ANALYSIS OF WIND SPEED SOUTH SEA AS A POTENTIAL SOURCE OF RENEWABLE ENERGY D.I YOGYAKARTA BASED ON SATELLITE REMOTE SENSING DATA USING FUZZY LOGIC

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Abstract —**How much energy prediction can be produced very important in electric energy markets. Electrical energy was sold before the actual energy produced is very important for the economic balance a power companies. Thus require analysis of wind speed as a potential source of energy. Analysis of wind speed were calculated using Sugeno's fuzzy with wind speed data based on the 24-year period data. An analysis of wind energy, the output value is based an analysis with assumes a constant density atmosphere, where is density of the air has a fixed value from sea surface level to top atmosphere. The model of Sugeno's fuzzy wind prediction system designed for first order, second order, third order, fourth order, twelfth order and twelfth order modified. Overall models can not follow pattern of data test. Then selected models Sugeno's fuzzy twelfth order, because have a small RMSE values. Furthermore, the wind speed prediction system and analysis of wind energy are designed using Graphic User Interface (GUI) in Matlab R2013a. Results are based variable height from ground level, shows that the value of wind energy potential in Gunung Kidul higher than Bantul and Kulon Progo.**

Keywords - **Wind Velocity, Fuzzy Logic, Forecasting and Class of Energy.**

I. INTRODUCTION

Energy is one determinants to survival people of a State. In modern society, need of energy, especially electricity has becomes integral discussion of three-dimensional at the same time, economic development, social welfare and environmental sustainability. Sustainable development is defined as development that meets the needs of the present without compromising ability next generations to meet their own needs (UNEP-IEA, 2002)[4]. Thus, the electrical energy needs are increasing with the increase of population requires not only equitable distribution of electrification, but also preservation of the environment.

Total world oil resources has reach 325 billion tons (US Geological Survey, 1995). Around thirty three percent have been utilized (Rebhan, 2002). Most of the fossil energy reserves have been consumed in a period of 200 years, about half of the fossil energy has been spent for human consumption within the last 20 years (Pykh and Pykh, 2002). It has been shows a massive increase of energy demand. Meanwhile about 1950, carbon emissions reached 1.6 billion tons per year and continue increase until the year 2000 to reach 6.3 billion tons per year. Carbon emissions Indonesia has predicted continue to increase from 116 million tons to 270 million tons on 2018. Eighty-five percent of these emissions, or about 228 million tonnes comes from burning coal as a power plant (PLN 2009)[4].

The amount of electric subsidies from 2004 to 2011 has increased from 3.31 trillion rupiah to 93.17 trillion rupiah. This will continue to increase in line with population growth, but it is also a ratio of the national electrification is still relatively low and became a separate task for the government.

II. LITERATURE REVIEW

Wind is an air mass moving horizontally that flows from high pressure into the low pressure region. As greater as difference of air pressure, as greater as wind speed blows (Hasse and Dobson, 1986)[11].

Coriolis force arises from earth rotation and cause changes motion of wind to right in northern hemisphere and deflection of wind to left in southern hemisphere (Pariwono and Manan, 1990). According to Wyrtki (1961), the monsoon system in Indonesia is divided into four groups, namely:

1. Northeast monsoon of winds and West Monsoon of winds

Monsoon was formed in December to February. In these months, the high air pressure are located in the continent of Asia. While on the continent of Australia formed a low air pressure, so that the wind blows from Asian continent to Australia continent. In the northern hemisphere (north of the equator) blowing northeast monsoon wind, whereas in the southern hemisphere (south of the equator) blowing northwest monsoon winds and in Indonesia known as west season.

2. Transition I

The first transition occurs from March to May. By the time Season Transition, wind speed is weak and direction become irregular.

3. Wind southwest monsoon and Winds southeast monsoon

In June to August, low pressure of air formed in Asia continent, while high pressure of air formed in Australia continent, so the wind is blowing from the Australian continent to Asia continent. In the northern hemisphere (north of the equator) blowing southwest monsoon of wind, whereas in the southern hemisphere (south of the equator) blowing southeast monsoon of winds.

4. Transition II

The second transition occurs in September to November. By the time Season Transition, wind speed is weak and direction become irregular.

U.S Departmnent energy (2005) used QuikSCAT data, the potential of wind speed in Yogyakarta coastal is 6m/s up to 7m/s [24]. Purba, Noir P (2014), wind speed averages in south of west java is about 5.3-12.6 m/s[18].

Wind power forecasting errors in grid dispatch are important to balance the power fluctuation caused by wind variations, With increasing penetration level of wind power (Ning Chen, et all, 2013)[17]. The behaviours of the forecasts in the transformed series is similar to that of the actual of velocities, use of the hourly mean and standard deviation values use on a monthly basis of the standardization is accurate (J.L Torres et all, 2004)[9].

Tiejun Ling, et. All (2003) The operational sea surface wind field forecasts system was not a mature work[25]. Various forecasting models are introduced and a lot of researches on the models all have their own characteristics. Some of them are good at short-term prediction, some are simple and widely used while other complex ones have more accurate results. Recently, with the development artificial intelligence and mathematical technique, a lot of new methods were put forward. Many of them are more excellent than the conventional methods and have good development prospect (Lei Ma, et all, 2008)[13].

III. RESEARCH METHODS

III. 1. Basic of Analysis

Research method used a review of the data library. The study was conducted by analyzing data of satellite remote sensing that recorded of wind speed in the coastal of Yogyakarta. Then uses fuzzy logic to analyze the potential of wind energy in the coastal of Yogyakarta. The software used as a tool of analysis is fuzzy toolbox and Graphic User Interface (GUI) in Matlab R2013a and SPSS 11.5.

III. 2. Model of Fuzzy

Sugeno's fuzzy used to predict the wind speed of the coming year with each variation fullfil the linear equation:

a. First order

$$y_n = a.x_{n-1} + b \quad (1)$$

b. Second order

$$y_n = a.x_{n-2} + b.x_{n-1} + c \quad (2)$$

c. Third order

$$y_n = a.x_{n-3} + b.x_{n-2} + c.x_{n-1} + d \quad (3)$$

d. Forth order

$$y_n = a.x_{n-4} + b.x_{n-3} + c.x_{n-2} + d.x_{n-1} + e \quad (4)$$

e. Twelfth order

$$y_n = a.x_{n-12} + b.x_{n-11} + c.x_{n-10} + d.x_{n-9} + e.x_{n-8} + f.x_{n-7} + g.x_{n-6} + h.x_{n-5} + i.x_{n-4} + j.x_{n-3} + k.x_{n-2} + l.x_{n-1} + m \quad (5)$$

f. Twelfth order modified (based on beaufort scale)

Where n is the month and n : 1, 2, ..., 11, 12.

