WIND ENERGY POWER PLANT
1 X 8 0 k W

NUSA PENIDA, BALI
INDONESIA

SUBMITTED FOR ASEAN ENERGY AWARDS 2007
NRSE PROJECT COMPETITION

CATEGORY "ON – GRID"

Submitted by
Listrik Perdesaan Bali
Jalan Letda Tantular no. 1
DENPASAR, BALI 80234

Pre Qualification.

One of the development of new energy newly (renewable energy) taken development to wind energy. Wind energy represent energy which clean friendly and environment because do not yield dioxide carbon (CO2) or other gases which playing a part in global warm-up, dioxide sulphur and oxide nitrogen (gas type causing sour rain). This energy even also does not yield dangerous waste to environment and or human being. Still, hope to be seen that as small as anything all form produce energy always have effect of to environment. Only very low wind turbine effect, having the character of easy and local management. Despitefully windmill or turbine have separate glamour and become attraction of tour interesting, like for example windmills in Dutch country.

In Indonesia, progress of economics in Indonesia cause improvement of requirement of energy that is equal to more or less 6 % per year for the mean of requirement of energy entire Indonesia and 9.08 % per year for the region of Bali. But this condition less made balance to with exploiting to source of new energy newly where us since early have depended to oil. This matter of crisis decreased of energy in Indonesia. To overcome this, passing Regulation of President of no. 5 Year 2006 which related to policy of National Energy, decanted by policy to lessen usage of Fuel oil.

In line with that matters, start to be executed by exploiting of new energy newly in Indonesia and PLN (Government Electricity Company) as right owner of Charged' Affaires of "Electricity Power (Ketenagalistrikan)" out for to in this time develop other new energy newly so that can depress usage of the oil which besides because of starting decreasing of oil supply, also because of tied of PLN with governmental regulation related to is ready of oil for the production of electrics.

In course of its business, PLN to be able to produce electrics use oil as its input, where price of oil the determined by government and so also to kWh yielded by PLN, price sell him determined by government pursuant to Elementary Tariff of Electrics so that result Cost Production bigger than existing Elementary Tariff of Electrics, which this matter cause PLN have to account loss operate for equal to 3,89 is trillion of rupiahs. To overcome this matter, efficiency later; then become most vital matter and become focus in course of business of PLN so that expected by operation loss can be depressed. And for that PLN have conducted some efficiency like one other has been executed by Power Station Of Wind Energy (Wind Energy in Nusa Penida – Bali).

Related to development of Power Station Of Wind Energy in Nusa Penida, development some generating of wind power which have adequate scale enough can fulfill requirement of electrics area. It is true, can telling Bali in this two the last year have started to blaze the way power station of wind power. In this time in Nusa Penida have operated generating of small scale wind power namely equal to 80 kW by the end of year 2005. Can be told, that Wind Energy 1 x 80 kW in Nusa Penida represent Power Station Of Energy Wind of on first grid in Indonesia and caught up as operating second generating with is same capacities in December 2006 and in 2007 year this expected can be woke up by generating of other wind power equal to 1 x 80 kW.

Is seen from potency and expanding technological for the generating of wind power, many is expert of energy which prediction in a few year forwards exploiting of wind power as evocation of electrics energy tend to increase, and so do development of generating of this wind power can be conducted in Indonesia and Bali specially particularly again because of still to the number of potency of wind energy which not yet been exploited and in fact can maximizing with existence of technology expanding in this time.

Originality.

Considering limitation of reserve of fossil energy which on the wane and utilize to support the effort Government in order to exploiting the availability of available resource, such as those which decanted in Ministerial Decree of Energy and Mineral Resource.

1. Ministry Decree of Energy and Mineral Resource number 0002 year 2004 dated 2nd January 2004 about policy of Development of New Energy and Energy Conservation (Green Energy Development).
2. Ministry Decree of Energy and Mineral Resource number 0983 K / 16/MEM/2004 dated 6th May 2004 about Policy Of National Energy.
3. Letter of Klungkung Regent number 951/ 777 / Pem dated 21th July 2005 ready subject of land ground for the Wind Energy Power Plant in Nusa Penida, Bali.

