UTILIZATION OF WIND ENERGY CONVERSION SYSTEM IN INDONESIA

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ABSTRACT

Wind energy is one of the alternative resources that has been developed in Indonesia to support the National Renewable Energy Program. Many areas in Indonesia, have annual wind speed between 2.5 to 5 meter per second. It is enough to support the rural electrification program by applying a small WECS for home lighting, battery charging, cold storage, telecommunication etc.
Certain areas in East Nusa Tenggara, West Nusa Tenggara, South Sulawesi and southern part of Java have annual wind speed more than 5 m/s. This gives a possibility to implement a medium to a large size WECS for electric generation. Various WECS of up to 10 kW have been developed. Field test on several villages are progressing. This paper also describes a prospect of WECS utilization, benefit and a possible barrier of WECS implementation and recommendation.

Keywords: Indonesia, WECS, wind energy technology, wind speed.

ABSTRAK

Energi angin adalah salah satu alternative energi yang telah dikembangkan di Indonesia guna mendukung nasional program dibidang pengembanga energi terbarukan. Banyak daerah di Indonesia memiliki kecepatanan angina rata-rata antara 2,5 sampai 5 meter per detik yang cukup untuk mendukung program pelistrikan perdesaan dengan menerapkan system konversi energi angin (SKEA) berskala kecil untuk penerangan, pengisian baterai, system pendingin, komunikasi dll.
Daerah tertentu di NTB, Sulawesi Selatan, bagian selatan pulau Jawa mempunyai kecepatan angin lebih besar dari 5 m/s yang memberikan kemungkinan memanfaatkan SKEA berukuran sedang dan besar untuk pembangkit listrik. Berbagai ukuran SKEA sampai ukuran 10 kW telah dikembangkan. Uji lapangan di beberapa lokasi di Indonesia sedang berlangsung dan berkembang.
Makalah ini juga menguraikan tentang prospek pemanfaatan SKEA, keuntungannya dan kemungkinan kendala dalam mengimplementasikan SKEA dan saran.

Kata kunci: Indonesia, kecepatan angin, SKEA, teknologi energi angin.

1. INTRODUCTION.

Wind data of Indonesia are measured by various institutions such as the National Meteorological Agency or BMG, LAPAN, Winrock International, Wind Guard (in cooperation with Local Government), Soluziona and others. Many locations are projected having a good wind potential but the data have not been accessed due to financial limitations and its remote or isolated locations. For such as locations and to improve wind data, the cooperation's with international institutions and private sector are required.
At some selected location, more measurements are taken using more reliable equipments in order to improve the wind data.

The main criteria for utilizing wind energy technology are:

- the availability of a good wind potential ,
- demand.

In order to prove the technology and a local acceptance, some pilot projects need to be actualized and be developed. In parallel selecting the most appropriate wind technology should be done since many remote areas are not easy to be reach.
Implementing the wind energy systems like "a chicken and an egg" which means the market has not developed because the product is not there and the product has not developed because the market is not there (Hansen, 2001).

The objective of wind energy technology development and its utilization in Indonesia is to establish the wind energy technology for electricity generating in rural and remote/isolated areas in Indonesia as a part of rural electrifications program.
Therefore, the local capability in mastering the science and technology of wind energy conversion system (WECS), their utilizations and dissemination need to be improved in cooperation with private sectors and local manufactures (Nenny Sri Utami, 2000).

To achieve the objective, the following programs have been specified:

a. Resource assessment that means wind measurement program to collect the wind data at several areas and wind mapping.
b. WECS technology development, that means developing a suitable prototypes and selecting of appropriate WECS for Indonesia by assessing WECS product word wide.
c. Utilization and dissemination of the pilot projects at selected locations,
d. Development a hybrids systems,
e. Techno-socio economic assessment for local manufacture of WECS.