The fuzzy structure :

Type :Sugeno
And method : Prod
Or method : Probor
Implication method : Prod
Aggregation method : Max
Defuzzification : Wtaver
Member function : Gaussmf
Clustering :Subclust used for order 1, 2, 3, 4 and 12. Order 12 modified uses Beaufort scale for clustering. See Table.1 for Beaufort scale.
Radius : 0.5

TABLE 1

BEAUFORT SCALE

Beaufort number	Wind speed	center	Description	Land conditions
1	0.3-1.5	0.9	Light air	Smoke drift indicates wind direction. Leaves and wind vanes are stationary
2	1.6-3.3	2.45	Light breeze	Smoke drift indicates wind direction. Leaves and wind vanes are stationary
3	3.4-5.4	4.4	Gentle breeze	Leaves and small twigs constantly moving, light flags extended
4	5.5-7.9	6.7	Moderate breeze	Dust and loose paper raised. Small branches begin to move
5	8.0-10.7	9.35	Fresh breeze	Branches of a moderate size move. Small trees in leaf begin to sway
6	10.8-13.8	12.3	Strong breeze	Large branches in motion. Whistling heard in overhead wires. Umbrella use becomes difficult. Empty plastic bins tip over
7	13.9-17.1	15.5	High wind, moderate gale, near gale	Whole trees in motion. Effort needed to walk against the wind

Based on beaufort scale, then get seven rules for order twelfth modified each for fuzzy model Gunung Kidul, Bantul and Kulon Progo. The figure of curve pattern are shown in Fig.1.

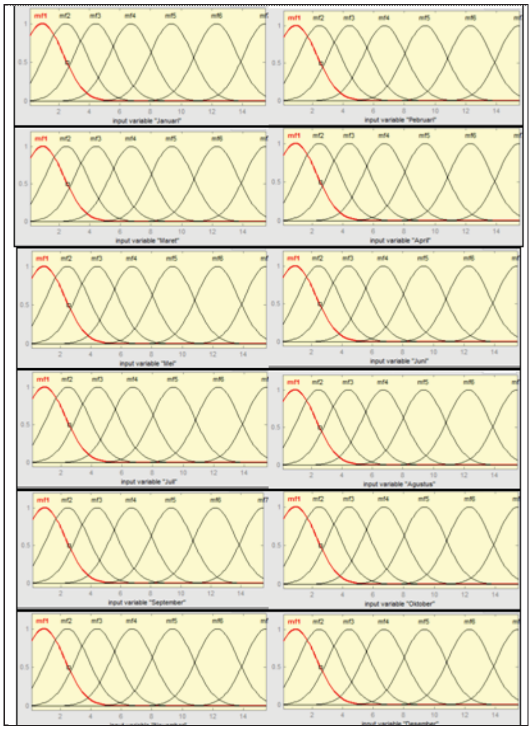

Fig. 1 Curve pattern of gaussmf based on beaufort scale

Formulation of gaussmf [10]:

$$f(x,\sigma,c) = e^{\frac{-(x-c)^2}{2\sigma^2}} \quad (6)$$

x : Range of wind speed (m/s)
σ : Sig
c : Center for each curve

III. 3. Model Atmosferic Analisys

Pressure variation of altitude is obtained from the hydrostatic equation[22]:

$$p_z = p_0 - \rho_0.g.z \quad (7)$$

Shrinkage temperature for real atmospheric is about $0{,}65^o\, C/_{100m}$, temperature at a height z is given by the equation[22]:

$$T_z = T_0 - \gamma z \quad (8)$$

T_0 = Surface temperature
γ = Shrinkage temperature
z = Height

The average wind speed formulated as follows[19]:

$$\bar{v} = \frac{1}{n}\sum_{i=0}^{n} v_i \quad (9)$$

The standard deviation for wind speed is[19]:

$$\sigma^2 = \frac{1}{n-1}\sum_{i=0}^{n}(v_i - \bar{v})^2 \quad (10)$$

Poisson probability function fullfil the equation[23]:

$$p(v,\bar{v}) = \frac{e^{\bar{v}}\bar{v}^v}{v!} \quad (11)$$

With $\bar{v}$ average value of a number observations of wind speed and v is an integer value range of wind speed data.

Gross energy (EG) is Total potential of annual wind energy with wind speeds at atmospheric pressure and temperature condition on site [19].

$$E_g = E_U c_H c_T \quad (12)$$

$$c_H = \frac{P}{P_0} \quad (13)$$

$$c_T = \frac{T_0}{T} \quad (14)$$

CH = Pressure coefficient (Pa)
CT = Temperature coefficient (C)
P0 = Absolute atmospheric pressure 101.3 kPa
T0 = Absolute atmospheric temperature 288.1 K or 14.95 C.
P = Annual average of atmospheric pressure on site.
T = annual average of temperature on site.
Estimates of energy based on the height from ground level [5].

$$\frac{V_{Zhub}}{V_{Zanem}} = \frac{ln\frac{Zhub}{Z0}}{ln\frac{Zanem}{Z0}} \quad (15)$$

V_{zhub} : Wind speed at hub height (m/s)
V_{Zanem} : Wing speed at anemometer height (m/s)
Z_{anem} : Anemometer height(m)
Z_{hub} : Hub height (m)
Z_0 : Land factor according to Manwell, Mc Gowan and Rogers. Used value Z_0 = 0,0002.

The amount of wind energy at annual average of wind speed [19].

$$E_{\bar{v}} = 8760\sum_{x=i}^{n} P_x\, p(x) \quad (16)$$

$$P_x = \sum_{x=i}^{n} 0.5\,\rho x^3 \quad (17)$$

Where ρ is air density and p (x) is probability to obtain x wind speed during a year.

Table 2 is explain wind power class :

TABEL 2
WIND POWER CLASS

Wind Power Class	Wind Power Density at 10m (W/m^2)	Resource Potential
1	0-100	Poor
2	100-150	Marginal
3	150-200	Fair
4	200-250	Good
5	250-300	Excellent
6	300-400	Outstanding
7	>400	Superb

Root Means Square Error (RMSE) [16].

$$RMSE = \frac{(Prediction - Data)}{\sqrt{Prediction}} \quad (18)$$

The research flowchart as shown in Fig.2. where, Normality tes is uses kolmogorov-smirnov method, probability is uses poisson method, compare model is uses one sample t-test, validation is uses paired sample t-test between data and simulation results for each months.