And also according to guidance of Director General of Electricity and Energy Utilization at the time of solution of compilation of Project List Budget (DIP) year 2005 and Director General letter of Electricity and Energy Utilization no. 2962/41/620.1/2004 dated of 22nd November 2004 as for TOR (Term Of Reference) and budget for Development of New Energy which affirm to activity plan which defraying from Project List Budget (DIP) year 2005 budget allocation can equal to 5 - 10 % utilizing to execute activity of new energy.

Pursuant to the mentioned above hence compiled by Plan Activity Of Development Of New Energy Newly in Region of PT PLN (Persero) Distribution Bali with the following steps :

1. Preparation Of Development Of Wind Energy.

   Preparation process of this Wind Energy Power Plant construction early cooperation on Duty Public Work of Bali Province by research concerning wind potency exists in Bali Province. Research conducted by on Duty Public Work of Sub on duty Mining and Energy executed by countryside of Klumpu, Nusa Penida in October up to November 2003, with installing Wind Energy Power Plant capacities 1000 watts. As result of research indicate that speed of highest wind during the research happened on 21st October to the 24th October 2003 with speed 6 to 8 m / second that happened around 3 p.m. to 6 p.m., wind blown from southward and South-East.

   Pursuant to the mentioned above and also supported with data about " Evaluation Work of Sample of Wind Energy Power Station Development " compiled by on Duty Public Works of Bali Province, hence budget allocation have utilize to develop; build Generating with renewable energy, that is Power Station of Wind Energy with planned capacities 80 kW to be woke up in "Puncak Mundi" (hill of Mundi), Nusa Penida, Bali. This Location choice start from conducted survey in the year 2003 the while determination of capacities 80 kW relied on calculation 30 percent of daytime normal load/burden which is on decrease moment.

   With reference to NASA (National Aeronautics Space Administration) data like seen at figure 2.1, for the region of Indonesia East there are some potential area to be exploited by wind power. There are 9 potential province, one of them is Nusa Penida Island, which located in Bali Province, and with mean speed of wind is 6 m / second. This matter supported also by result of research by On Duty Public Works Of Bali Province, Sub Duty of Mining and Energy executed in countryside of Klumpu-Nusa Penida, Bali in October to November 2003. The results of research as shown in table 2.1 indicating that speed of highest wind during the research happened on 21st to. 24th October 2003 with speed of wind 6 to. 8 m / second, that happened between 3 p.m. to 6 p.m.. Wind blown from southward and South-East.

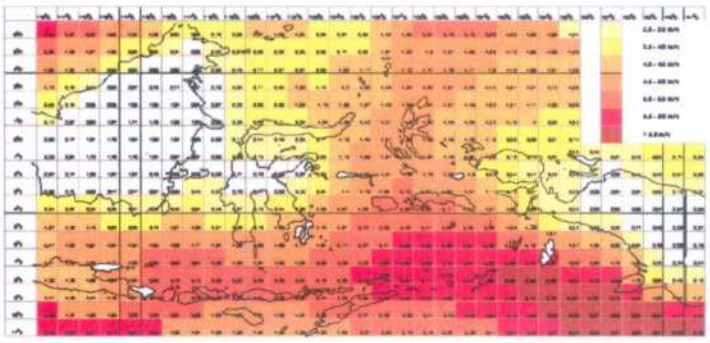

Figure no 2.1 : Wind Power Potential in East Indonesia (Source: NASA)

23rd Oct 03 Time	Wind Direct. (degrees)	Wind Speed (m / sec)	Generator Current (Ampere)	Generator Voltage (Volt)	Power (Volt x Amp)
15.00	195	8	15,8	20,8	328,64
16.00	190	87	13,6	21,0	285,60
17.00	190	7	9,5	20,3	192,85
18.00	190	8	12,8	21,7	277,76

24th Oct 03 Time	Wind Direct. (degrees)	Wind Speed (m / sec)	Generator Current (Ampere)	Generator Voltage (Volt)	Power (Volt x Amp)
15.00	210	4	2,1	19,8	41,58
16.00	210	5	3,8	20,7	78,66
17.00	200	8	15,5	23,1	358,05
18.00	195	5	4,0	20,4	81,60

Table 2.1 : Results of Publics Works Department Recearch on year 2003 of Wind Energy Potential in Nusa Penida, Bali.

