WIND FARM DESIGN FOR OELBUBUK IN EAST NUSA TENGGARA, INDONESIA

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ABSTRACT

Electrification ratio of NTT is 28.7 % in 2008. Technical and economical assessments to investigate the possibilities to implement wind farm in East Nusa Tenggara (NTT) province is directed to contribute in the effort to raise the electricity ratio in this province. Some areas are having yearly average wind speed greater than 5 m/sec and the wind power density greater than 300 Watt/m^2 . Wind farm is proposed to reduce local dependency to Diesel Power Plant (DPP) and to exerting an effort to reduce CO_2 emission.

The result of survey, Wind Energy Conversion (WEC) selection and simulation to get wind farm configuration for Oelbubuk, in South Central Timor (TTS) Regency in NTT is described. The evaluation of three different WEC having capacity greater than 250kW per unit and its formation are described. The assessment of electricity facilities of DPP in SOE city, its load profile in 2008 and the possible of interconnection to wind farm are described.

Key words : East Nusa Tenggara (NTT), diesel power plant (DPP)Indonesia, SOE, WEC, wind farm.

ABSTRAK

Rasio elektrifikasi NTT 28,7% pada tahun 2008. Pengkajian secara teknis dan ekonomis untuk mengetahui kemungkinan penerapan ladang angin (*wind farm)* di propinsi Nusa Tenggara Timur (NTT) diarahkan untuk berkontribusi dalam upaya meningkatkan rasio kelistrikan di provinsi ini. Beberapa lokasi memiliki kecepatan angin rata-rata tahunan lebih besar dari 5 m/detik dan densitas tenaga angin lebih besar dari 300 Watt/m2. "Wind Farm" diharapkan dapat mengurangi ketergantungan pada Pembangkit Listrik Tenaga Diesel (PLTD) dan merupakan usaha mengurangi emisi CO2.

Disini dipaparkan hasil survey, pemilihan Sistem Konversi Energi Angin (SKEA) dan simulasi untuk mendapatkan konfigurasi angin untuk lokasi Oelbubuk, di Kabupaten Timor Tengah Selatan (TTS) di NTT. Evaluasi dari tiga SKEA berbeda yang memiliki kapasitas lebih besar dari 250kW per unit dan disain formasi peletakannya juga dijelaskan. Pengkajian fasilitas pembangkit listrik tenaga disel (PLTD) di Kota SOE, profil beban pada tahun 2008 dan kemungkinan interkoneksi untuk "wind farm" juga diuraikan

Kata kunci : Ladang angin, Nusa Tenggara Timur (NTT), Pembangkit Listrik Tenaga Diesel (PLTD), Sistem Konversi Energi Angin (SKEA), SOE.

1. INTRODUCTION

Blue Print Pengelolaan Energi Nasional 2005 [1] shows the road map of wind energy conversion (WEC) implementation target. In 2025, WEC *off-grid* will be 5 MW and WEC *on-grid* 250 MW.
The Second Accelerated Electric Development will apply Renewable Energy (RE) until 70% of 10000 MW target, mainly geothermal and hydro [2]. However, this policy is expected giving a more chance to implement WEC. The investigation described following is in the frame of incentive research 2008, managed by the Ministry for Research and Technology. The target is to design wind farm in South Central Timor (TTS) Regency in East Nusa Tenggara (NTT) Province that having the best wind potential among other locations in West Timor island. These areas have not reach by the grid of the existing diesel power plant (DPP) in SOE city, the capital of TTS Regency.

Policy for electricity power plant in NTT is directed to reduce the use of diesel fuel. This policy and the local wind energy could be combined to create a grid extension possibility for WEC implementation. This combination can be named as Hybrid WEC- DPP.
The electricity from the existing DPP could be used to raise electricity supply to the closer surrounding areas without disturbing the diesel supply chain.

<u>Comparing RE Electricity Power Plant (REEPP) with Conventional Electricity Power Plant (CEPP)</u>

Mindset that compares the initial capital needed to implement RE Electricity Power Plant (REEPP) to Conventional Electricity Power Plant (CEPP) that use fossil fuel need to be assessed.

National burden to maintain fossil fuel subsidy need by PLN (the national electricity provider) in the year 2007 reach IDR 70 10^{12}. In 2009, the subsidy is expected to decline to IDR 60.4 10^{12} [3]
Fossil fuel subsidy (FFS) and fuel budget (FB) need to be counted. CEPP implementation is considered cheap however the emission comes out from CEPP that is believed raised the global warming need to be counted. Let say, a compensation that should be pay for this pollution is:
IDR zz/$kWh_{emission}$. The capital for CEPP implementation is: IDR xx/kWh_{CEPP}

Capital for RE Electricity Power Plant implementation is IDR yy/kWh_{REEPP}
Bad whether and storm as Climate Change consequent raise the risk of distribution ship to sail for a certain period. This will lead to void of good and diesel fuel in some islands.
In this situation, WEC could provide electricity. This means a better fuel security (BFS) and increase the security of electricity supply (SES). The existing WEC could raise the local pride (LP) indicating local toughness (ILT) in overcoming the energy scarcity problem. The difficulties in WEC implementation is a good point to show local ability in

exhibiting local energy self sufficient (LESS). There is a chance to learn and practice on WEC that will raise the local knowhow (RLK). The following equation represents a new mindset that is written as:

$$\mathbf{yy/kWh_{REEPP} + (BFS+SES+LP+ILT+LESS+RLK) = xx/kWh_{CEPP} + zz/kWh_{emission} + FFS + FB} \quad (1)$$

(BFS+SES+LP+ILT+LESS+RLK) is valuable and priceless. It covers targets of development purpose in several sectors (energy and security, implemantation of the national planning, education that indicate the quality of human resource and character building). Tax holiday will raise the attractiveness to implement REEPP.

