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Gross Annual Energy Production for Wind Turbines in Sweden as a Function of Wind Speed from the MIUU Mesoscale Atmospheric Model

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Abstract

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ABSTRACT
In this thesis I find a function for how Gross Annual Energy Production per square meter of rotor area depends on wind data from the MIUU Mesoscale Atmospheric Model. The result can be used in the early stages of the process of finding a suitable site for a new wind farm. The relationship is found by looking at 325 wind turbines in Sweden and calculating the GAEP/m2 and plotting it against the wind speed given by MIUU. The final function is given by a linear regression and is stated in the equation below:

GAEP/m2 = -576.96 + 209.18*MIUU

Wind farm producers will be able to get a estimate of the GAEP by using the equation and the easily available data from the MIUU-model and can then make a shortlist of possible locations for the new turbines.

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Contents

1 Introduction

The construction of a wind farm is the result of a long process that starts with the screening for the most suitable location. One important step of this process is to calculate the expected annual energy production (AEP) of the wind farm. The AEP depends on variables that can be hard to predict. Therefore, the AEP estimate is often associated with an uncertainty. Different levels of confidence may therefore be used to define the expected AEP of a wind farm. The so called P50 value refers to the 50% confidence level, that is, 50% probability that the actual AEP will exceed the P50 value. The P75 value refers to the 75% confidence level corresponding to 75% probability of exceeding. Note that this assumes that the probability function of the AEP follows a Gaussian distribution.

To estimate the AEP value the developer needs to make several assumptions. In short the process includes two parts. The first part consists in trying to estimate the maximal energy that is possible to produce given the winds at the locations and the characteristics of the model of the wind turbine. We will call this the Gross Annual Energy Production (GAEP). The second part consists in trying to measure the amount of time the turbine will be unavailable due to reparations and maintenance, technical problems, ice on the turbine, problem with the electricity grid or other problems that may cause the turbine to stand still. None of these factors can be determined with absolute accuracy but are estimated based on mathematical models and experience from previous turbines. Klug (2004) has estimated that the uncertainty in the P50 estimate is somewhere around 13% annually. Klug also points to additional difficulties with determining the P50: Even if you have a good estimate of the amount of time the turbine will be down due to maintenance, it will effect the AEP estimate differently depending on when this maintenance is performed. If the turbine must stand still when the wind is blowing at optimal speeds more energy will be lost compared to if the downtime is during an hour when the wind speed is too low to create any energy any way.

A power curve is typically provided by the turbine manufacturer that defines how much energy is created from the turbine given a specific wind speed. If wind measurements conducted at the proposed location of the new turbine are available, it is then possible to calculate the GAEP by applying the power curve to the long-term corrected wind series. However, getting reliable wind measurements takes several months and is typically associated with high costs. Before this is done the location of the measuring instruments must be chosen. This is done by looking at climate models that simulate wind speeds at several locations and heights and by looking at the topography and land use of the site. These models are not as accurate as real measurements but can help to find sites with optimal conditions for wind power establishment. In Sweden, the most commonly used model for this is the MIUU-model developed at Uppsala University. This model can estimate the wind speed with a spatial resolution of 0.25 square kilometers and is available at heights from 50 to 150 meters above ground with 10 meters interval.

The GAEP is based on data on wind speeds and wind direction over time at a specific location. The MIUU model, however, only includes the average wind speed. To estimate the GAEP with the help of the easily available MIUU data is therefore not a straightforward task. It is difficult to derive a theoretical relationship and in this thesis I will try to find a relationship between the MIUU data and the GAEP by looking at monthly energy production data for hundreds of wind turbines and compare it to the MIUU data.

The objective of this study is to investigate the relation between the MIUU mean wind speed and the expected GAEP.

2 Methodology

2.1 Outline of methodology

This chapter will begin with a brief outline of how the study has been performed and continue with a description of the data sources used. One turbine is then singled out and each step of the process is presented using the data available for this particular turbine. Finally, a description is given of how the resulting data of each turbine is aggregated and used to create the final regression between gross annual energy production, GAEP, and wind speed from the MIUU model.

Available data in this study

- A list of properties for each turbine such as hub height, nominal power, rotor diameter and location coordinates.
- Monthly data of the energy produced by each turbine.
- Monthly data of the downtime of each turbine.
- Last twelve months (LTM) production index specific for the location of each turbine.
- A measure of the average wind at the location and height for each turbine from the MIUU model.
- Expected icing losses at the location of each turbine.

Methodology

In this study the following steps are done with data for each turbine:

- Get monthly energy production data.
- Find the gross monthly energy production by adjusting data for downtime and ice losses.
- Sum the last twelve month of gross monthly energy production to get a LTM-value (Last Twelve Month)
- Plot LTM gross energy production with the LTM production index for the same period. The production Index is a measurement of how much energy was available for that month. Months with strong winds have a higher value and months with weak winds have a lower value.
- Fit a regression to find the linear function between production index and gross energy production. Use this function to find long term gross annual energy production
- Compare Gross Annual Energy production value to the wind speed from the MIUU model

When this step is done for each turbine we have a list of gross annual energy production and MIUU wind. We then try to find a function that explains the relationship between the two variables.

2.2 Data sources

Several sources are used to find the data necessary to study the relationship between MIUU and the GAEP measure. Below is a presentation of these sources and a description of the used data.