As for development of Wind Energy Power Plant in Nusa Penida, Bali is representing effort to lessen oil fuel consumption and to exploit existing natural potency. In planning development of Wind Energy Power Plant in Nusa Penida, Bali Rural Electrification has conducted the following steps :

a. Presentation of Wind Energy Power Plant,

   To introduce technology of wind energy to society, hence Electrics Countryside Bali make letter with number 005/240/Lisdes Bali / 2004 dated 11st May 2004 which addressed to Local Government Of Sub-Province of Klungkung about presentation of Wind Energy Power Plant to be done at 19th May 2004. Intention of this presentation besides to introduce technology of wind energy to assure society that wind energy it is true very required by society specially residing in isles which is difficult to be reached by electrics network of PLN as well as to lessen depend on oil fuel which more and more rareness and costly.

b. Allocation Budget.

   On 24th August 2005 Leader of Bali Rural Electrification make addressed letter to Director General of Electricity and Energy Utilization attn. to Director of Electricity Program with number 010/512/Prolisdes BALI & NTB / 2004 as for Forwarding of Project Listing Proposal Budget (DUP) year 2005 Bali & Nusa Tenggara Barat Rural Electrification which is on its core request to be fund allocation 5-10% from budget, for the activity of renewable energy. Director General Electricity and Energy Utilization give guidance at the time of studying compilation of Project Listing Budget (DIP) 2005 and its letter no. 2962/41/620.1/2004 22nd November 2004 as for TOR

(TERM of Reference) and budget estimate for Development of New Energy which affirm to activity plan defrayed from Project Listing Budget (DIP) Year 2005 budget allocation can equal to 5-10% utilizing to execute activity of new energy.

To develop and build PLT Wind cost money equal to 3.532.815.000 Indonesian Rupiahs. Stemming from fund of Project Listing Budget (DIPA) Year Budget 2005 which consists of the expense of supply and install of Wind Energy Power Plant equal to 2.805.423.000 Indonesian Rupiahs. and expense of installation including of civil works and supply and install of transformator equal to 379.518.000 Indonesian Rupiahs. and also the expense of supply and install of Medium Voltage Transmission Line equal to 347.874.000 Indonesian Rupiahs.

c. Location Choice.

Before determining location development of Wind Energy Power Plant in Nusa Penida, Bali of course PLN Distribution Bali in this case the Project Rural Electrics Bali (Prolisdes Bali) also considers other factor. Besides considered of factor of wind speed, also paid attention height factor, environmental factor, load factor, interconnection. Pursuant to supplementary factor and data, hence the "Puncak Mundi" (Top of Mundi), Desa Klumpu, Nusa Penida Island, Bali is up to standard and correct place to be build Wind Energy power Plant, because this place reside in position 400 meter above of sea level and wind speed in this area in average 4,6 to 5,6 meter / second, so that suited for Wind Energy power Plant. While determination of capacities 80 kW relied on calculation 30% from daytime burden at present, compilation of work load is equal to 235 kW.

d. Coordination with Local Government

After location of Wind Energy Power Plant specified already, on 19th May 2005 Project Of Rural Electrics of Bali Area have letter to Regent of Klungkung by letter number 009/240/Lisdes Bali / 2005 subject of land ground for the Wind Energy Power Plant. On 6th June 2005 Chief of Klungkung Regent make invitation according to number letter 005/124/Bappeda to perform a socialization about Wind Energy Power Plant.

At presentation of Wind Energy Power Plant in Sub-Province of Klungkung on the 9th June 2005, Local government support for development of Wind Energy Power Plant planning at Nusa Penida Island. Therefore, Lead of Planning Development of Klungkung Regent (Bappeda) suggests that as soon as co-ordinate with Deputy of Bupati.

Coordination with Deputy of Bupati by Superintendent Of Governance executed on 14th June 2005, where Superintendent Of Governance will co-ordinate beforehand

with Head on Ranch Duty, which requested ground represent asset on Ranch Duties. And Head on Ranch Duty suggest that can involve and fully support also.

On 21st July 2005 Government of Sub-Province of Klungkung according to his letter number 591/777/Pem agreed to provide land ground for the 600 square meter for the location of Wind Energy Power Plant in Nusa Penida Island, Bali Province representing answers to letter from Project of Rural Electrics of Bali Area, number 009/240/Lisdes Bali / 2005.

Social Consideration.

The Work of physical activity for development of Wind Energy Power Plant started in August 2005 and finished in December 2005. Any information of work execution for development of Wind Energy Power Plant in Nusa Penida submitted by Lead of Rural Electrics of Bali Area, to Klungkung Regent by letter number 015/240/Lisdes Bali / 2005 dated 18th August 2005.

a. Phase of Pre Construction of Wind Energy power Plant in Nusa Penida, Bali.