2. WIND ENERGY RESOURCE.

Wind data measurements are obtained from BMG and in situ measurement by LAPAN and other institutions. More than 150 (one hundred fifty) sites of BMG (at 10 m height) and more than 110 measured sites by LAPAN and other institutes (at 10 m, 15 m, 24 m, 30 m and 50m heights) have been identified and the average wind speed are shown at **Table 1.** Three categories of wind speed shown on Table 1 means that sites with low wind speed range from 2.5 – 4 m/s, medium for wind speed of 4 – 5 m/s and good/excellent with wind speed for > 5 m/s (Soeripno, 2005; Sulistyo Atmadi, 1997).
Other measurements done by several institutions in cooperative with local government are:

- Wind Guard GmBH have identified the wind potential at 12 sites in 3 Regency in East Nusa Tenggara (NTT), those are: Kabupaten Rote Ndao, Kabupaten Kupang and Kabupaten Timor Timur Selatan. These three areas have a good wind speed.
- Soluziona have identified the wind potential at 3 sites at Kabupaten SIDRAP, Kabupaten Selayar and Kabupaten Gunung Kidul. The evaluation shows that these three areas also have a good wind potential.

Sustain wind mapping should be done.

- Need to extent the wind measurement program and its assessment to obtain as many as wind data for a better wind map of Indonesia.
- Need to cooperate with various institution, national and internationally.
- Need to assess other data from The National Meteorological Agency or BMG, National Climate Data Center (NCDC) and others as a reference.

Table 1: The average wind speed at several areas measured by LAPAN and other institutes.

No	Province,	Number of measurement	Wind Speed classification		
			low	medium	Good/ Excellent
1	Nusa Tenggara Timur	43	10	23	10
2	Nusa Tenggara Barat & Bali	10	2	7	1
3	Maluku & Papua	6	4	2	
4	Sulawesi	19	8	6	5
5	Jawa & Madura	12	1	4	7
6	Sumatera	5	2	3	
7	Kalimantan	2	1	1	
8	Other	9			9
Sum of measurements		110			

3. WECS DEVELOPMENT.

Today, many types of small wind turbines are implemented in Indonesia.
Some small wind turbines of certain size in total are less cost efficient than one of the large wind turbines of the same size, and also less efficiency in term of kWh/year per swept area. The cost per installed kW of a hundred small wind turbines of 5 – 10 kW capacity is 3 times more expensive than that of one large size of 500 – 1000 kW capacity.
Wind turbine technology of different size range is tabulated in **Table 2** (Gipe, 2003; Lundsager et al., 2001; Gasch and Twele, 2003)
R & D activities particularly on specific topics such as rotor (advanced airfoil), low speed generator and controller are assessed to see the possibility for local production in Indonesia.

Various WECS types of small up to medium size (ranging from 50 W up to 300 kW) and its design are assessed to investigate its possibility to be applied in different areas of Indonesia that have low wind speed in the range of 2.0 to 15 m/s.
Several types WECS of small to medium scales with capacity between 50W to 10 kW have been developed for electrical and mechanical pumps, see **Table 3.**

Capability of local manufacture in producing the wind energy conversion systems of various sizes range from small to medium size up to 10 kW capacity is given in **Table 4.**

Tabel 2. A simple overview of some typical wind turbine of different size.

	Size <1 kW	Size 1 – 10 kW	Size 10-100 kW	Size100kW-1MW	Size 1-5 MW
Rotor Diameter		3 – 10 m	10 – 20 m	20 – 55 m	50 -100 m
Rotor	More than 3 blades	Mostly 3 blades Up or downwind Furling (or pitch) Passive variable speed	Mostly 3 blades Up / downwind Stall (or pitch) Fixed speed (few as variable speed)	Mostly 3 blades Up / downwind Stall (or pitch) Fixed speed (few as variable speed	Mostly 3 bladed Up-wind active yaw Pitch, active stall (or stall). Variable speed for the largest machine
Blade		Several non airfoil types Varying material	Airfoil profiles GRP	Airfoil profiles GRP	Airfoil profiles GRP
Tower		Guyed steel pipes or lattice-pivot base	Lattice / tubular steel pivot base available	Tubular steel	Tubular steel
Control systems		Mechanical or PLC	Relay or PLC	microprocessor	Microprocessor
AC/DC generator	DC for battery charging	Mostly DC type for battery charging and AC types for grid connection	AC Asynchronous	AC Asynchronous multipole	AC Asynchronous multipole optislip
Track record	Many on ships and in remote locations	Few for AC supply Many for DC	Good track-record for many wind turbines	Good track-record for many wind turbines	Limited experience, but present main interest of main players in industry
Availab-ility	China main supplier	Few makes for a small market	limited availability	limited availability for smaller types in this range	Present main market many makes, types and models