2. SITE SELECTION

Wind data from various sites in East Nusa Tenggara Province are shown in Table 1**.** Three villages having the highest wind speed are selected for evaluation, those are: Fatukolen, Oelbubuk and Tomenas in the South-Central Timor (TTS) Regency. The evaluation based on the existing infrastructur, wind energy potential, electricity demand leads to eliminating Tomenas.

WEC implementation and installation at the selected location will require considerations of:

- the weight of each component (ton)
- the size of each component (its length, wide,
- thickness and height)
- easiness in transport, installation, operation and maintenance.
- capital needed for installation.

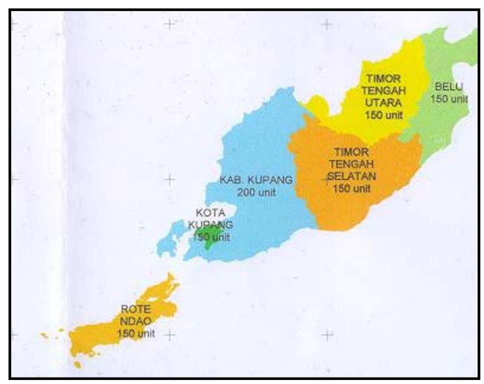


Fig. 1. West Timor island, NTT

Fatukolen is in a mountanous area. The road is winding. Finally Oelbubuk is the candidate to be analysed further. Oelbubuk lies at 124°17'18" East Longitude, 09°46'23.3" South Latitude, 1100 meters above sea level and 13 kilometers from SOE. Wind data in 1998 is given in Fig. 2. Wind direction distribution is shown in Fig. 3. Wind speed data and wind direction per hour are evaluated statistically to see its wind distribution per sector (*Energy Rose*), see Fig. 4. Weibull Distribution is given in Table 2.

Table 1. Wind potential at some location in NTT [4;5]
Energy Pattern Factor (EPF) = 2

No	Location	Yearly average wind speed (m/s) at height of 50 m	k	A	Power density, W/m2	Energy density, kWh/m2
1	Oelbubuk, TTS,	7.30	2.00	7.63	456.91	8005.0
2	Fatukolen, TTS	7.64	2.34	8.62	557.43	9766.2
3	Babia, TTS	5.59	2.29	6.72	218.35	3825.4
4	Buat, TTS	6.31	2.50	7.11	314.05	5502.1
5	Niki, TTS	4.38	2.00	4.94	105.03	1840.2
6	Amarasi, Kupang	4.47			111.64	1955.9
7	Ekateta, Kupang	4.31			100.08	1753.4
8	Hansisi, Kupang	4.39			105.76	1853.9
9	Sulamu, Kupang	4.75			133.96	2347.0
10	Hituk, Rote	6.43			332.31	5822.1
11	Boa, Rote	6.20			297.91	5219.4
12	Hundihopo, Rote	4.74			133.12	2332.3
13	Sanggaem, Rote	5.76			238.88	
14	Sakteo, TTS	6.26			306.64	
15	Tomenas, TTS	7.56			540.10	
16	Netpala, TTS	5.83			247.69	

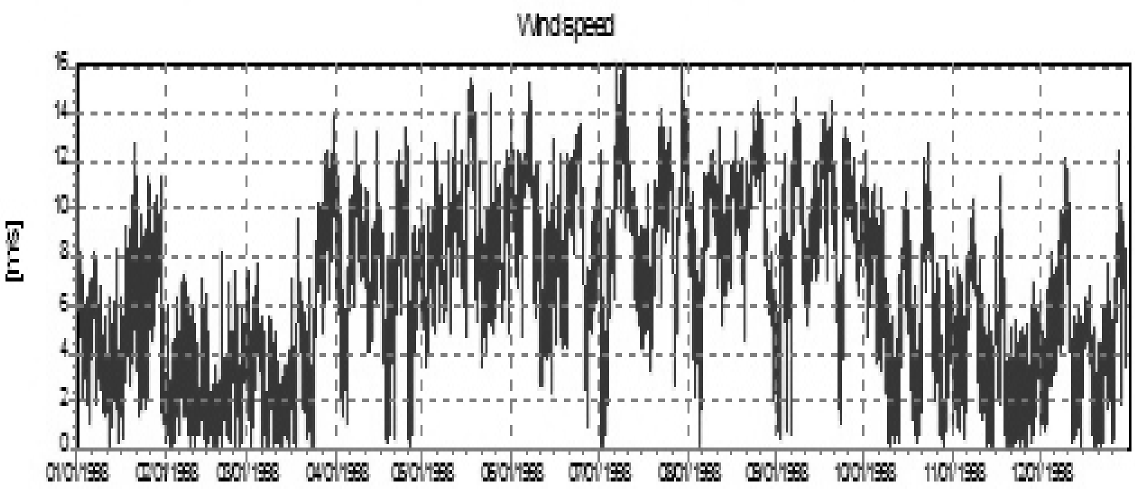


Fig. 2. Average wind speed at Oelbubuk in 1998.
There are two average values: the high value (7.5m/sec) in April until the first week of October and the low value (4m/sec) in the second week of October until the end of March.

