 m/s)	74	DB
20) Lifetime	20	Years
21) Is the machine self-starting	Yes	
22) Use of an asynchronous generator	Yes	
23) Yaw control system	Independent	
24) Upwind or downwind	Downwind	

Calculated power curve

Wind speed (m/s)	Power* (W)
1	0
2	0
3	0
4	1%
5	
6	
7	
8	50%
9	
10	100%
11	100%
12	100%
13	100%
14	100%
15	100%

Power curve

XCO2

VAWT – 6 kW

Contact name: Richard Cochrane
Address: 1-5 Offord Street, London, N1 1DH
Telephone: +44 (0) 207 700 1000
Country : **United Kingdom**

EMAT references

Site	Use	Country
Southwark Bridge Rd, London	Pilot installation – due 12 / 2005	UK
Temple Meads Roundabout, Bristol	Pilot installation – due 1 / 2006	UK

XCO2 / 6 kW

Technical information

POWER		Unit
1) Rated power	6	kW
2) Rated wind speed	~ 12,5	m/s
3) Cut-in wind speed	4,5	m/s
4) Cut-out wind speed	16	m/s
5) Maximum wind speed the turbine can withstand	DK	Km/h
DIMENSIONS		
6) Nacelle and rotor weight	DK	kg
7) Rotor diameter	3,1	m
8) Rotor height (for VAWT only)	5	m
9) Swept area	15,5	m^2
10) Height of the mast	5-10	m
OTHER INFORMATION		
11) Maximum rpm	DK	At rated wind speed
12) Gear box type	None	
13) Brake system	DK	
14) Number of blades	3	
15) Blades material	Carbon fibre	
16) Output voltage	48 dc or 240 ac	V
17) Minimum operation temperature	-40	°C
18) Maximum operation temperature	100	°C
19) Acoustic levels at a distance of 20 m? at nacelle ? (wind = 5 m/s)	Silent	DB
20) Lifetime	20	Years
21) Is the machine self-starting	Yes	
22) Use of an asynchronous generator	No	
23) Yaw control system	n/a	
24) Upwind or downwind	n/a	

Calculated power curve

Not available

Wind speed (m/s)	Power (kW)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	

Power curve