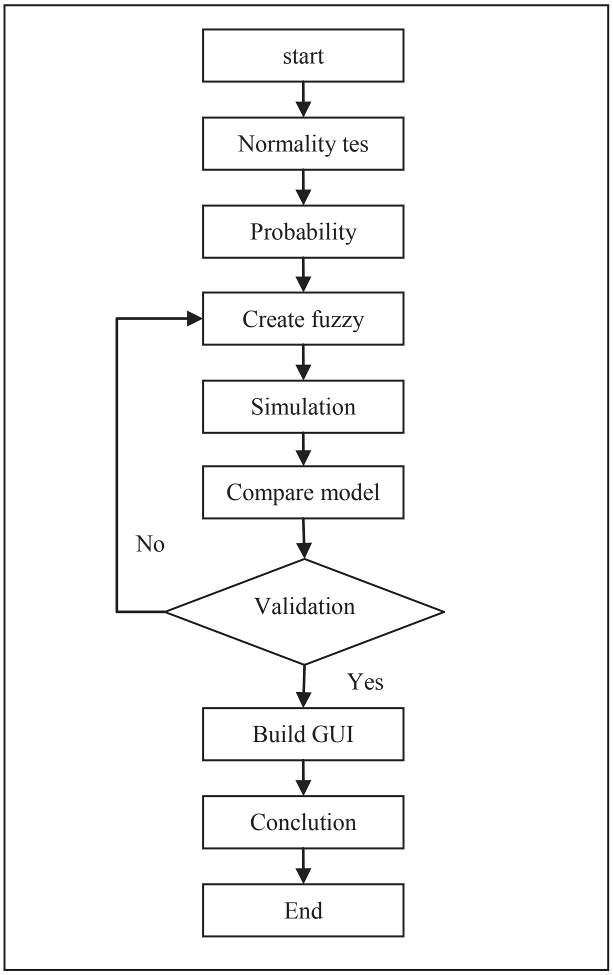

Fig. 2 Research flowchart

IV. RESULTS AND DISCUSSION

The normality test of data is uses Kolmogorov-Smirnov method, indicates that the data are normally distributed. With Asymp.Sig value (2-tailed) for the Kulon Progo 0.36> 0.05, Bantul 0.838> 0.05 and Gunung Kidul 0.105> 0.05, see Table 2. In Fig.2, Fig.3 and Fig.4 are shown a normal distribution of wind speed data for each region.

TABLE 3

ONE SAMPLE KOLMOGOROV-SMIRNOV TEST

		Kulon Progo	Bantul	Gunung Kidul
N		294	294	294
Normal Parameters[a,b]	Mean	5.1735	5.2718	5.2554
	Std. Deviation	1.43752	1.72393	1.47506
Most Extreme Differences	Absolute	.054	.036	.071
	Positive	.048	.036	.045
	Negative	-.054	-.024	-.071
Kolmogorov-Smirnov Z		.924	.619	1.214
Asymp. Sig. (2-tailed)		.360	.838	.105

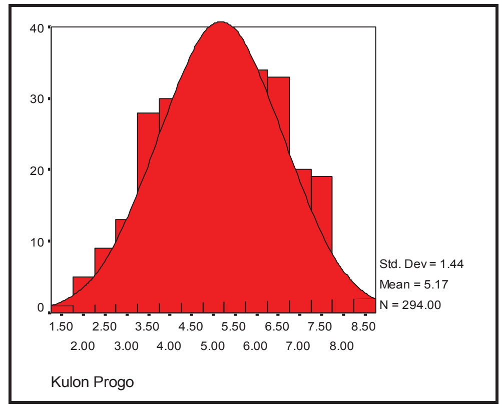

Fig.3 Result of normality test for Kulon Progo

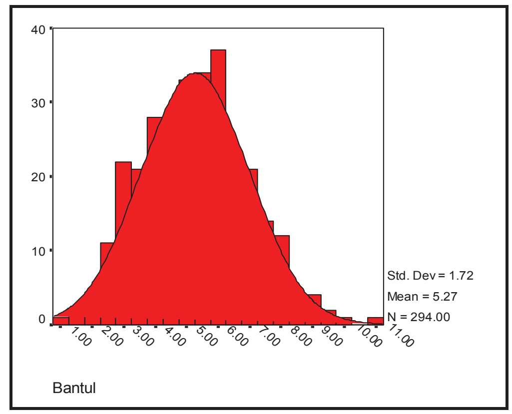

Fig.4 Results of normality test for Bantul

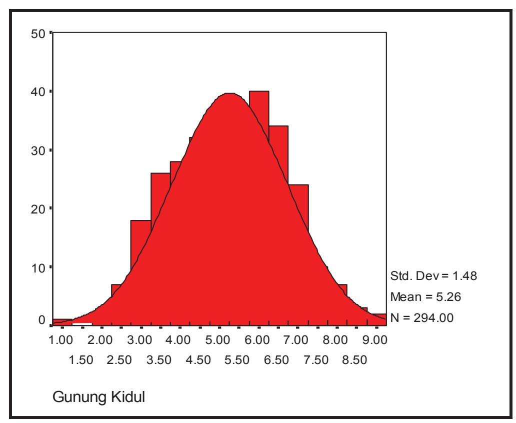

Fig.5 Results of normality test for Gunung Kidul

Furthermore, by using t-test one sample method to test the average value for each region. Based on sample of average wind speed for Kulon Progo is 5,17m / s, Bantul 5,27m / s and Gunung Kidul 5,25m / s. Then selected sample with average value for each region is 5,2m / s as average value for test. The results are shown in Table.3, With Asymp.Sig value (2-tailed) for Kulon Progo coastal 0.75> 0.05, Bantul coastal 0.476> 0.05 and Gunung Kidul coastal 0.52> 0.05.So, 5,2m / s as average test value for wind speed each location is valid with alpha value 0.05 and time series data for wind speed is normal.

TABLE 4

NORMALITY TEST FOR WIND SPEED DATA EACH LOCATION

			Statistik	Std. Error
Kulon Progo	Mean		5.1735	.08384
	95% Confidence Interval for Mean	Lower Bound	5.0085	
		Upper Bound	5.3385	
	5% Trimmed Mean		5.1898	
	Median		5.2500	
	Variance		2.066	
	Std. Deviation		1.43752	
	Minimum		1.50	
	Maximum		8.60	
	Range		7.10	
	Interquartile Range		2.2000	
	Skewness		-.114	.142
	Kurtosis		-.652	.283
Bantul	Mean		5.2718	.10054
	95% Confidence Interval for Mean	Lower Bound	5.0739	
		Upper Bound	5.4696	
	5% Trimmed Mean		5.2429	
	Median		5.3000	
	Variance		2.972	
	Std. Deviation		1.72393	
	Minimum		1.20	
	Maximum		11.10	
	Range		9.90	
	Interquartile Range		2.4250	
	Skewness		.240	.142
	Kurtosis		-.128	.283
Gunung Kidul	Mean		5.2554	.08603
	95% Confidence Interval for Mean	Lower Bound	5.0861	
		Upper Bound	5.4248	
	5% Trimmed Mean		5.2548	
	Median		5.4000	
	Variance		2.176	
	Std. Deviation		1.47506	
	Minimum		.80	
	Maximum		8.80	
	Range		8.00	
	Interquartile Range		2.2000	
	Skewness		-.083	.142
	Kurtosis		-.476	.283

Table 4 shown result from normality test of data monthly. Data monthly for each location is normal, see Fig.5 as shown curve of normality data. Then Table 5 are shown average of wind speed and amount of data.