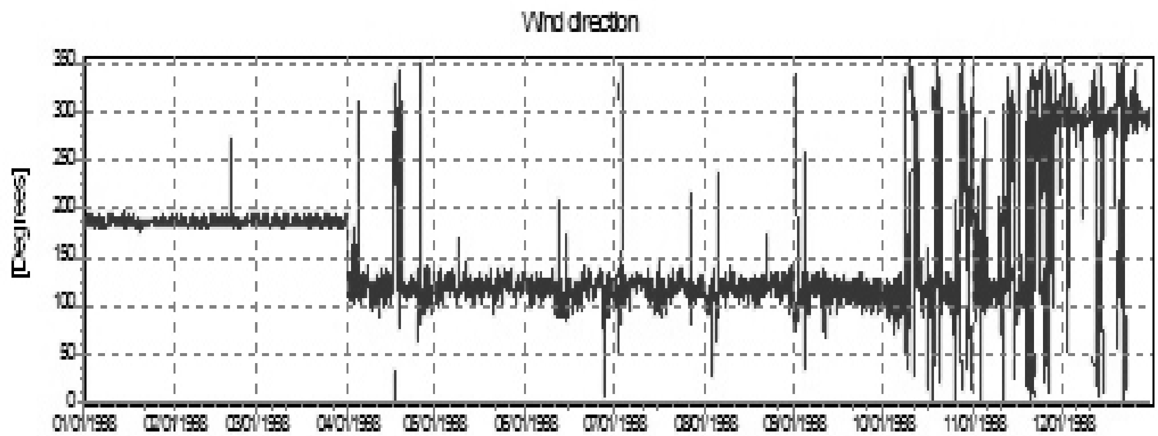


Fig. 3. Wind direction at Oelbubuk in 1998.
In April until middle of October, the wind direction is sTable at 120 degree.
In January until April is sTable at 190 degree

Table 2. Weibull Distribution at Oelbubuk, NTT

Sector	Parameter-A	Average wind speed (m/s)	Parameter-k	Frequency (%)
0- N	2.276	2.561	1.2053	0.685
1-NNE	3.288	2.938	1.6662	0.434
2-ENE	4.658	4.153	1.7225	0.365
3-E	8.319	7.469	3.3560	10.171
4-ESE	9.824	8.877	3.7848	46.689
5-SSE	5.590	5.060	1.4664	2.763
6-S	4.787	4.288	1.6191	25.103
7-SSW	2.874	2.579	1.5898	1.050
8-WSW	2.866	2.626	1.3559	0.559
9-W	4.040	3.673	1.4249	1.861
10-WNW	5.570	4.944	2.0104	9.053
11-NNW	3.437	3.066	1.7075	1.267
	7.634	6.762	2.0657	100

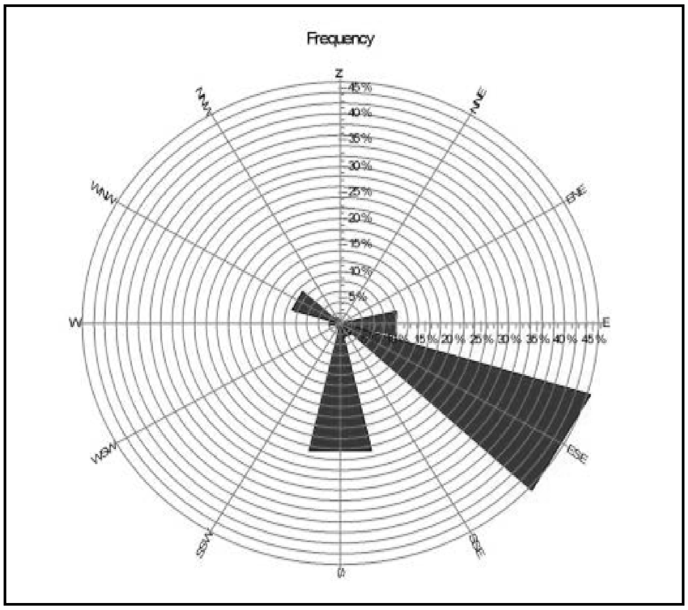


Fig. 4. Wind distribution per sector (*Energy Rose*) at Oelbubuk

3. WEC SELECTION FOR WIND FARM

Wind farm consist of a number WEC's, inter-connection system such as transmission system, transformer, current cut-off, distribution cable etc., panel for monitoring and distribution control.

Selection criteria of WEC for Wind Farm are:

- Nominal power, Installed capacity
- Rotor sweeping. Need to consider rotor ability to match the wind speed fluctuation and direction change as shown in wind rose diagram**.** This input is important to calculate the efficiency of conversion.
- WEC operational need (start up, cut in, rated, cut out, maximum)
- Capacity factor (CF)
- Annual energy production (kWh or AkWh)
- Availability to provide electricity
- Life time and Reliability
- WEC selection criteria also consider the possibility for local fabrication.

The annual energy production of wind turbine could be projected based on information of Weibull distribution curve and a power curve given in factory's technical leaflet, see Fig. 5. The annual energy production and the c*apacity factor (CF) of 32 different* WEC having capacity in the range of 250 kW – 600 kW are shown in Table 3.

To find out a wind farm configuration, a software named WindPRO 2 Version 2.5 that developed by EMD International A/S Denmark and software named Homer are used.
The following assumptions are used for trial.