2.2.1 Vindstat.nu

Vindstat AB is collecting data of the energy production from the majority of wind power plants in Sweden on behalf of the Swedish Energy Agency (Energimyndigheten). Each day the turbines are automatically sending information about the energy production, and once a month a technician is manually sending in data about the downtime during that month. The downtime is the amount of hours when the power plant have been standing still due to planned reparations, or unforeseen technical problems with the turbine or the electricity grid. Vindstat AB continuously publish the energy production from wind power and each month a report is published with detailed data and properties about each turbine. Also available on the site is the file "AllMonth" which contains the monthly energy production of each turbine. In Table 1 an explanation of the columns in the monthly report is available. The columns of AllMonth is explained in Table 2. The monthly report for A ugust 2011 and the "AllMonth"-file were extracted from the vindstat.nu website and is available in appendix A and B.

Field	Unit	Description
Nr		The ID number given by Vindstat for each turbine
Nominal Power	W	The nominal effect of the turbine
Location		The locations based on the Vindstat grid
Diameter	m	The diameter of the rotor
Height	m	Distance between the ground and the rotor's hub
Downtime	hours	Amount of down time

Table 1: Description of data in the monthly report, available at www.vindstat.nu

Field	Unit	Description
ID		The ID number of the turbine
Month	YYYYMM	Year and month of the energy data
Energy	kWh	The amount of energy produced by the turbine during this month

Table 2: Description of data in the file AllMonth, available at www.vindstat.nu

Vindstat divide Sweden into a 14 by 32 grid. Each of those areas are further divided into 9 squares. The location of each turbine is specified as being in one of those squares. Each square measures roughly 17 by 17 kilometers. The size varies slightly due to the curvature of the earth, and the uncertainty of the location of each turbine is therefore about 17 kilometers. The grid and the position of the turbines is shown in Figure 3. The midpoint of the squares are translated from the Vindstat coordinate system to the WGS 84 latitude, longitude coordinate system.

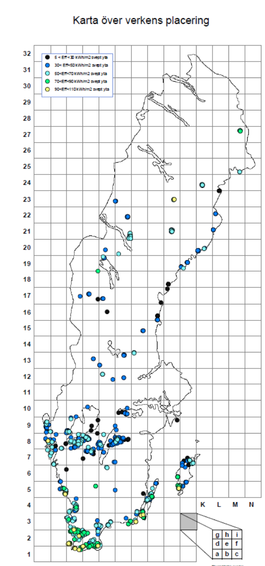


Figure 1: Location of all wind farms, based on the grid designed by Vindstat.

The data from Vindstat is split into three different tables. Two of them single out the energy and the downtime for each month and the third includes all the properties that characterize each turbine. The structure of these tables is described in table 3.

Downtime Data	Energy Data	Property Data
ID	ID	ID
YEAR	YEAR	NOMINAL POWER
MONTH	MONTH	LAT
DOWNTIME	ENERGY	LONG
		DIAMETER
		HEIGHT

Table 3: The data in the three main tables used in the study.

2.2.2 MERRA

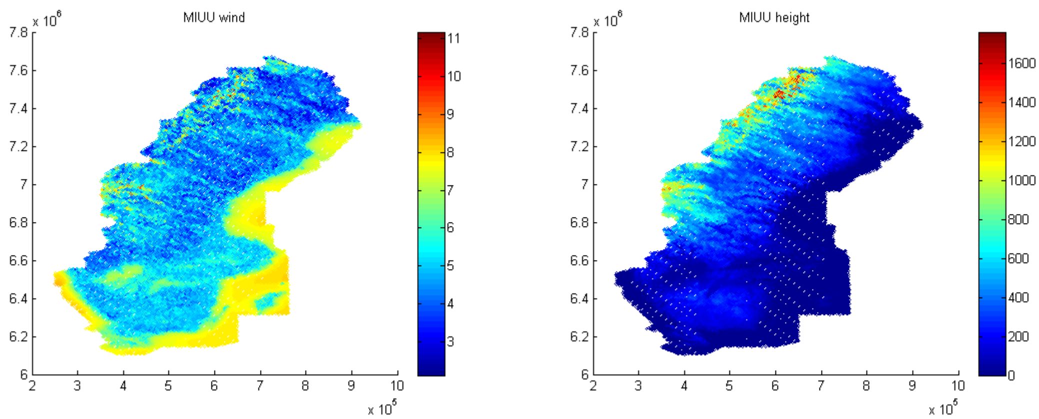
A Last Twelve Month, LTM, production index was calculated based on the MERRA wind speed data. MERRA is a publicly available data set of atmospheric data maintained by NASA (Lileo, Petrik 2011). It is has a spatial resolution of 1/3 latitudes and 2/3 longitudes, which means that Sweden is covered by about 300 MERRA points. The LTM production index is defined as the ratio between the energy production that a wind turbine may extract from the wind during a given LTM period, and the average of the energy production for all the LTM periods during the period 1979-2010. A ratio of 1 indicate that the energy production during a particular LTM period is the same as a normal, long term LTM period. A ratio of 70% indicates that the energy production is 70% of the long term average. The LTM production index shows how much energy a turbine can be expected to produce during a given LTM period in relation to the expected annual energy production. The LTM production index was calculated for the nearest located grid point to each turbine position. In Table 4 we see a description of the data.

Field	Unit	Description
YEAR	YYYY	
Month	MM	
LTM Production Index	%	LTM production index for the location

Table 4: Description of data from MERRA

2.2.3 MIUU Mesoscale Atmospheric Model

The Meteorological Institute Uppsala University, MIUU, numerical model gives us the long term, average wind speed at different heights and locations in Sweden. The model is developed at Uppsala University and sponsored by the Swedish Energy Agency (Energimyndigheten). The resolution is 0.25 square kilometers and is available for every ten meters between 50 and 150 meters above ground level. In Figure 2(a) we see the wind speed according to the MIUU model in Sweden at the height of 50m. 2(b) show the ground level. Table 5 describe the columns of the MIUU data. The MIUU data comes in several files, one for each height.