1. Site Survey.

   Site Survey conducted to find the best location according with amount of wind speed which is biggest to be got in hilltop of Mundi orchard flatten of Klumpu Area, reference data from Department of Meteorology and of Geophysics and also Nasa data with average mean speed of wind is 6 meter / second at 400 meter above of sea water level.

   Field situation

   - Height of location is about 400 meter above of sea water level.
   - Apart from housing of resident closed 400 meter.
   - Wind speed is 6 meter to 12 meter per second.
   - Its land consists of chalk and massive stone land.
   - Air temperature 26 degree average.

2. Land Acquisition.

   For the build of Wind Energy Power Plant require the new farm, and in this case using farm property of Local government of Klungkung Regent, hence its process only limited to permission usage of farm. Land required more or less 600 square meters for the location of Wind Energy Power Plant provided by Government of Sub-Province of Klungkung according to its letter [of] no.591/777/Pem dated 21st July 2005 subject Land for the Wind Energy Power Plant, representing answers to letter of Lead of Rural Electrics Bali Area, number 009/240/Lisdes Bali / 2005 subject of land for the Wind Energy Power Plant.

Figure no 2.2 : Field survey.

3. Permission and notification to related parties

   After obtaining Approval of Permission Usage of farm released by Local Government of Klungkung Regent, by Letter Regent of No.591/777/Pem dated 21st July 2005. In Principle agreed for land support for the 600 square meter (6 acre) in Puncak Mundi (Hill of Mundi), District of Nusa Penida Island, Bali for the development and constructing of Wind Energy Power Plant.

   Later counseling to surrounding citizen about existence of Wind Energy Power Plant planning, such of society around more can accept and make this project as early starting of usage of New Wind Energy Power Plant as far as is the first time build started in Indonesia and make separate pride because there will be many obtained benefit later.

b. Phase Construction.

Execution of construction more or less during 5 month; started from March 2005 up to July 2005, whereas PT PLN (Persero) Distribution Bali, through Rural Electrics of Bali Area (Prolisdes Bali) send letter to government of Sub-Province of Klungkung with letter number 009/240/Lisdes/Bali/2005 subject of Land for the Wind Energy Power Plant. This Letter later; then replied by government of Sub-Province of Klungkung by providing land for the 600 square meters for the development of Wind Energy Power Plant. On 18th August 2005 started for construction of Wind Energy Power Plant in Puncak Mundi (Hill of Mundi), Nusa Penida Island, Bali which finish to be woke up and come to operate at the 15th December 2005.

Work activity construction of Wind Energy Power Plant 1 x 80 kW as follows :

- Land Clearing.

This activity started after decided of one of the contractor pass through auction process.. Labor which is employed in this activity, representing local resident / local labor. This work covered of dig of land for the Foundation of Tower, House of Control, fence and also other preparation.

- Mobilization Equipment and Materials.

Mobilization material and equipments covered evacuation of equipments to and from work location in the early, during and by the end of activity. Activity of this work also entangles local labor / local resident.

Figure no. 2.3 : Wind Turbine Mobilization.

Figure no.2.4 : Sea Transportation

Figure no. 2.5 : Excavation for Tower foundation.

Figure no. 2.6 : Concrete Process for Tower foundation

Figure no. 2.7 : Rechecking of Tower Foundation construction.

Figure no. 2.8 : Tower Erection.

Figure no. 2.9 : Tower Erection.

Figure no. 2.10 : Turbine Blades Erection.

Technical, Economic And Market Consideration.

Expense needed to develop and build a Wind Energy Power Plant 1 X 80 kW is more or less equal to 3,5 Billion rupiahs which consist of the expense of supply and install of Wind Energy Power Plant equal to 2,8 Billion rupiah, expense of civil works and supply and install of Transformator equal to 380 million rupiah and supply and erection of Medium Voltage Transmission Line equal to 350 million rupiah which source of its fund come from fund of Government (DIPA) budget year 2005.

Technical Specification of Wind Turbine Power Plant 1 x 80 kW

Turbine

1. Turbine Specification : As according to NEN 6069
2. Certification : CIWI
3. Minimum wind speed : 3 meter / second.
4. Nominal wind speed : 12 meter / second
5. Maximum wind speed : 25 meter / second
6. Top wind speed : 60 meter / second.
7. Nominal Energy : 80 kW.
8. Voltage : 400 V $\pm$ 10 %
9. Frequency : 50 Hz + 3 Hz
10. Type wind turbine : Speed of variable.