- WEC capacity 330 kW (similar to Enercon E-33), blade number 3, diameter (D) 33m,
- Tower height >50 m, use pitch control.
- Annual energy production per unit at the average wind speed of 7.5 m/s is 1171.5 MWh
- Number of WEC is 10 to reach total capacity of 3.3 MW.

The local parameters applied are:
Geographical site: 124°17'18" East Longitude, 09°46'23.3" South Latitude

- Yearly average wind speed: 7.5 m/s, at height of wind measurement: 50 m
- Dominan wind direction: from south-east
- Height type: Weibull 30 m
- Annual energy density: 3.763 kWh/m2
- Wake model data:
    - naf height: 50 m, air density at naf height, ρ = 1.175 kg/m3
    - average temperature at naf height: 25.5 Celcius
    - air pressure at wind turbine: 100.5 hPa
    - wake decay constant: 0.075

The simulation shows:

- Annual energy production of each WEC is 1171.5 MWh.
- Capacity factor: 40.5 %
- Annuall, the wind farm provides 11.715 GWh.
- Efisiensi wind farm: 96.1 %
- Annual energy netto from the wind farm: 10.543 GWh
- Capacity factor of wind farm: 36.4 %

The electricity grid in remote area usually is very weak in voltage, while the wind energy so strong. This limitation causes difficulties in making decison to select the WEC capacity.

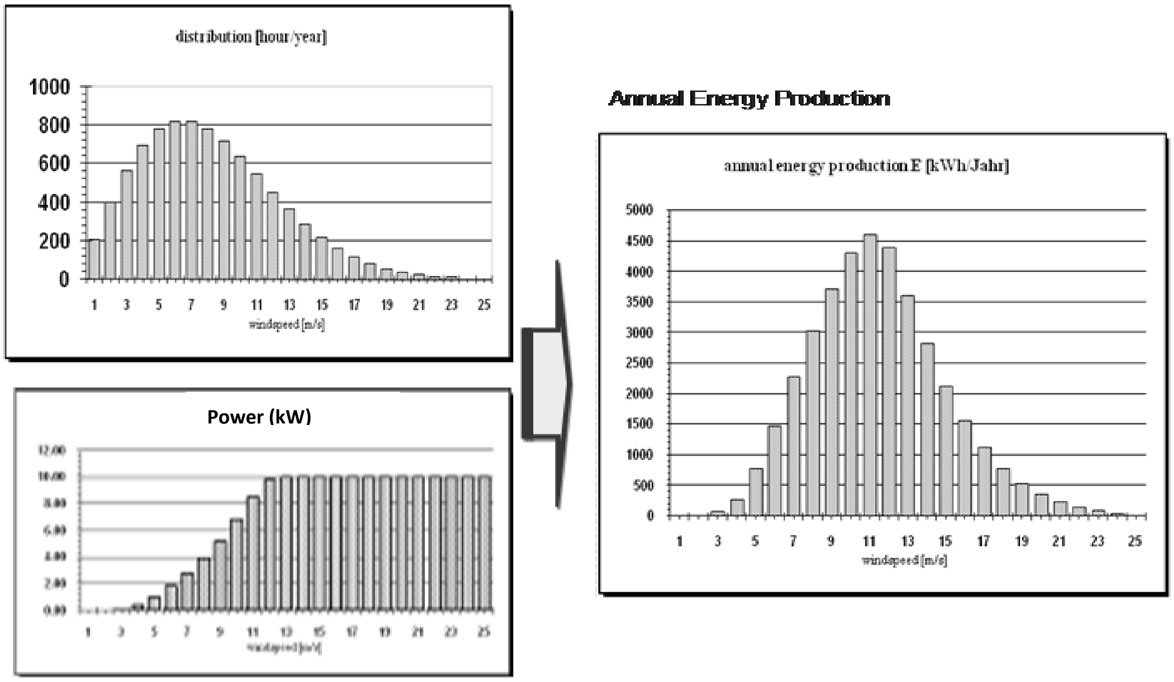


Fig. 5. Weibull distribution curve, power curve and annual energy production curve of WEC

Table 3. Evaluated Annual Energy output from several wind turbine

The average wind speed is 7.5 m/s at the height of measurement 50 meters above ground level.

Factory name	Type of WEC	Power (kW)	Diameter (m)	Annual Energy Production (MWh)		Capacity Factor (%)
				Max	netto	
AN BONUS	AN 300	300	33	1019	917	38.8
BONUS	MKII	300	33	1002	903	38.1
DEWIND	D4/46	600	46	2071	1864	39.4
ENERCON	E-33	330	33	1165	1049	40.3
MICON	M750	250	31	833	750	38.0
MICON		250	25	626	564	28.6
FURLANDER	FL 250	250	29.5	689	621	31.5
JACOBS	41/500	500	43	1718	1547	39.2
MADE	AE-32	330	32	958	862	33.1
FLOWIND	EHD	300	19	416	374	15.8
LAGERWEY		250	30	733	660	33.5