(a) Long term wind speed in Sweden, 50 meters above ground level, According to MIUU data.

(b) Ground level as meters above sea level.

Figure 2

Field	Unit	Description
N	SWEREF99	North coordinate of the SWEREF99 coordinate system
E	SWEREF99	East coordinate of the SWEREF99 coordinate system
Wind Speed	m/s	The long term average wind speed
Ground Level	m	The height of the ground above sea level

Table 5: Description of MIUU data

2.2.4 Ice loss data

Wind turbines in Sweden are effected by the cold weather. During the coldest periods they risk to stand still due to ice formation on the turbine blades. The amount of time the turbine stands stills due to icing varies geographically.

Limited amounts of data of icing losses is available but assumptions on of how large the icing losses may be in different regions of Sweden has been is made from experience and is presented in Table 6. Note that the icing losses may vary from year-to-year. Due to lack of better data, we have assumed that the icing losses during all the analyzed LTM periods were the same at each turbine location.

Ground level(m)\latitude	lat≤59	59<lat≤63	lat>63
0-100	0%	2%	4%
100-300	2%	4%	6%
300-500	3%	6%	8%
500-700	4%	8%	10%
>700	8%	11%	12%

Table 6: Assumptions made for the expected production losses due to icing losses in different regions of Sweden.

2.3 Aggregated information about the raw turbine data

The data set consist of 1220 turbines and in this section the distribution of the most important properties is shown to give the reader an overview of the data.

Location

Most of the turbines are found in the southern part of Sweden, and especially in the coastal areas, see Figure 3. This is because wind speeds are generally larger in the south due to the flat landscape. Another reason is the slightly warmer climate which decreases the risk of ice losses.

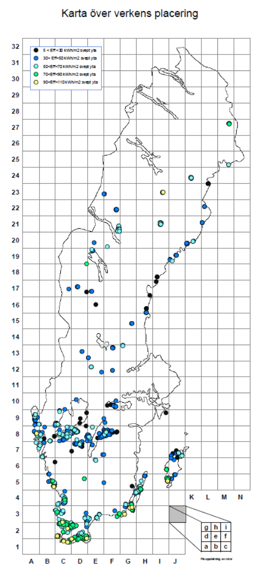


Figure 3: Vindstat map. Locations of Turbines

Energy production

Figure 4 shows the distribution of energy for each month. The absolute majority is about 10 to 20 MWh per month with higher values getting increasingly more rare. It is also worth noting the negative values that show some of the irregularities in our data.

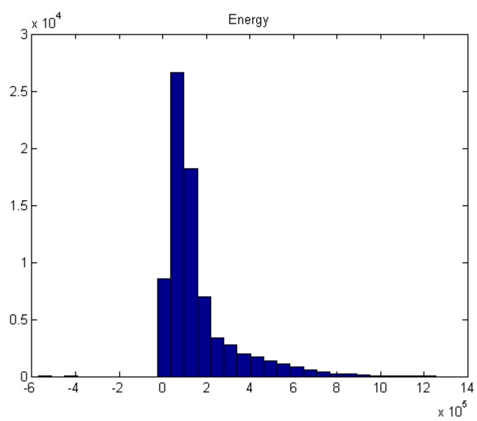


Figure 4: Frequency of monthly energy production in kWh.

Height

The height of a turbine is very important since wind speeds are generally larger and more stable when you get above the turbulence caused by the terrain on the ground. Turbines have over the years become taller and taller as the production costs decline. A histogram is shown i Figure 5

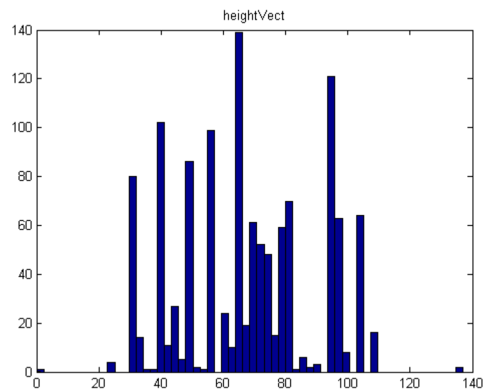


Figure 5: Histogram of height (m) on the x-axis and frequency on the y-axis

Effect

The decreased production costs and improved technology have made it possible to create larger and more powerful generators, allowing the same wind speed to generate more energy. There are a relatively small number of wind turbine producers available and this creates a discrete amount of models available. That is why a few spikes is visible in the data rather than a continuous variety. See Figure 6

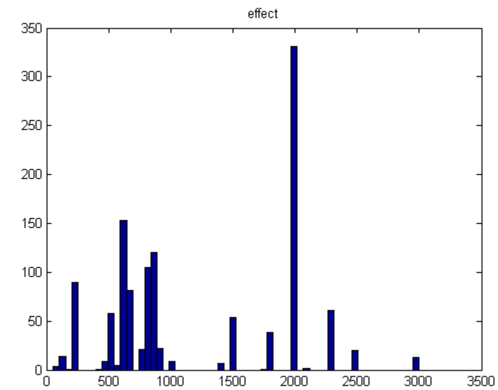


Figure 6: Histogram of nominal power (W) on the x-axis and frequency on the y-axis

Downtime

Figure 7 shows the downtime for each month and the absolute majority of months have a downtime between 0 and 100 hours, A more detailed look at this range shows that a lot of months never had any down time reported. This is quite remarkable since it's generally common with downtime of about 3%. This is caused by sub par reporting to vindstat.