Table 3. Developed WECS Prototypes

No	WECS Type, series	Power / Capacity	Type, number of blades, rotor diameter	Remark
1	Nila – 80	50 W	propeller, 6 blades , 0.8 m	Electrical
2	LPN – 200E	200 W	propeller, 3 blades , 1.6 m	Electrical
3	LPN – 1000E	1000 W	Propeller, 3 blades, 3.0 m	Electrical
4	LPN – 2500 E	2500 W	Propeller, 3 blades , 5.0 m	Electrical
5	LPN – 3500E	3500 W	kurve plate, 6 blades , 4.5 m	Water pumping
6	LPN – 5000 E	5000 W	propeller, 3 blades , 6.0 m	Electrical
7	LPN – 10000E	10 kW	propeller, 3 blades , 7.5 m	Electrical
8	LPN – SM–4TG		wood, 4 blades , 3.0 m	Water pumping
9	LPN – SM–8		kurve plate, 8 blades , 3.2 m	Water pumping
10	LPN – SM–12		kurve plate, 12 blades , 3.2 m	Water pumping
11	LPN – SM-18		kurve plate ,18 blades , 6 m	Water pumping
12	Other types	50 kW	Propeller, 3 blades, ~ 16 m	Electrical (under construction)

Table 4. Local capability for WECS Fabrication up to 10 kW

Component	Status	Remark
Rotor , diameter < 10m	√	GRF materials are locally available
Rotor head (hub) and nacelle	√	can be produced at local workshop
Generator permanent magnet	√	development stage for small size
Frame and Orientation subsystem	√	can be produced at local workshop
Control sub system, regulator	√	availability of electronic components
Inverter (dc to ac)	√	locally available in markets (up to certain size/capacity)
Tower	√	locally fabricated

4. WIND TURBINES UTILIZATION

The implementation of isolated wind energy systems in remote areas or remote islands are frequently installed as part of development project. A number of pilot projects have been implemented in several locations (Soeripno, 2005), these are :

- Wind Energy Village Project at Bulak Baru village and Kalianyar village, Jepara, Central Java have been installed in 1991 until 1995.
- Nyamuk Island – Karimunjawa Islands (2 units of 1 kW and 6 units of 2.5 kW)
- Karya Island, near Jakarta (1 unit of 2.5 kW & 4 units of 1 kW), for public lighting and water pumping.
- Selayar village in East Lombok Regency, West Nusa Tenggara (7 units of 1 kW), for household and public lightings.
- Oitui village – Bima Regency - West Nusa Tenggara (1 unit of 1 kW and 1 unit of 2.5 kW) for public lightings facility.
- Samas village Yogyakarta (2.5 kW, 3.5kW and 10 kW), for shrimps growing (germination), for water pumping of fresh and sea water, for lighting and compressor,.
- Kuwaru village – Bantul Regency (2 units of 3.5 kW), for water pumping and 1 kW for public lighting on cow breading.
- Sundak Gunung Kidul Regency (1 unit of 10 kW), for water pumping in bandeng fishery, for lighting and compressor.
- Giliiyang Islands Sumenep Regency East Jawa (6 units of 5 kW), for lighting see **Fig.1**
- Under construction, Pilot project of hybrid system at Rote Ndao East Nusa Tenggara (4 unit of 10 kW WECS and 50 kWp PV and diesel)
- Under construction, Local grid interconnection in Nusa Penida Bali (4 units of 80 kW and 3 unit of 85 kW). 2 units of 80 kW WECS has been installed

- There are some WECS of several kW have been installed in some areas and used for various application: water pumping, lighting (public and household), communication power supply, battery charging, freezer and other.