LAGERWEY	LW27/250	250	27	592	533	27.0
NEDWIND	NW31/2	250	31	830	747	37.9
NEDWIND	NW41/2	500	40.8	1419	1277	32.4
SUDWIND	S-33	350	33.4	986	887	32.1
SUDWIND	S-31	270	31.4	833	750	35.2
NORDTANK		300	31	907	816	34.5
NORDTANK		500	37	1345	1211	30.7
TACKE	TW300	300	33	924	832	35.1
NORDEX	N29-250	250	29.7	764	688	34.9
NEPC		250	27.6	656	590	29.9
VESTAS	V29	225	29	773	695	39.2
TURBOWIND	T400_34	400	34	1136	1022	32.4
VENTIS	V40	500	40	1484	1335	33.9
WEST	MEDIT	320	33	988	889	35.2
WTN	329	300	29	729	657	27.7
WTN	646	600	46	2019	1817	38.4
WINCON	W250/29	250	29	648	583	29.6
WINCON	W600/45	600	45	1793	1613	34.1
WINDWORD	W-2920	250	29.2	726	653	33.1
WINDWORD	W-3700	550	37	1344	1209	27.9
WINDMASTER		300	30	911	820	34.6

4. WIND FARM CONFIGURATION FOR OELBUBUK

Considering the infrastructure in Oelbubuk and the existing limitation in transport facilities and lifting equipment, therefore three WEC of 250-350 kW is selected for further evaluation, those are:

- Vestas type V-29 (225 kW)
- Enercon type E-33 (330kW)
- DeWind type D4/46 (600 kW)

For Oelbubuk, wind farm configuration could be in matrix formation, a minimum distance between WEC is 3D in serie/line and 4D in parallel/colom. More WEC can be used depend on the electricity distribution demand and a future development that aim to provide electricity for wider areas surround TTS Regency.

From the simulation, the first configuration is 10 units Enercon E-33 of 330 kW each and is given in Fig. 6. The arrangement is 3 lines shaping 3-4-3 formation. The tower height is 50 m. The best orientation is 60 degree. Dominant wind direction is sector 5 (90-120degree). Annual energy production of the wind farm is 10.544 GWh and CF is 40.5%.

The second alternative is 5 units DeWind D4/46 of 600 kW each that give a total energy output of 3 MW. The arrangement is 2 lines shaping 2-3 formation. The best orientation is 30 degree. Dominant wind direction is sector 5, see Fig. 7. Annual energy production of the wind farm is 9.411 GWh and CF is 35.8 %.
The third alternative is 14 units Vestas V-29 of 250 kW each that will give total energy as much as 3.15 MW. The arrangement is 3 lines shaping 5-5-4 formation. The best orientation is 60 degree. Dominant wind direction is sector 5, see Fig. 8. Annual energy production of the wind farm is 9.832 GWh and CF is 35.6 %.

Fig. 6. The configuration of 10 units Enercon E-33, having capacity of 330 kW each

Fig. 7. The configuration of 5 units DeWind D4/46, having capacity of 600 kW each

Fig. 8. The conFiguration of 14 units Vestas V-29, having capacity of 250 kW each

Annual energy production of these three wind farm are given in Table 4. Optimum orientation that give high efficiency for Vestas V-29 and Enercon E-33 is 60^o, while for DeWind D4/46 is 30^o

Table 4. Annual Energy Production of Wind Farm at Oelbubuk

WEC type	Hub height (m)	Diam. Rotor (m)	Orientation (degree)	Useful efficiency (%)	Eff LA (%)	Capacity Factor		Annual energy production (MWh)	
							-10 %		-10%
Enercon E-33, 10 units of 330 kW	50	33	30	35.2	95.2	40.1	36.1	11599	10439
			45	35.4	95.7	40.3	36.3	11664	10498
			60	35.5	96.1	40.5	36.4	11715	10544
			75	35.3	95.5	40.2	36.2	11631	10468
			90	35.2	95.2	40.1	36.1	11599	10439
DeWind D4/46, 5units of 600 kW	50	46	30	33.4	96.4	39.8	35.8	10456	9411
			45	33.4	96.2	39.7	35.7	10439	9396
			60	33.3	96.0	39.6	35.7	10419	9378
			75	32.9	94.7	39.1	35.2	10275	9248
			90	32.4	93.4	38.5	34.7	10135	9122
Vestas V-29, 14 units of 225 kW	50	29	30	31.1	95.6	39.2	35.3	10815	9734
			45	31.3	96.4	39.5	35.5	10899	9809
			60	31.4	96.6	39.6	35.6	10925	9832
			75	31.0	95.3	39.1	35.1	10783	9705
			90	30.7	94.3	38.6	34.8	10666	9599

5. DIESEL POWER PLANT (DPP) in SOE CITY

This section is the result of team investigation during survey to TTS Regency. In 2004, *PLN- Wilayah Nusa Tenggara Timur* had peak load 105 MW. Installed capacity of the existing diesel power plant is 147 MW. Transmission system is a middle voltage of 20 kV. The average electricity selling growth in the last 5 years is 8.7% /year. The distribution grid is connecting four areas: Kupang-area, SOE-area, Kefamenanu-area and Atambua-area, see the map in Fig. 9. At southern side, SOE-area separates with Kupang-area at Takari substation (gardu Takari). At the northern side, SOE-area separates with Kefamenanu-area at Polen substation. The map shows that the grid for SOE-area is not connecting to the other grid system. This give a good chance to expand the grid to connect to the wind farm in Oelbubuk .

Data dated 9 Agustus 2008 stated that DPP in SOE city has ten diesel generators:

No	Diesel Type/Mark	Power	No	Diesel Type/Mark	Power
1	MTU 12V	500kW	6	MWM TBD616 V12	500 kW
2	MAN D2842	500 kW	7	MTU 12V	500kW
3	MWM TBD616 V12	500 kW	8	MWM 616 V12	500 kW
4	MAN D2842	500 kW	9	MTU 18V	500 kW
5	Daihatsu 6PDTc-22	250 kW	10	Deutz F3L	20 kW

The total installed capacity is 4490 kW. The capability of supply is 3120 kW.