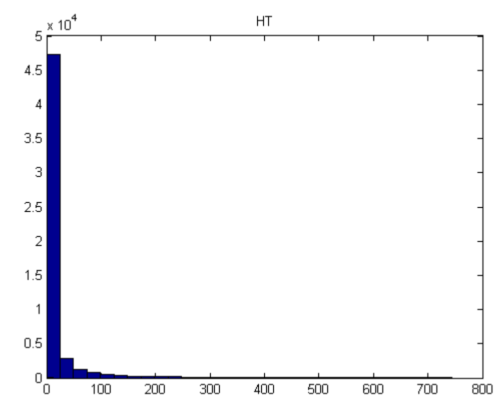


Figure 7: Histogram of downtime (h) on the x-axis and frequency (months) on the y-axis

MIUU data

We also take a look at the data from MIUU. The MIUU data is divided into the squares of vindstat.nu. Even if MIUU have a very high resolution the turbines are only located with an uncertainty of 17 by 17 km. The MIUU data is therefore divided into these squares and in Figures 8- 11below the distribution of wind and height in these squares. Also visible is the difference between the smallest and largest value of wind speed and height in each of these squares. If the height difference within a square is big the icing data will be vary different depending on where the turbine is located. Identifying squares with large differences and removing them will be neccessary in order to for the anlysis to work.

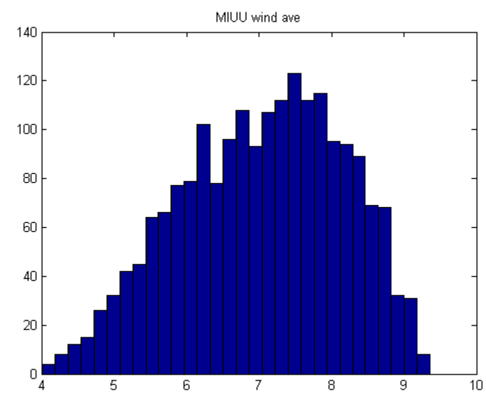


Figure 8: MIUU wind speed on the x-axis, number of squares from vindstat on y-axis.

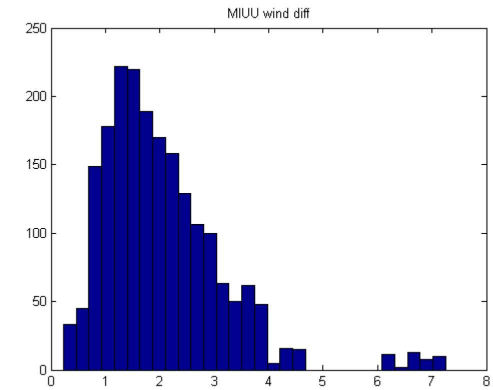


Figure 9: Difference between largest and smallest wind speed within a square

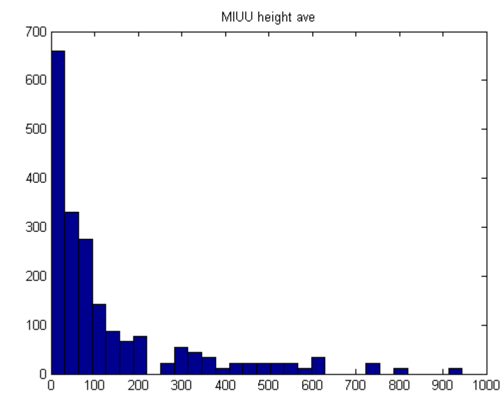


Figure 10: Height above sea level in each square

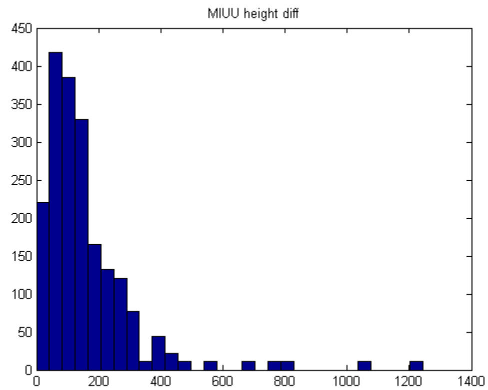


Figure 11: Maximum difference in height within a square

2.4 Methodology explained by single out Turbine #656

To better explain the methodology a single turbine is singled out and every step is described and the data is visualized. Turbine with ID-number 656 is chosen and it is located on the south-west coast of Gotland. This particular turbine is chosen because of well behaved data and because it is situated in an area of interest for wind turbine producers. It is therefore suitable to use as an example.

2.4.1 Characteristics of Turbine 656

In Table 7, the properties of this turbine is shown and in Figure 12 the energy produced each month is visible. Figure 13 shows the down time.

Property	Value
ID	656
Effect	850
Location	'I5i'
Longitude	18.06
Latitude	57.20
Diameter	52m
Height	55m

Table 7: Properties of turbine

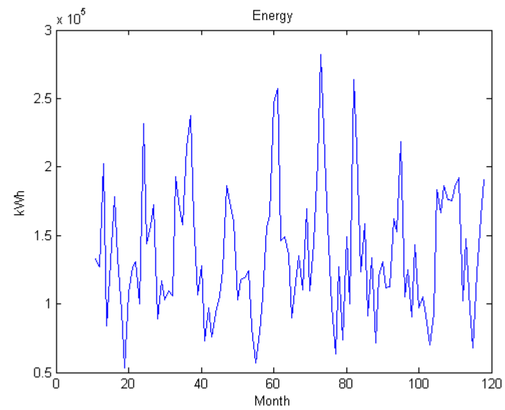


Figure 12: Actual energy production kWh per month

The x-axis shows the number of months, where 0 is January 2002 and 120 is October 2011. There is a large variation between the months with large spikes in the winter months and lower levels in the spring time.