Rotor

1. Blade : Two.
2. Rotor position : wind direction Facing Angle.
3. Corner major axis : 7 degrees to horizontal.
4. Diameter : 18 meters.
5. Wide sweep : 254 sq. meters.
6. Speed turn around : Variable 60 - 120 rpm
7. Arrangement of energy :
   - Passive : tuning of angle corner of blade.
   - Active : mutator system variable
8. Angle;Corner of flapping : 180 degrees – 164 degrees.
9. Direction turns around : clockwise rotation.
10. Main bearing position : gearbox.

Gearbox.

1. Step Amount : 2
2. Ratio : 1 : 2
3. Break Safety : available.

Blade.

1. Blade Lengths : 8 meters length.
2. Blades heavy : 90 kilogram each.
3. Material : fiber carbon with epoxy.
4. Blades position : Flexible.

Generator.

1. Type : Asynchronous
2. Nominal Power : 80 kW.

3. Pole : 4
4. Nominal Voltage : 230 / 400 V
5. Variable Frequency : 40 - 80 Hz.
6. Heavy : 475 kilograms.
7. Safety Protection : IP 55.

YAW System.

1. System : Active.
2. Signal : Wind direction reference.
3. Activator : Electromotor with gear.
4. Power of yaw - motor : 550 watt.
5. Yaw speed : 1,2 inches / second.

Controller

1. Controlled by : PLC.

Safety Protection.

1. First protection : Passive Turn around of Blades.
2. Activating : Rotor speed (110 rpm).
3. Second protection : Bangle goes out from wind.
4. Activating : rotor speed (120 rpm).

Weight.

1. Nacel and rotor : 3000 kilograms.
2. Rotor : 900 kilograms.

Interconnection with Medium Voltage Transmission Line.

1. Converter type : Mutator.
2. Converter type : AC - DC – AC.
3. Thrystor : 6 pieces.
4. Diodes : 6 pieces.
5. DC filter : 4 mH
6. Network Filter : Low Pass filter.
7. Mutator Controls : KRS240000.
8. Alarm voltage minimum : 300 Volts.
9. Alarm voltage maximum : 500 Volts.
10. Culminate voltage minimum : 200 Volts.
11. Culminate voltage : 650 Volts.
12. Synchronization : Synchronize with network. (Medium Voltage Transmission Line).
13. Protection : Over Load..

Spare parts.

Except for blades, turbine and some of Converter – Inverter components, are representing domestic product. For the component of Blade and of Turbine, supplier [s obliged to enclose available statement of access of Wind Energy Power Plant during 10 (ten) years.

Tower.

Type : Bolted Lattice, Self Supporting.
High : 30 meters (adapted for factory standard).
Materials : Construction of Tower made by hot dip galvanized elbow profile becomes other supply, with steel quality of ST. 37 / SS 400 with 2400 kg / square cm. tension.

Commissioning test

Commissioning test represent with refer to assure installation have functioned. Execution of commissioning test for the Wind Energy Power Plant conducted after all of work which supports operation of Wind Energy Power Plant has been complete. Execution of Commissioning on 15th December 2005 by entangling element of Manufacturer of goods, Contractor as Executor and staff of Rural Electrics Bali Area as a inspector of work.

Commissioning test have been done with result of goodness like data required at technical condition as according to Contract of No.011.P/611/Lisdes.Bali/2005 dated 18th August 2005 and amendment no. 001.Amd/011.PJ/611/Lisdes Bali / 2005 dated 24th October 2005.

Operation and Maintenance Scheme.

In with operated of Wind Energy Power Plant 1 x 80 kW, hence since commercial operation in April 2006 up to December 2006, PLN conduct thrift of usage to substituted oil with wind power equal to 16.665 liters with thrift equal to. 108.320.550 Indonesian Rupiahs.

Month	Energy transfer (kWh)
April	4.953
May	5.930
June	12.490
July	10.393
August	11.971
September	5.207
October	403
November	3.007
December	1.195
Total	**55.549**

Table 3.1 : kWh production of Wind Energy Power Plant 1x80 kW, from April to Dec. 2006.