TABLE 5

NORMALITY TES FOR WIND SPEED DATA MONTHLY

Months	Gunung kidul	Bantul	Kulon Progo
January	0.288	0.412	0.855
February	0.735	0.687	0.906
March	0.836	0.999	0.832
April	0.974	0.841	0.998
May	0.805	0.723	0.806
June	0.985	0.545	0.515
July	0.973	0.863	0.897
August	0.694	0.740	0.896
September	0.986	0.736	0.988
October	0.907	0.988	0.367
november	0.966	0.431	0.933
December	0.471	0.902	0.543
All periode	0.360	0.838	0.105

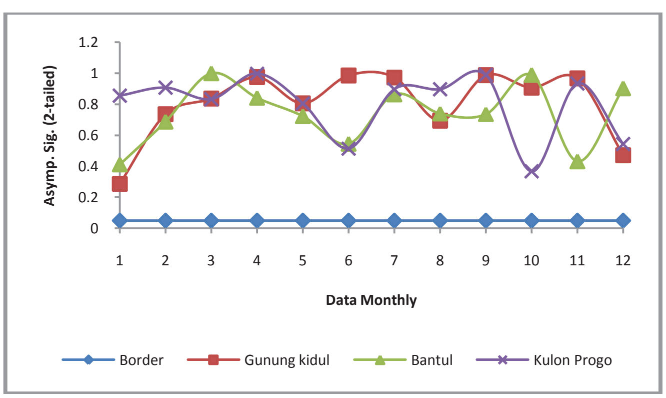

Fig.6 Result of normality test for data monthly

TABLE 6

WIND SPEED AVERAGE AND DATA MONTHLY

Months	Gunung kidul		Bantul		Kulon Progo	
January	4.829	24	4.670	24	4.470	24
February	5.275	24	5.650	24	4.841	24
March	4.108	24	4.000	24	4.237	24
April	4.775	24	4.758	24	4.875	24
May	5.812	24	5.300	24	5.675	24
June	6.229	24	5.866	24	5.925	24
July	6.162	24	6.866	24	6.283	24
August	6.179	24	5.958	24	6.129	24
September	5.779	24	5.766	24	5.825	24
October	5.175	24	5.812	24	5.375	24
november	4.537	24	4.462	24	4.683	24
December	4.120	24	4.141	24	3.708	24
A/T	5.173	294	5.271	294	5.255	294

A/T* : Average and Total.

Annual wind speed data of Kulon Progo coastal, Bantul coastal and Gunung Kidul coastal are normal distribution with sample of data is relatively large, or nearly infinite, so use the poisson probability distribution function as shown Table 6. Probability of wind speed average for each location is same relatively. See Fig 6.

TABLE 7

POISSON PROBABILITY DISTRIBUTION FUNCTION

PDF Poisson			
Winds speed (m/s)	Gunung Kidul	Bantul	Kulon Progo
1	0.0407	0.0435	0.0435
2	0.0969	0.1018	0.1018
3	0.1539	0.1587	0.1587
4	0.1832	0.1856	0.1856
5	0.1744	0.1736	0.1736
6	0.1384	0.1353	0.1353
7	0.0942	0.0904	0.0904
8	0.0561	0.0528	0.0528
9	0	0.0275	0

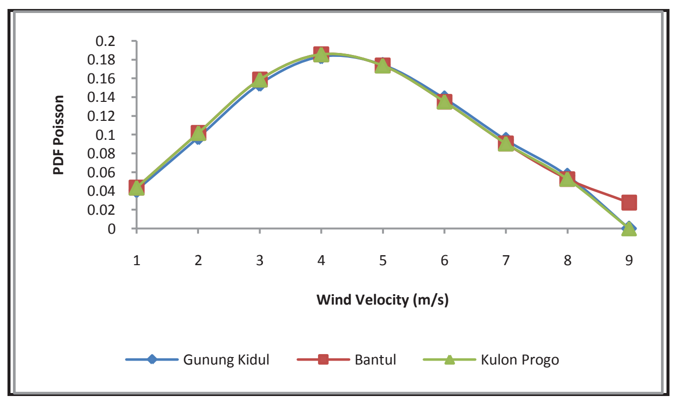

Fig.7 Curve of poisson probability distribution function

Fig.7 shown the result of fuzzy model for wind prediction in Matlab.

Compare models of fuzzy is doing with chose value minimum of Root Mean Square Error (RMSE). Than doing t-test one sample from minimum value of RMSE to known correlation among the model. See Tabel 7 and Tabel 9, the minimum value of RMSE achieved by fuzzy model with order 12.

TABLE 8
ROOT MEAN SQUARE ERROR
FUZZY MODEL OF KULON PROGO

	Kulon Progo					
Bulan	Orde 1	Orde 2	Orde 3	Orde 4	Orde 12	Orde 12T
Januari	0.000	3.190	3.720	3.190	2.340	2.510
Pebruari	2.200	2.200	3.280	1.410	0.390	2.050
Maret	4.063	0.420	0.400	0.080	2.380	1.670
April	3.227	0.280	5.650	2.000	0.890	3.420
Mei	2.700	3.990	1.040	1.040	0.300	0.730
Juni	2.800	3.780	1.020	1.020	1.230	1.620
Juli	0.000	0.180	2.080	2.080	0.680	1.620
Agustus	1.400	1.400	0.220	2.730	2.700	1.790
September	2.500	2.940	2.940	2.940	1.390	0.620
Oktober	2.561	1.510	1.510	2.270	0.100	0.980
November	1.227	0.320	0.050	0.700	1.320	0.740
Desember	1.400	0.590	1.160	0.520	0.390	0.660
Rerata	2.007	1.733	1.923	1.665	**1.176**	1.534

Based on Table 8 and Table 10, among fuzzy models order 2, 3, 4, 12 and 12 modified are not different significant with alpha value is 0.05.

TABLE 9
THE RESULTS ONE SAMPLE T-TEST
FOR FUZZY MODELS OF KULON PROGO

One-Sample Test

	Test Value = 1.176					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
orde1	2.327	11	.040	.83050	.0450	1.6160
orde2	1.341	11	.207	.55733	-.3573	1.4719
orde3	1.538	11	.152	.74650	-.3218	1.8148
orde4	1.667	11	.124	.48900	-.1567	1.1347
orde12m	1.450	11	.175	.35817	-.1856	.9020

TABLE 10
ROOT MEAN SQUARE ERROR
FUZZY MODEL OF BANTUL

	Bantul					
Bulan	Orde 1	Orde 2	Orde 3	Orde 4	Orde 12	Orde 12T
Januari	2.500	0.902	0.384	0.208	2.989	1.554
Pebruari	2.000	1.512	5.200	7.195	1.131	0.274
Maret	2.772	2.771	0.187	1.437	0.045	4.087
April	4.100	0.135	0.987	0.987	0.373	1.334
Mei	2.579	4.433	0.766	0.324	0.923	2.386
Juni	3.700	2.661	2.087	2.078	0.050	0.398
Juli	0.152	0.152	1.402	1.402	2.989	1.554
Agustus	0.430	0.719	0.719	0.335	1.131	0.274
September	0.529	0.455	1.225	1.225	0.045	4.087
Oktober	3.837	0.496	0.114	2.258	0.373	1.334
November	2.108	2.084	2.084	1.751	0.923	2.386
Desember	0.600	1.739	1.739	1.739	0.050	0.398
Rerata	2.109	1.505	1.408	1.745	**0.919**	1.672

TABLE 11
THE RESULTS ONE SAMPLE T-TEST
FOR FUZZY MODELS OF BANTUL

One-Sample Test

	Test Value = 0.919					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
orde1	2.933	11	.014	1.18992	.2969	2.0829
orde2	1.556	11	.148	.58592	-.2428	1.4146
orde3	1.234	11	.243	.48883	-.3831	1.3608
orde4	1.549	11	.150	.82592	-.3473	1.9991
orde12m	1.930	11	.080	.75317	-.1056	1.6119

Based on Table 11 and Table 12, minimum RMSE achieved by fuzzy model with order 4. Then among fuzzy models order 1, 2, 3, 4 and 12 is not different significant with alpha value is 0.05.