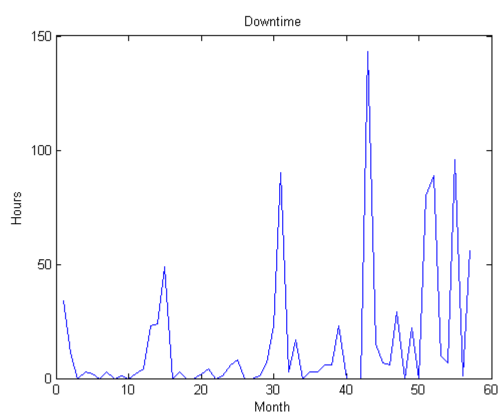


Figure 13: Number of hours per month that the turbine was not used.

Data about the down time is available from January 2007 and September 2011.

Figures 14 and 15 below show the MIUU wind speed and the height above sea level of for all the grid points located inside the 'I5i' square on which turbine 656 is stationed.

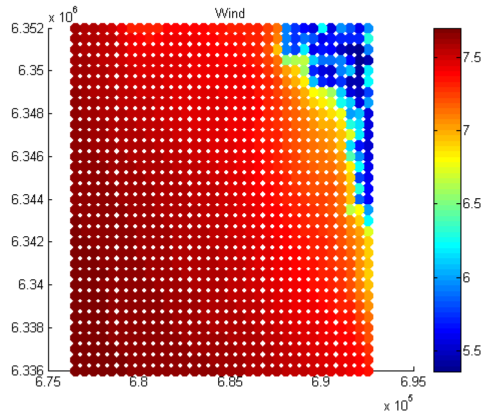


Figure 14: Wind speeds at 50 meters above ground in the I5i square, according to MIUU

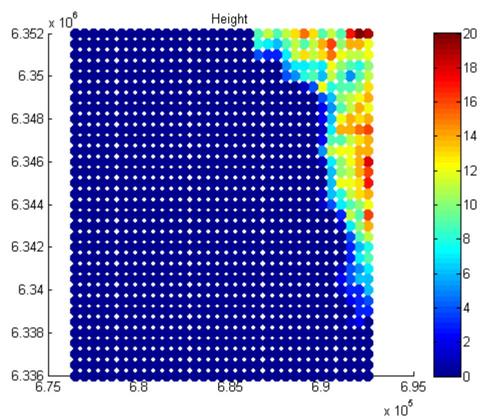


Figure 15: Height above sea level for the ground in the I5i square. This is on the south west coast of Gotland and the coast line is easily seen.

2.4.2 Calculating LTM-data

The LTM produced energy is calculated by adding the energy produced during each 12-month period. The reason for this is that the LTM data have a lower variance than monthly data and thus gives us a more reliable measure. For example, the corrected energy produced between May 2010 and April 2011 is summed and this is the LTM-value for April 2011. Next we look at the estimated icing losses for this particular turbine. The location is in square 'I5i' and the latitude is 57.20 degrees. Given the latitude and the total height Table 6 gives us the estimated ice loss during one year to be 0%. This means that the LTM-data previously calculated do not need to be corrected again for this ice loss and the data is representing the annual gross energy production for this turbine. In Fable 16 the LTM-periods are visible for some of the months. In reality there are more LTM-values available but this table is shown to demonstrate how the LTM values are calculated.

Variable	Value
Energy (kWh)	68070
Downtime (hours)	96
Downtime (% of hours in month)	96/(24*31) = 12.9%
area	pi*(52/2)^2=2123 m^2
Gross Energy Production per m^2	Energy/(1-downtime-iceloss)/area = 36.8 kWh/m^2

Table 8: Calculated Energy for August 2011

Month	Month energy	LTM energy
2010-5	49.4788232696842	
2010-6	42.9708928895863	
2010-7	***40.7606011759446***	
2010-8	***44.5922487506638***	
2010-9	***87.0551399669174***	
2010-10	***78.9845242513497***	
2010-11	***91.4841567729544***	
2010-12	***83.0129581281917***	
2011-1	***85.2474247635394***	
2011-2	***87.3991365154727***	
2011-3	***101.518972299049***	
2011-4	***55.0714101249208***	847.576288908274
2011-5	***70.5827474253443***	868.680213063934
2011-6	***45.7288763334576***	***871.438196507805***
2011-7	36.8007874495096	867.47838278137

Figure 16: Calculated LTM periods

In Table 8 the calculations made to create the corrected gross energy production are visible. The corrected value represents the amount of energy the turbine would be producing during a twelve-month period if it never stood still due to downtime or icing.

2.4.3 Finding Production Index Data and finding a relationship to energy production

By matching the longitudes and latitudes of the location of the turbine the closest MERRA point is found. Consequently the corresponding LTM production index series is identified. Knowing the MERRA point and the production index, data is found. In Figure 17 the production index data is visible.