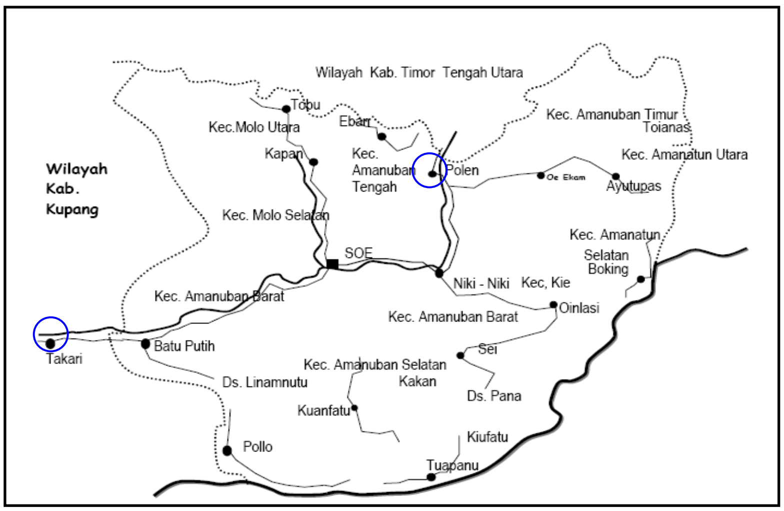


Fig. 9. Map of Electricity Distribution Grid of Diesel Power Plant in SOE city Kecamatan or Kec. is District. TTS Regency has 10 districts.

Electricity distribution cable for SOE-area: 9555 meter, for Kapan district: 64681 meter, for Batu Putih district: 68835 meter, for Tubuhue district: 9473 meter, for Niki Niki district: 77336 meter.
In Juli 2008 only 7 diesel generators were operating, total installed capacity is 3490 kW. The capability of supply is 2350 kW. Average power reserve is rated suitable to the demand in save category. The capacity factor is 75-85%. The load profile of SOE-area is given in Fig. 10. The based load at 8:00 until 16:30 is about 1 MW. After 18:30 the load increase and the peak of 2.8 MW happen at 19:30. This load profile is almost constant throughout the year.

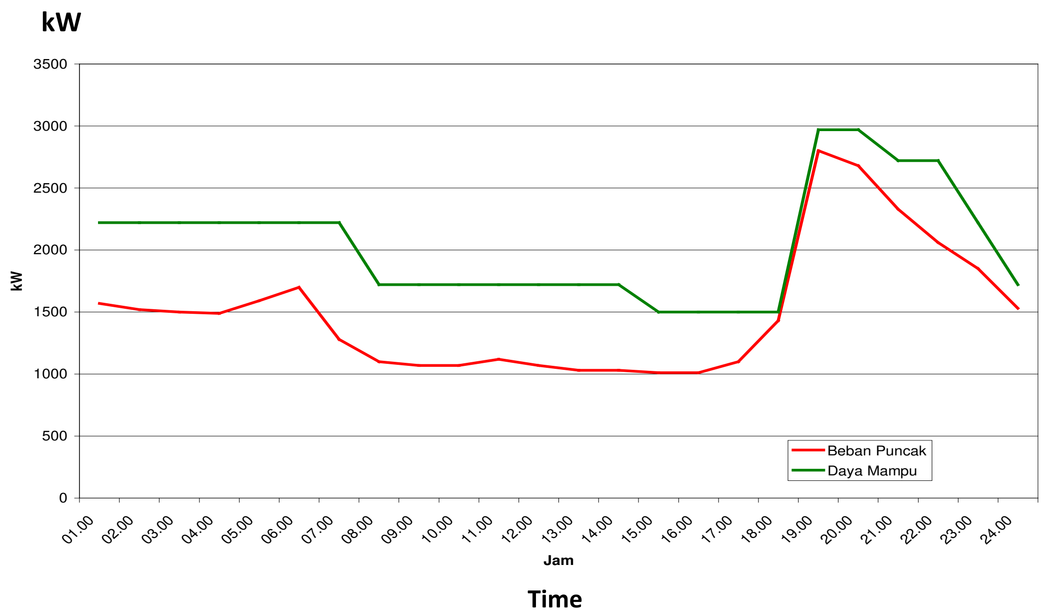


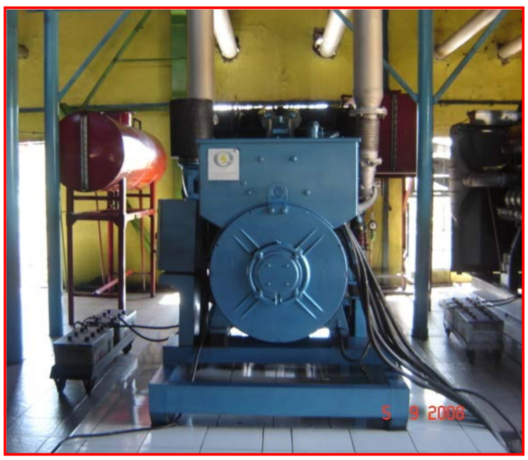
Fig. 10. The load profile of SOE area. Red is peak load. Green is capability power

(a) (b)

Fig. 11. (a) DPP SOE that supply electricity for TTS Regency.
(b) Monitoring panel for SOE area, Niki-Niki District, Kapan District, Batu Putih District and Tubuhue District.