TABLE 12
ROOT MEAN SQUARE ERROR
FUZZY MODEL OF GUNUNG KIDUL

	Gunung Kidul					
Bulan	Orde 1	Orde 2	Orde 3	Orde 4	Orde 12	Orde 12T
Januari	0.100	2.757	3.945	3.945	1.954	1.412
Pebruari	0.552	0.600	2.147	1.238	1.232	1.012
Maret	0.718	1.559	1.459	1.232	3.522	5.226
April	1.450	1.260	1.260	1.260	0.992	2.213
Mei	5.109	4.141	0.043	0.042	0.544	2.919
Juni	1.150	2.296	1.920	1.920	3.751	3.196
Juli	1.284	0.400	2.577	2.577	1.954	1.412
Agustus	0.871	0.146	0.146	0.026	1.232	1.012
September	1.744	1.512	1.817	1.817	3.522	5.226
Oktober	1.400	0.019	0.226	0.863	0.992	2.213
November	1.274	0.615	0.931	1.109	0.544	2.919
Desember	2.431	2.610	2.283	0.494	3.751	3.196
Rerata	1.507	1.493	1.563	**1.377**	1.999	2.663

TABLE 13
THE RESULTS ONE SAMPLE T-TEST
FOR FUZZY MODELS OF GUNUNG KIDUL

One-Sample Test

	Test Value = 1.377					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
orde1	.351	11	.732	.12992	-.6840	.9438
orde2	.320	11	.755	.11592	-.6811	.9130
orde3	.563	11	.584	.18583	-.5402	.9118
orde12	1.675	11	.122	.62217	-.1956	1.4399
orde12m	3.093	11	.010	1.28600	.3708	2.2012

Based on one sample test for fuzzy models in Table 8, Table 10 and Table 12 are chose fuzzy model order 12 for each location.

Furthermore, fuzzy models has chosen will be tested by paired samples t-test.

The results are shown in Table 14.

TABEL 14
THE RESULT PAIRED SAMPLES T-TEST
FOR FUZZY MODEL OF KULON PROGO

Paired Samples Test

		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	DATA1 - KP0121	.9000	1.58367	.64653	-.7620	2.5620	1.392	5	.223
Pair 2	DATA2 - KPO122	1.6833	.79854	.32600	.8453	2.5214	5.164	5	.004
Pair 3	DATA3 - KPO123	.3000	1.25220	.51121	-1.0141	1.6141	.587	5	.583
Pair 4	DATA4 - KPO124	-.8000	1.62111	.66182	-2.5013	.9013	-1.209	5	.281
Pair 5	DATA5 - KPO125	1.3000	2.26539	.92484	-1.0774	3.6774	1.406	5	.219
Pair 6	DATA6 - KPO126	.4333	1.97349	.80567	-1.6377	2.5044	.538	5	.614
Pair 7	DATA7 - KPO127	1.3667	.82624	.33731	.4996	2.2337	4.052	5	.010
Pair 8	DATA8 - KPO128	1.4667	.73394	.29963	.6964	2.2369	4.895	5	.004
Pair 9	DATA9 - KPO129	.9333	1.62193	.66215	-.7688	2.6354	1.410	5	.218
Pair 10	DATA10 - KPO1210	2.0333	1.19778	.48899	.7763	3.2903	4.158	5	.009
Pair 11	DATA11 - KPO1211	1.0667	1.13255	.46236	-.1219	2.2552	2.307	5	.069
Pair 12	DATA12 - KPO1212	.3833	1.15484	.47146	-.8286	1.5953	.813	5	.453

Table 13. shown the results test of T-Test for wind predictive model of Kulon Progo coastal. By using alpha value of 0.05, the results are valid for the month of January, March, April, May, June, September, October and November.

TABLE 15
THE RESULT PAIRED SAMPLES T-TEST
FOR FUZZY MODEL OF BANTUL

Paired Samples Test

		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	DATA1 - BO121	.5667	1.56801	.64014	-1.0789	2.2122	.885	5	.417
Pair 2	DATA2 - BO122	1.3500	1.40677	.57431	-.1263	2.8263	2.351	5	.066
Pair 3	DATA3 - BO123	.8500	1.04833	.42798	-.2502	1.9502	1.986	5	.104
Pair 4	DATA4 - BO124	.3333	2.81330	1.14853	-2.6190	3.2857	.290	5	.783
Pair 5	DATA5 - BO125	1.0000	2.34435	.95708	-1.4602	3.4602	1.045	5	.344
Pair 6	DATA6 - BO126	-1.5667	2.22950	.91019	-3.9064	.7730	-1.721	5	.146
Pair 7	DATA7 - BO127	1.9500	.76616	.31278	1.1460	2.7540	6.234	5	.002
Pair 8	DATA8 - BO128	-.2833	1.00879	.41184	-1.3420	.7753	-.688	5	.522
Pair 9	DATA9 - BO129	.2167	1.66543	.67991	-1.5311	1.9644	.319	5	.763
Pair 10	DATA10 - BO1210	2.7833	.50761	.20723	2.2506	3.3160	13.431	5	.000
Pair 11	DATA11 - BO1211	1.5667	.93310	.38093	.5874	2.5459	4.113	5	.009
Pair 12	DATA12 - BO1212	.4500	2.02064	.82492	-1.6705	2.5705	.546	5	.609

By using alpha value of 0.05, the results obtained are valid for prediction models on January, February, March, April, May, June, August, September, December.