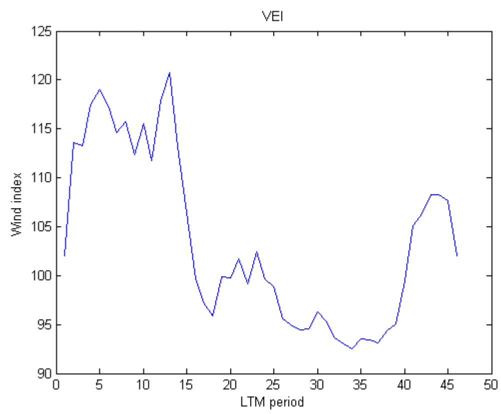


Figure 17: Production Index from MERRA for from the MERRA point closest to turbine 656

The next step is to match the Production Index data with the gross energy production for the turbine. Matching the time periods for the Production Index and the GEP and running a regression a linear relationship between Energy Production and Production index is found. This relationship can be seen in Figure 18 and the information from the regression is available in Table 9.

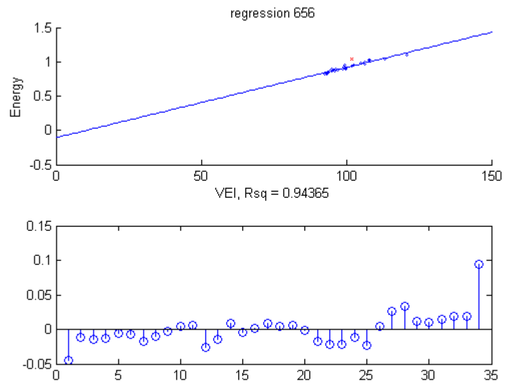


Figure 18: ID regression

Rsq	stdev	slope	intercept	Estimated long term GAEP/m^2
0.94	0.018	0.010	-0.107	780.77 kWh

Table 9: Turbine 656 regression Table

The relationship is stated in equation (1)

$$GAEP = Intercept + slope * ProductionIndex \tag{1}$$

Letting Production_index be equal to 100 in the equation yields the GAEP divided by the sweep area for this particular turbine.

2.4.4 Comparing GAEP with MIUU wind speed.

The next step is to compare how the calculated GAEP measure compares to the MIUU models prediction of the wind speed in the same area. Since the location of the turbine is only known to a 17 by 17 kilometers area some uncertainty is associated with the MIUU value. Instead we calculate the average wind speed from the MIUU model in this entire square. The wind speed depends on the height and the MIUU model gives us data for every 10 meters. The hub height of the turbine is 55 meter according to the property data and we get the wind speed by interpolating between the average wind speed in this square at the closest available MIUU heights, in this case 50 and 60 meters. It turns out to be 7.5 m/s. In a graph with wind speed on the x-axis and GAEP on the y-axis we can plot our measure of GAEP for this particular turbine. If this process is repeated for several turbines it will be possible to investigate on the relationship between wind speed and the GAEP divided by rotor area.

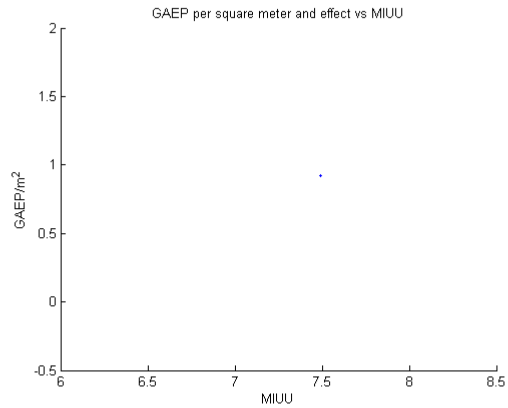


Figure 19: GAEP per square meter and effect (kWh) and MIUU (m/s)

2.5 Removing turbines from the data set

The previous steps are performed on every turbine. However, not all turbines are suitable for our study. First the turbines with missing values are removed. Some values are missing completely while some are obviously wrong, such as negative energy production or negative downtime. Since a large data set is available it is possible to remove all of those turbines and still have enough data to perform a statistically sound analysis. Other considerations of the data include the length of the time series. If the turbine is new not enough data is available to create a good regression. A lower limit on 20 LTM-periods are used which leaves 747 turbines.

Further, the location of the turbine is only known to be within a 17 by 17 km square. It is not possible to find a more precise estimate of the location given the data from Vindstat. The average height above the sea and wind speed for each square is used which causes problem if the square has a varied terrain and a large variation of wind speed. To remove this uncertainty all turbines in a square that show large variation are removed. The height difference is vital for determine the level of icing losses and we therefore remove all squares that has heights on both sides of the heights limit of the ice data. All turbines within a square that has a height difference within the square of above 100 meters is removed. Even if the terrain is flat the wind might vary within each squares. Only squares where the average wind is a good approximation for the entire square is acceptable for the study and we therefore remove all squares with a maximal difference between largest and smallest wind speed of 2 m/s. The number of turbines left that are suitable for the study is 325.

3 Results

Figure 21 shows the calculated GAEP and the MIUU wind for the location of each turbine. The GAEP is calculated from the linear regression made for each turbine. A summary of those regressions is visible in Figure 20. The summary shows that almost all regressions have a positive slope meaning that the energy production is larger for larger wind speeds, as expected. The intercepts are close to zero for most turbines which is consistent with the intuition that zero wind speed produces zero energy. The R square values are almost evenly spread out between 0 and 1 with slightly more regressions on the upper side of the scale.