Figure no 3.2 : Wind Energy Power Plant 1 x 80 kW in Nusa Penida, Bali.

Management of Wind Energy Power Plant in Nusa Penida

With reference to the policy of Government to Directorate General of Electricity and Energy Utilization, hence local government of Sub-Province of Klungkung with Governmental Letter of Sub-Province of Klungkung number 531/284/Bappeda dated 21st November 2005 mentioned that Bappeda have the kindness to manage and operate Wind Energy Power Plant in the Nusa Penida.

After construction of Wind Energy Power Plant 1 x 80 kW in Nusa Penida, and as according of letter of Director Construction of Program of Ketenagalistrikan number 2618/05/620.5/2005 dated 26th August 2005 about Taking Over Activity of Renewable Energy, hence Wind Energy Power Plant hand over to Government of Sub-Province and management will be conducted by "Koperasi" as showed by Local Government. Hereinafter Institute this Organizer will sell electrics production awakened by Wind Energy Power Plant to PT PLN (Persero) Distribusi Bali.

Operating System of Wind Energy Power Plant.

Wind Energy Power Plant design to be able to operate in parallel (on grid) with generating set power station of existing that is passing Medium Voltage Transmission Line 20 kV. As for operating system and condition of Wind Energy Power Plant as follows:

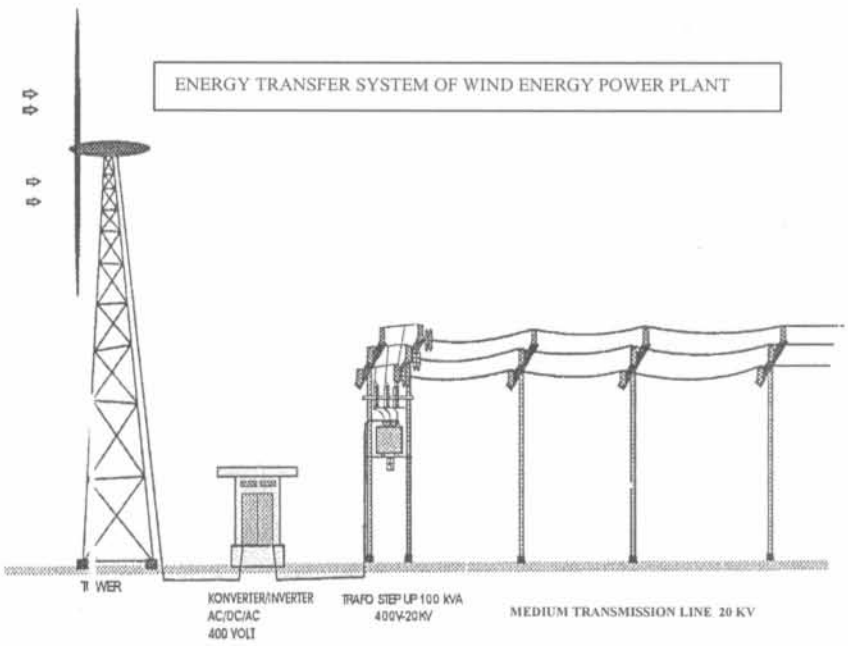

Figure no 3.3 : System of energy transfer of Wind Energy Power Plant.

Advantage and Benefit of Wind Energy Power Plant with parallel systems / interconnection (" on grid" with electric power distribution network which have been existed), with a purpose

to step by step can lessen dependence to oil which its cost tend to rise progressively. Beside that to society around Wind Energy Power Plant will be able to addition of electrics supply, expected can improve their life level.

In general, benefit of Wind Energy Power Plant :

a. Lessening depend on oil which progressively rareness & costly

b. Lessening environment damage and air as effect of combustion of oil and of oil flooded ex- lubricating oil discard

c. Exploiting cheap natural potency to realize efficiency culture

d. Job opportunities for local resident

e. Adding electricity supply

f. As object of "tour-study" (because representing first on-grid system : in Indonesia) to have positive impact potency' to society with vending handicraft and also food / beverage selling.

g. As effort to enable the vicinity of society.

Obviated CO2

Production of Wind Energy Power Plant 1x80 kW since April 2006 up to December 2006 is equal to 55.549 kWh.

When assumed by Factor diesel emission (FE) = 0.9 kilograms / kWh, Hence obviated emission of Machine of Generating Set is equal 0.9 x 55.549 = 49.994 kilograms of CO2.