TABLE 16
THE RESULT PAIRED SAMPLES T-TEST
FOR FUZZY MODEL OF GUNUNG KIDUL

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	DATA1 - GKO41	-1.6167	1.79824	.73413	-3.5038	.2705	-2.202	5	.079
Pair 2	DATA2 - GKO42	.4167	2.37774	.97071	-2.0786	2.9120	.429	5	.686
Pair 3	DATA3 - GKO43	1.0500	.86891	.35473	.1381	1.9619	2.960	5	.032
Pair 4	DATA4 - GKO44	.8667	1.96435	.80194	-1.1948	2.9281	1.081	5	.329
Pair 5	DATA5 - GKO45	-.2333	1.33965	.54691	-1.6392	1.1725	-.427	5	.687
Pair 6	DATA6 - GKO46	-1.7500	1.12205	.45808	-2.9275	-.5725	-3.820	5	.012
Pair 7	DATA7 - GKO47	-.3333	2.41053	.98410	-2.8630	2.1964	-.339	5	.749
Pair 8	DATA8 - GKO48	-.5833	1.51844	.61990	-2.1768	1.0102	-.941	5	.390
Pair 9	DATA9 - GKO49	.1500	1.59593	.65154	-1.5248	1.8248	.230	5	.827
Pair 10	DATA10 - GKO410	.9167	1.04003	.42459	-.1748	2.0081	2.159	5	.083
Pair 11	DATA11 - GKO411	-.5500	1.36931	.55902	-1.9870	.8870	-.984	5	.370
Pair 12	DATA12 - GKO412	.3500	1.59844	.65256	-1.3275	2.0275	.536	5	.615

By using alpha value of 0.05, the results are valid except for the month of March. Predicted winds Gunung Kidul coastal for March have significance below 95%.

The results paired samples t-test all location in Yogyakarta coastal as shown in Table 16.

TABLE 17
VALIDITY FUZZY MODELS FOR WINDS PREDICTION IN YOGYAKARTA COASTAL

Months	Gunung Kidul	Bantul	Kulon Progo
January	Valid	Valid	Valid
February	Not valid	Valid	Valid
March	Valid	Valid	Not valid
April	Valid	Valid	Valid
May	Valid	Valid	Valid
June	Valid	Valid	Valid
July	Not valid	Not valid	Valid
August	Not valid	Valid	Valid
September	Valid	Valid	Valid
October	Valid	Not valid	Valid
november	Valid	Not valid	Valid
December	Not valid	Valid	Valid

Fig.7 shown fuzzy model for wind prediction in Kulon Progo with 18 rules from results of the substractive cluster method. Amount of rules for fuzzy model Bantul and Gunung Kidul are same, 18 rules.

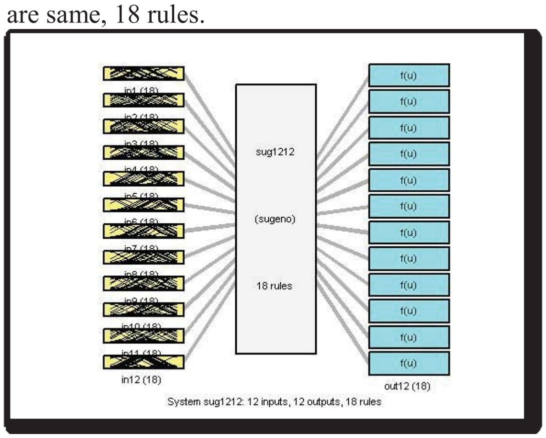

Fig.8 Fuzzy model twelfth order for wind prediction Kulon Progo

See Fig.8, Fig.9 and Fig.10 for curve pattern between winds speed data with results of prediction wind speed. The data was represented with blue line and results of prediction was represented with red line. The results consecutive Kulon Progo, Bantul and Gunung Kidul did not able to follow pattern of data.