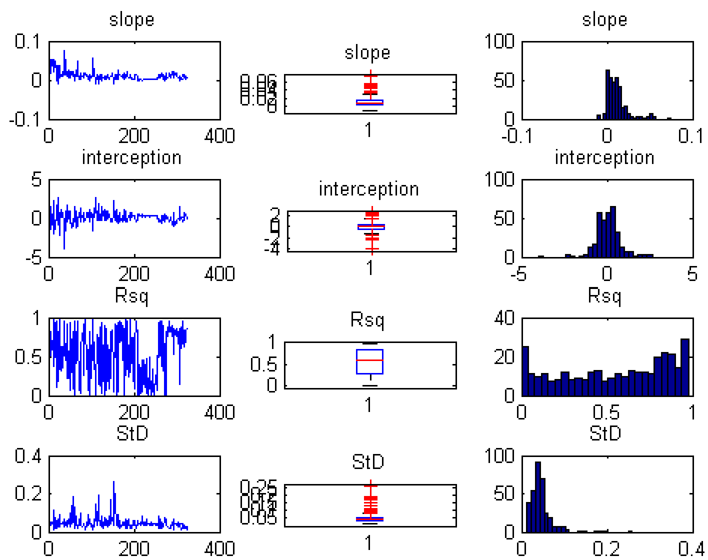


Figure 20: Regression summary. 4 parameters (each row) is presented in 3 different ways for the 375 regressions.

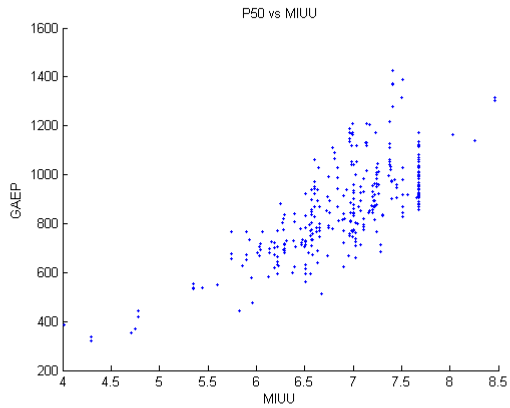
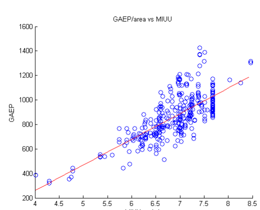
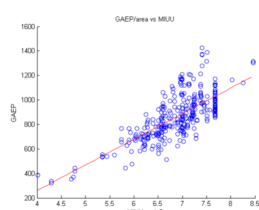
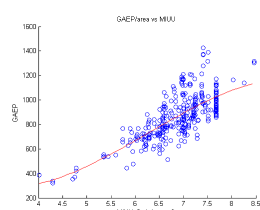


Figure 21: GAEP (kWh/m^2) vs MIUU (m/s)

For each turbine the regression line gives us the GAEP if we insert 100 as the Production Index. These values are plotted in Figure 21. Another regression is made to find a suitable function that can be used to estimate the GAEP for a new turbine given the MIUU wind in the proposed area. Polynomial functions of one, two and three degrees are tried. Figure 22 shows the three regression models and in Table 10 information about the regressions is found. Visually we notice that all the functions look rather linear. In the table we can see that the linear regression is the only one with significant Beta-values and it has the highest adjusted R square value. Therefore, it is decided to use the linear regression as our relationship for the data within this range of values.



(1)


(2)


(3)

Figure 22: Regression with polynomial of one (1), two (2) and three (3) degrees.

Coefficient	Estimate	Std.Error	t value	Pr(>|t|)	significance
intercept	-576,96	73,38	-4,8763	5367e-14	***
beta1	209,18	10,60	19,727	< 2e-16	***
R square: 0,5465	Adj Square: 0,5450				
Coefficient	Estimate	Std.Error	t value	Pr(>|t|)	significance
intercept	-616,18	386,3121	-1,895	0,1117	
beta1	221,3377	118,0663	1,875	0,0617	.
beta2	-0,9302	8,9948	-0,103	0,9177	
R square: 0,5465	Adj R square: 0,5436				
Coefficient	Estimate	Std.Error	t value	Pr(>|t|)	significance
intercept	1538,055	1878,962	0,819	0,414	
beta1	-844,366	917,312	-0,920	0,358	
beta2	171,102	147,123	1,163	0,246	
beta3	-9,093	7,762	-1,172	0,242	
R square: 0,5484	Adj R square: 0,5442				

Table 10: Summary of polyomial regressions

Our resulting function is therefore
$GAEP/m^2 = -576,96 + 209,18 * MIUU$
However, the data show a large variation and we which to estimate the error margins for the equation. In figure 23 the 90% prediction intervals are added to the regression. The distance between the function and prediction interval as a percentage of the GAEP is also plotted in figure 23 for further clarification. We notice that between 4 and 8.5 m/s the distance between the function and 90% prediction interval is between 230 and 207 kWh/m^2. In the end the prediction levels increase due to limited data points on the edges of the measured MIUU interval.

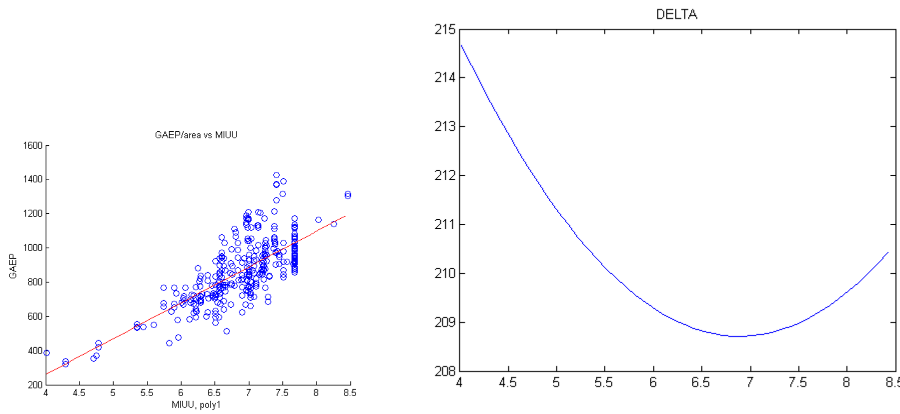


Figure 23: Linear regression and 90% prediction intervals

4 Discussion

The aim of this thesis was to investigate the relation between the energy production of wind farms with data in vindstat and the corresponding MIUU wind speed. The resulting function can be a great tool for wind farm developers who want to get an early estimate for their financial decision when planning for a new wind farm. To arrive to the function many assumptions are made and some of the data have been noisy or of low quality. Some of the problems include:

Downtime-data This data is manually reported to vindstat and it appears like this is not done consistently. Missing values and misreporting is likely to have occurred which can affect the result when adjusting the energy production to a long-term corrected gross energy production value.