(c)

(d)



(e)

(f)

Fig. 11. View of one diesel generators in DPP SOE, (c) left view; (d) right view; (e) front view, the red – horizontal cylinder tank is filled with diesel oil; (f) back view.
Photographs by Herliyani Suharta

DPP SOE, see Fig. 11, operates in unsafe load factor, in which the power reserve is only 10%. If the load changing, operator will adjust the control setting of diesel generator speed manually to keep the output as needed by the peak load.

6. CONNECTION TO THE LOCAL GRID

There are 4 categories of power transmission system in Indonesia to suit the number of population/ electricity subscribers: Low voltage (220V, 380V 3fasa); Medium voltage (20 kV and 70 kV); High voltage (150 kV, 275 kV) and Extra high voltage (500kV). For WEC, the categories are shown in Table 6. Thus the transmission system for wind farm is matching to the local existing grid of DPP in SOE city, that is a medium voltage of 20 KV.

Table 6. Power transmision capacity at various voltage [6]

Voltage system	Size of wind turbine or wind farm	Transmittable power
Low voltage system	For small to medium wind turbines	up to ≈ 300 kW
Feeder of the medium voltage system	For medium to large wind turbines and small wind farms	up to ≈ 2–5 MW
Medium voltage system, at trans-former substation to high voltage	For medium to large onshore windfarms	up to ≈ 10–40 MW
High voltage system	Clusters of large onshore windfarms	up to ≈ 100 MW
Extra high voltage system	Large offshore wind farms	> 0.5 GW

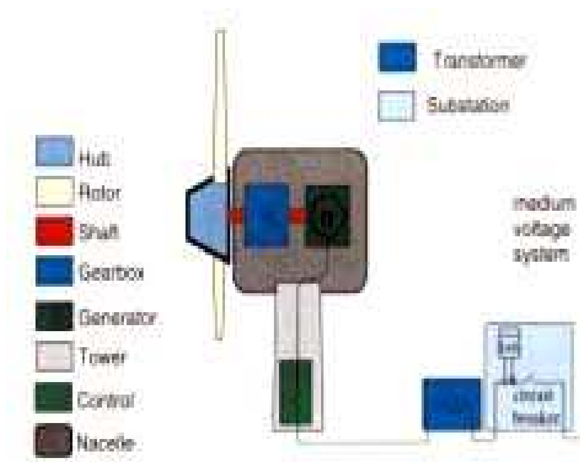


Fig. 12. The inter-connection system of WEC of medium voltage power transmission. It consists of: power transformer; substation with current cut-off equipment for isolation during repair or to avoid short circuit; and the measurement equipments

WEC will be connected to the grid via transformer of medium voltage. Transformer will raise the WEC voltage from 380 or 480 V to the grid voltage level of 20 kV. Transformer stays closed to WEC to reduce the length of low voltage transmission.

Electricity will be generated when the wind blow to turn the turbine generator. If the wind power higher than the system capability will put the whole system in a risk. Therefore, safety consideration is needed. Continuous voltage change will damage the system. Normally, the tolerance of voltage elasticity is ±10 %.

Short circuit ability (S_{sc}) at a ”point of short circuit” is a value to rate the strength or quality of power system that show how far the system able to absorb the disturbances.

$$S_{sc} = U_{sc}^{2} / Z_{sc} \tag{2}$$

U_{sc} is the voltage of the system, Z_{sc} is impedance for short circuit. S_{sc} in mega volt ampere (MVA) If turbine generator of P mega watt is installed to a power system, the ratio for short circuit is:

$$R_{sc} = S_{sc} / P \tag{3}$$

The power system will be rated strong at R_{sc} = 20-25, and rated weak at R_{sc} = 8-10.
Generally turbine generator is equipped with induction generator that needs reactive power. At no load, the reactive power needed is about 35-40 % of nominal power and rise at the peak load to 60%. Thus, the power system connected to WEC need to have reactive power for induction generator and the load itself. To minimize power loss and to raise the stability, WEC should have a compensation tool so that the need of reactive power stays in the range of zero load to the peak load.
Inverter that equipped with pulse width modulation (PWM) can adjust the need of reactive power and to control the reactive power to rise or sink.

7. BUDGET FOR IMPLEMENTATION

The budget needed is influence by the selected WEC, infrastructure, local facilities, regulation and the existing grid system. The evaluation in 2007 to derive the budget to implement wind farm project in Europe is given in Table 7. The budget range is 1.2 – 2 million euro/MW.

Total budget covering:
- Design as shown in this paper (WEC selection based on the local wind speed)
- WEC procurement and interconnection to the existing grid
- Cost for intallation detail
- Cost to investigate parameter related to the implemented WEC
- Feasibility Assessment for wind farm project
- *Cash flow analysis*
- Management cost, legal aspect, and other transaction

Four different conditions consider:
- WEC price fluctuation
- balance of plant cost over time
- balance of plant charge due to terrain
- difficulties in transport of components and installation
- the difference in electricity prices and the existing grid

Table 7. Budget needed to build 10 units Enercon E-33 in four conditions.