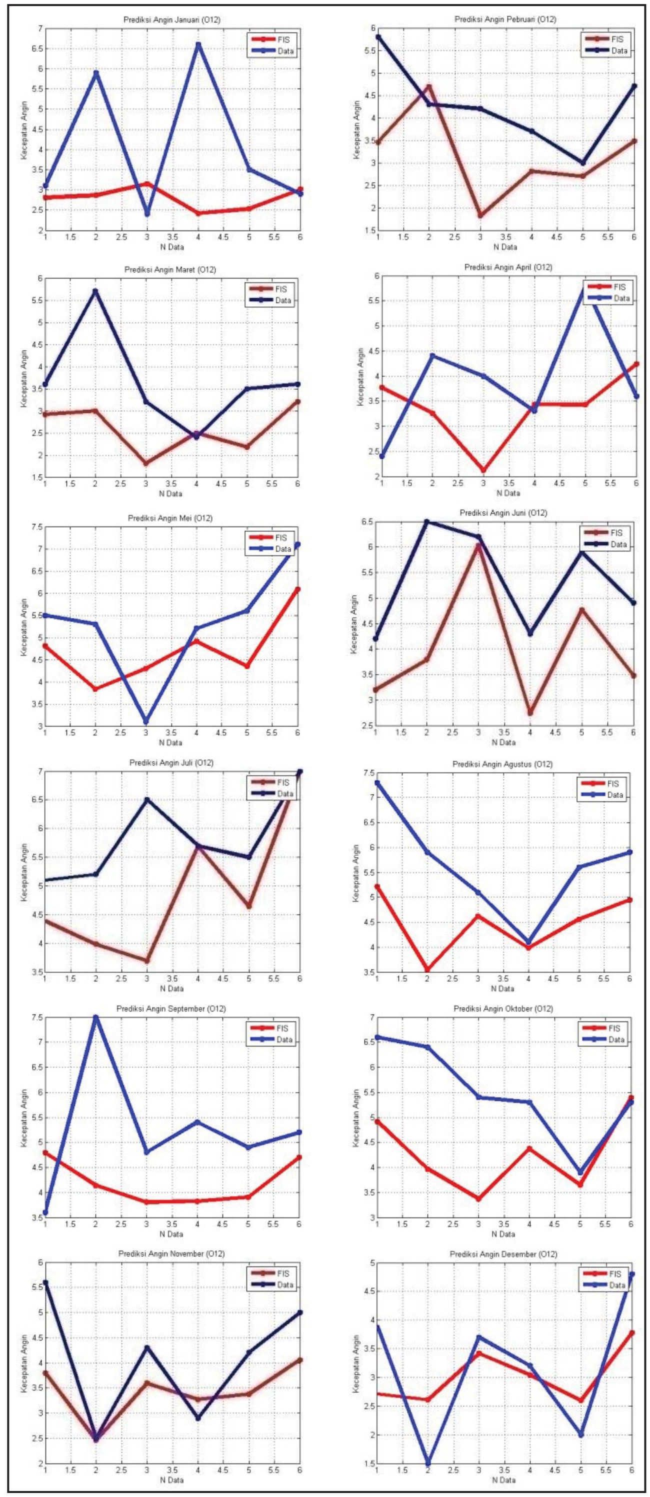

Fig.9 Results of simulation for winds prediction Kulon Progo

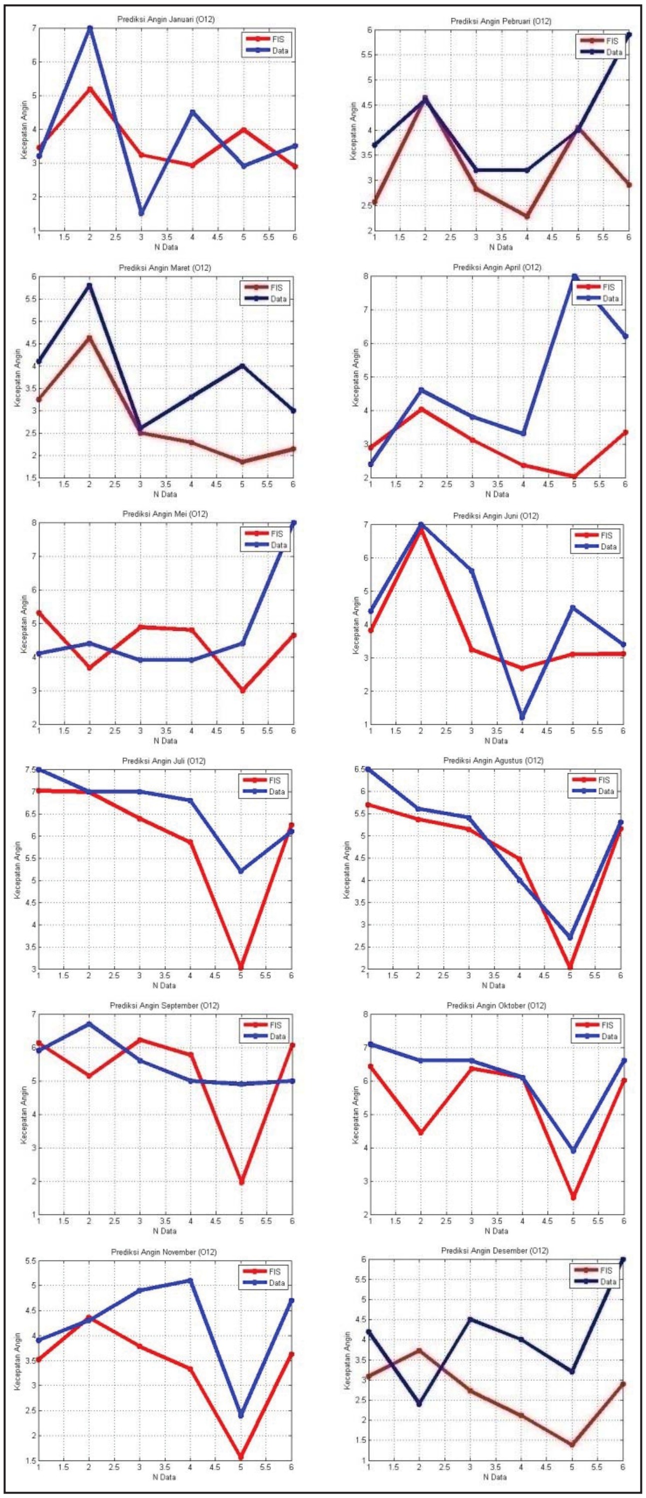

Fig.10 Results of simulation for winds prediction Bantul

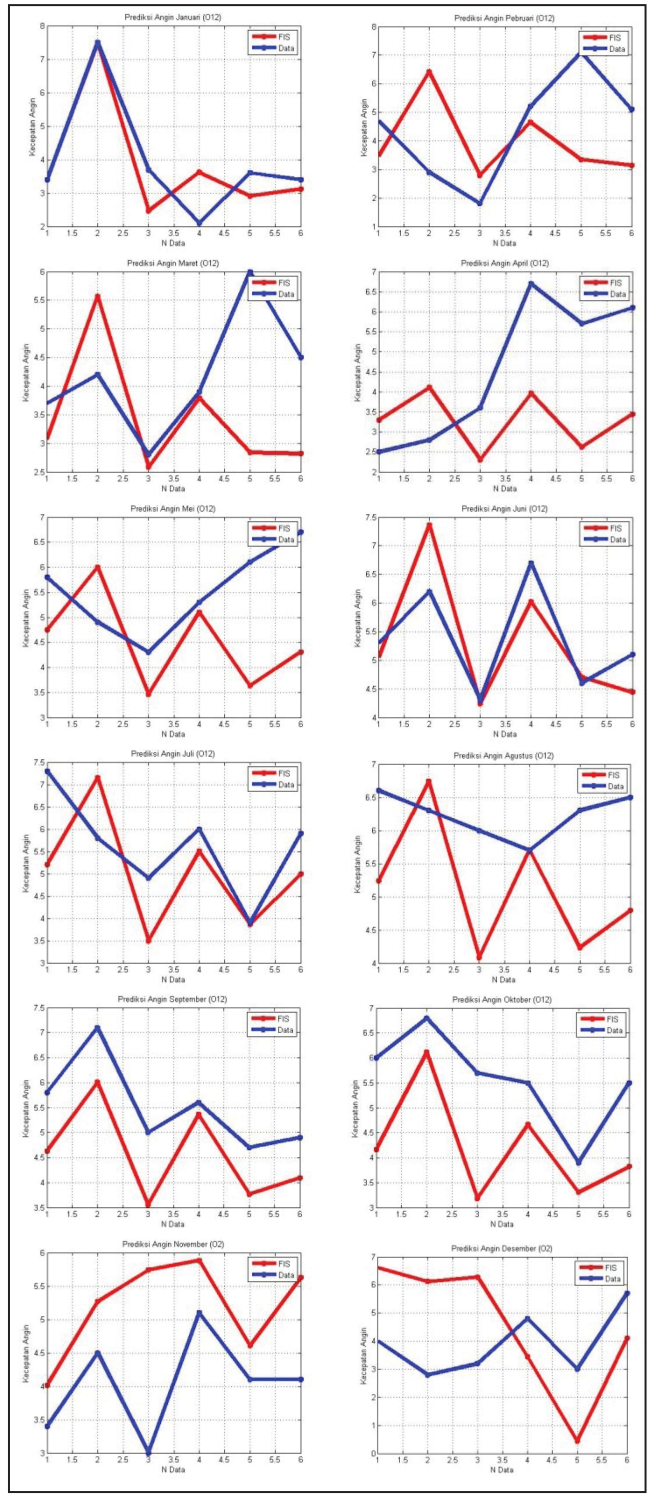

Fig.11 Results of simulation for winds prediction Gunung Kidul

Fig.11 shown the results of the design analysis of wind energy for one year using Matlab R2013a, then Fig.12 shown the results for monthly prediction. Blue bar diagram are represents the value of the wind speed data. Green bar diagram are represents the predicted value of the wind speed in the next year. Red line is the value of the averages wind speed Yogyakarta coastal for a period of 18 years.