Ice data During the study no detailed data on the icing losses for each turbine was available. Instead, estimated values based on latitude and hub height above sea level was used. No concern was made for the year-to-year variability of the icing losses.

Position The position of a turbine is only known to be located somewhere within a 17 km x 17 km area, in which the terrain and climate can vary. In this study areas with larger variations in terrain are removed due to possible miscalculations, but it is still possible that the average wind speed and height above sea level in this area is not representative for the turbine.

With more accurate data about the operation of the turbines the same study could be repeated and hopefully a function with a narrower prediction interval could be obtained. However, the aim of the study was to find a function of GAEP and MIUU data to be used in the early stages of choosing a location for wind turbine. In this phase uncertainty will always be present and correctly used it can be used as an powerful, although blunt, tool for producers who want to create a shortlist of location to move forward with.

Reference List

Klug, H., 2004 , "P50-P75-P90 How to reduce the risk of a wind farm project" Proceedings of the EWEC, London

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Vindstat 2012, *Om,* Läst 2012-02-10 från http://vindstat.nu/stat/index.htm, EWEA 2011 paper

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Appendix

A

August 2011 report from Vindstat AB

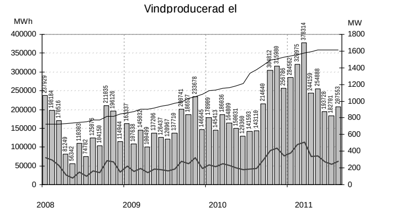
Driftuppföljning av

Vindkraftverk

augusti 2011

Internetadress: http://www.vindstat.nu

Vindproducerad el



Staplarna visar producerad energi per månad i MWh, linjerna visar installerad effekt respektive månadens medeleffekt i MW

Sammanfattning

Installerad effekt	(MW)	1617
Antal verk	(st)	1323
Rapporterade denna månad	(st)	1107
Elproduktion		
2009	(MWh)	1 806 416
2010	(MWh)	2 331 478
2011	(MWh)	2 066 878
Rapporterat denna månad	(MWh)	207 553
Medeleffekt denna månad	(MW)	279

Vindens energiinnehåll

Månaden jämfört med samma månad tidigare år	122 %
Året hittills jämfört med samma period under tidigare år	112 %
Senaste 12 månaderna jämfört med samma period under tidigare år	108 %

Förklaringar till tabellen på följande sidor

Ber	Av ägaren lämnad uppgift på beräknad elproduktion		
Årtal	Sammanlagd elproduktion under respektive år		
12mån	Elproduktion och tillgänglighet senaste 12 månaderna		
Månad	Elproduktion under månaden		
Tid	Andel av månaden som generatorn varit inkopplad på nät		
*	Nytt verk		
AHT	Avläst hindertid		
MS	Mindre störning	PU	Planerat underhåll
YNS	Yttre nätstörning	ÖPS	Övrigt planerat stopp
ÖYS	Övrig yttre störning	TF	Tekniskt fel

Ett projekt finansierat av Energimyndigheten

Sammanställningen gjord 2011-09-09

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162 16 Stockholm
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B

Snippet of Allmonth.xls from www.vindstat.nu

Effekt	Fabrikat	Namn	Nr	201104	201105	201106	201107	201108	201109	201110
150	WindWorld	Snaigsto	15	19913	28037	10035	12377	13813	8791	21678
150	WindWorld	Tjautet	16							
150	WindWorld	Sladdkvenni	17	22074	8377	6054	12159	20091	39106	
150	WindWorld	Elvina	20	19954	13605	9735	4179	6999	955	0
225	Vestas	Ölandstok	24	38660	37019	25893	28705	36377	37780	43019
225	Vestas	Solvändan	25	37121	35606	24157	26999	35516	36127	40564
225	Vestas	Hästholmen 1	27	37036	34946	21839	10758	17015	44722	59801
225	Vestas	Mårten	28	29197	32028	19424	26801	23046	35652	40952
225	Vestas	Tovsippan	33	43043	43118	30264	32036	41573	43788	50060
225	Vestas	Vitsippan	34	43715	41211	27791	30155	39747	29055	45194
450	Bonus	Lyse Bonus	50	65598	92481	17426	62	44	0	0
225	Vestas	Utö	51	20209	20689	24528	19155	5211	0	8680
225	Vestas	Elmer I	54	19532	27742	14435	8346	8654	22668	21290
225	Vestas	Albert	56	23299	38843	28359	13166	35408	47458	52512
225	Vestas	Erik	57	21479	36576	26247	11899	27908	45176	49344
99	WindWorld	Oaxen	58	0	94	0	8	0	0	0
225	Vestas	Bösarp	63	38861	31744	20448	31496	31493	30465	31480
225	Vestas	August	65	28076	30414	18583	17190			
225	Vestas	Kristinelund 1	68	43235	47050	33313	32436	44360	47069	52141