	I	II	III	IV
Total Project Cost, 10 Enercon E-33, EU	4,455,000.0	6,105,000.0	5,065,500.0	7,639,500.0
Rasio Input / Output	2.137	1.415	1.849	0.976
Finansial Internal rate of return (FIRR)	0.299	0.203	0.258	0.148
Finansial Net Present Value (NPV)	99,633,121,185	54,755,493,491	82,944,370,532	20,649,827,430
Benefit/cost	2.657	1.588	2.204	1.040
Break Event Point, at year	4	6	5	6

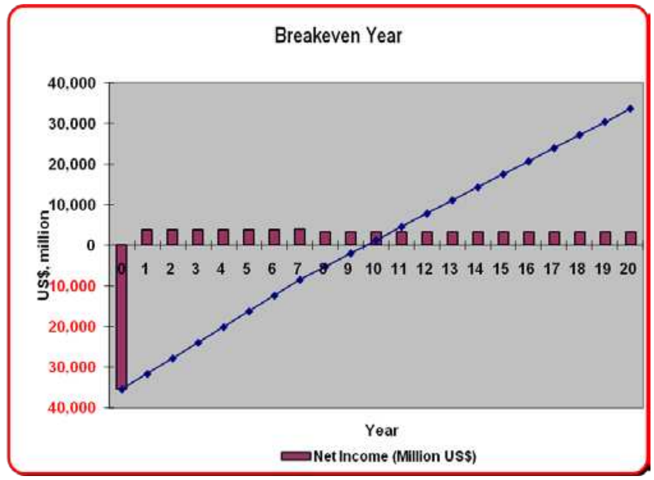
Based on the experience of WEC installation in Europe, India and China, the breakdown cost for the components is given below.

WEC	~ 80 %	US$ 1,040,000 /MW
Foundation	~ 9 %	US$ 78,000
Electrical installation	~ 2 %	US$ 78,000
Control system and interconnection to the existing grid	~ 4 %	
Consultation	~ 1 %	US$ 13,000
Land cost	~ 2 %	US$ 26,000
Road and others	~ 2 %	
TOTAL	100 %	US$ 1,235,000

Financial Sensitivity Analysis for wind turbine ENERCON E-33 and the Break – even point of wind farm project are shown below. The asumption used are:

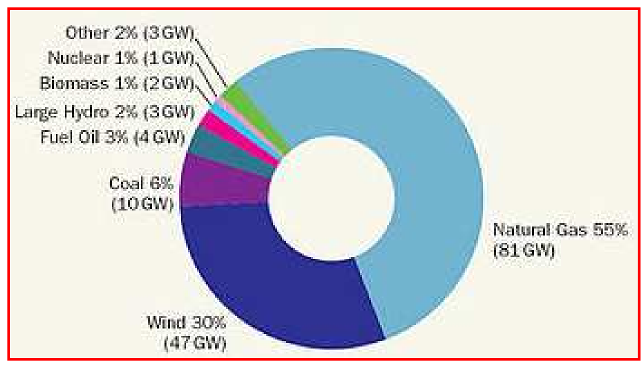
- Electricity price/ kWh used is IDR 927
- *Interest Rate (IR)* 6 % , *Equity* 10 % dan *Contingency* 5 %
- *Life time* of Enercon E-33 is 20 years
- The cost for WEC is added 30 % for tax and overseas transportation.
- Others that use the valid prices in Europe

Discount Rate	**8%**	
Interest Rate	**6%**	
IRR	**8%**	
NPV	**34,984,732,702**	IDR
	3,802,688	US$
Average Incremental Cost	**583.81**	IDR/kWh
	0.063	US$/kWh



At the time in the future, when the wind farm is decided to be installed, it is needed to make recalculation in the same procedure but need to change all components prices and the currency exchange to get the real capital needed.

8. ENVIRONMENTAL VALUE IN IMPLEMENTING WEC



WEC emits less NOx and CO2, it is about 4g C_{eq} / kWh or about 1.9 % of CO2 emitted by coal fire power plant [7]. Therefore, in 2000-2007, WEC implementation in European Union raised to be 47 GW or 30 % of the total electricity generation [8]. Until the end of 2006, the whole WEC in Europe have reduced 80 Mton CO2/year and in 2010, it is targeted to improve to be 140 Mton/year or equal to 30% of total CO2 emission that should be reduced by European Union.

In California, the use of DPP increase rapidly, therefore the government need to put in order considering its affect to human health. Matthew Marquillies [9], pulmonologist of Physicians for Social Responsibility in Caloornia, stated that life close to DPP of 1 MW along the life will raise the risk to get cancer by 50 %. Kevin Finney [10] from Coalition for Clean Air, California, stated that DPP emit polution 130 times than those emitted by *combined cycle gas power plant.*

In Indonesia, all small islands use DPP. It is good to do diversification with the local available resources.

Life Cycle Analysis is used to compare energy generated by various power plant that covers the use of energy input and its capacity factor [11]. Energy ratio (output/input) represents the energy input to be converted to electricity and its thermal efficiency. Greater energy ratio means the better the power pant. Hydro, nuklir and fossil fuel have high energy ratio because of their high energy density lead to high capacity factor. Energy ratio of WEC is better than that of coal fired power plant. WEC made after 2000 has inputs 2% of lifetime outputs, smaller than the conventional power plant that use fossil fuel. Energy Ratio (output/input) WEC increase along with its technology development.

9. CONCLUDING REMARKS

Low electrification ratio leads to low productivity. The only local industry in Oelbubuk is marble industry. This wind farm is expected could raise the local economical activities, raise the local knowledge by giving them a chance to get information via TV. In the beginning of this paper, it has been described several societel advantages. However, the implement of wind farm in Oelbubuk will depend on the political will of the goverment and the exerted efforts, funding, international cooperation, local toughness to conquere the difficulties in reaching the target in the road map.

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