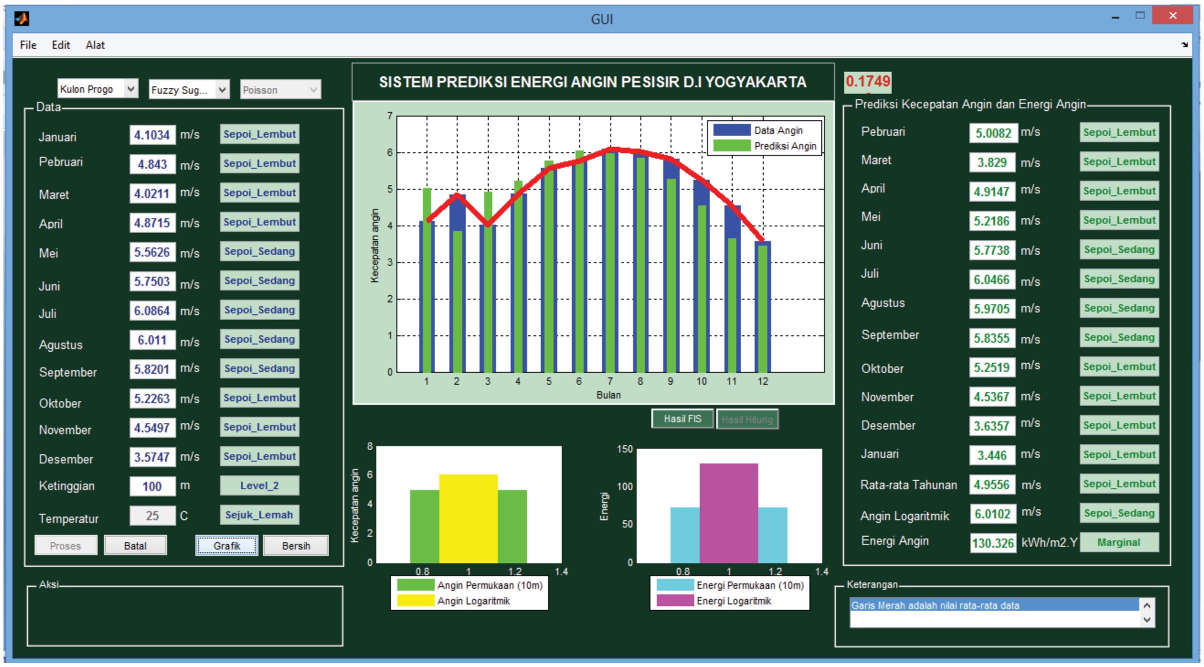

Fig.12 Design Program for yearly energy analysis

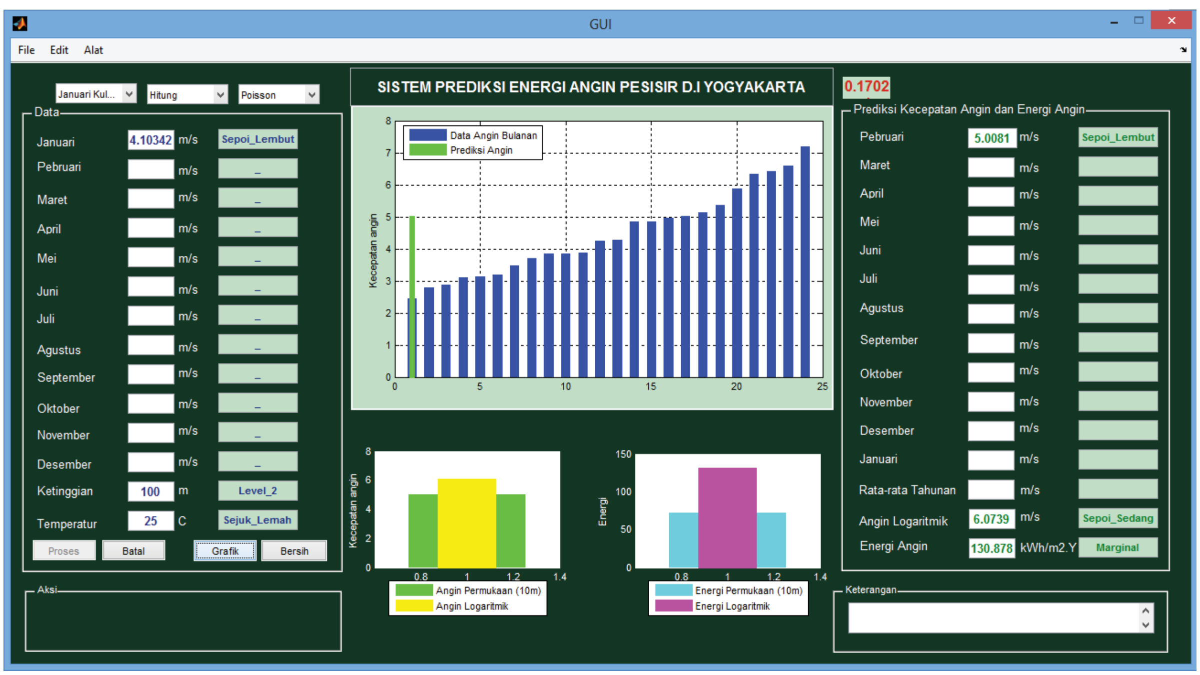

Fig.13 Design Program for monthly energy analysis

See Table 17, a scenario for supply wind energy from winds speed in Yogyakarta coastal. The results of prediction achieved by input value of wind speed average from data.

TABLE 18

THE RESULTS OF PREDICTION WIND SPEED FOR NEXT YEAR

Months	Gunung Kidul	Bantul	Kulon Progo
January	4.4	4.5	3.4
February	5.2	5.5	5.0
March	3.8	3.7	3.8
April	4.7	4.9	4.9
May	5.3	5.0	5.2
June	6.0	5.5	5.8
July	6.0	6.5	6.0
August	6.0	5.7	6.0
September	5.8	5.8	5.8
October	5.1	5.7	5.2
november	4.6	4.4	4.5
December	4.0	3.8	3.6
Average	5.1	5.1	4.9
Probability	0.17	0.17	0.17
Class of Energy	77.66	77.93	72.15

The results prediction consecutively Gunung Kidul, Bantul and Kulon Progo are 5.1m/s, 5.1m/s and 4.9m/s. it is different with QuikSCAT where the potential of wind speed in Yogyakarta coastal is 6m/s up to 7m/s.

Based on Table 17, then calculate class of energy to know potential. The correlation between class of energy with hub height were shown in Table 18. We chosen 5.0m/s for potential of wind speed to analysis class of energy.

TABLE 19

THE CLASS OF ENERGY IN YOGYAKARTA COASTAL

Height hub	Wind Prediction	Power (kWh)	Class of Energy
10	5.0	74.34	Poor
50	5.7	113.31	Marginal
100	6.1	134.27	Marginal
150	6.2	148.16	Marginal
200	6.4	158.95	Fair
250	6.5	168.02	Fair
300	6.6	175.97	Fair
400	6.7	189.79	Fair
500	6.8	201.93	Good

At last, the operational sea surface wind field forecasts system was not a mature work. We must do more experiments to study how initial and boundary condition affect the model, and improve the model predict capability to forecast different weather procedures better.

V. CONCLUSION

There are some things that was generated in this study :

a. Annual wind speed coastal Yogyakarta, like in Kulon Progo, Bantul and Gunung Kidul are 5.0m/s-5.3m/s.

b. The results shown that the potential of wind energy in Yogyakarta coastal, including poor energy class at a height of 10m. While it is based on a variable height of terrain from sea surface indicate that wind energy potential in Yogyakarta coastal will be entered into good class at a height of 500mdpl. Based on data elevation from sea surface, Gunung Kidul coastal is potential to wind energy, because have height about 50m-250m.

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