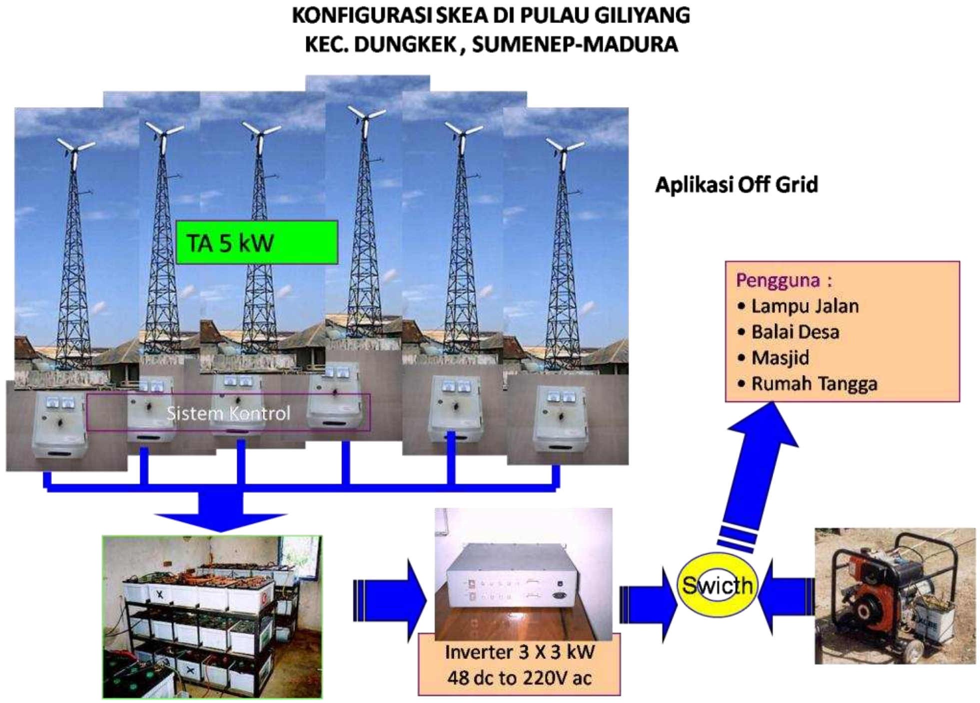

Fig. 1. WECS application configuration at Giliiyang-Sumenep.

5. IMPLEMENTATION PROSPECT

The main aim of applying WECS for electric generation is mainly to save fossil fuel. The wind turbine can be operated in parallel with coal fired power plant or oil fired power plant. The WECS in this context can be thought as a retrofit to the existing electricity supply.

5.1. WECS Configuration

An appropriate configuration is considered based on:

- demand size and consumption pattern,
- WECS size,
- site accessibility,
- infrastructures and
- quality of energy production,

Then, the configurations of the systems shall be as follows:

a. Stand alone systems consist of several units of small scale WECS (up to 10 kW installed capacity per unit) equipped with battery banks as a storage subsystems and inverters for producing 220 V, 50 Hz power system. This type of applications is used for areas with average wind speeds between 3.0 m/s to 4.0 m/s.
b. For higher average wind speed in the ranges of 4.0 m/s to 5.0 m/s, the configurations might consist of medium scale WECS (10 kW-100 kW installed capacity per unit), can be combined with PV or with diesel generating sets as back-up. The main function of diesel generating sets is to take over the supply of electricity during low wind speed.
c. For areas with average wind speeds greater than 5.0 m/s, a larger WECS of more than > 100 kW installed capacity per unit can be applied. The system can be interconnected to the existing grid (grid-interconnection) or can be interconnected to the power generating using generating sets.

5.2. Benefit of WECS Implementation

The WECS installed in the villages are primarily for electricity generation and for mechanical utilization such as water pumping for public consumption and irrigation.

The apparent advantages of the used of WECS are the increasing communal productivity, which in turn will improve many aspects of social and economic progress.

The communal developments observed are:

Income. The availability of electric energy for home and small industries raises productivity caused by increasing working hours, give a possibility to using a modern electric tool in the production process. These raise people incomes, extend businesses and raise job opportunities for the whole villagers.

Education. Normally, children will only study for one hour using oil lamps, but with a fluorescent light many are willing to learn longer until night. Electricity provides a possibility to learn and to get more information from radio and television.

Health. Sanitary and health is closely associated with availability of energy. Insufficient clean water is a major health hazard. Availability of energy will give a better chance to pump water leads to a cleaner sanitary. This means a healthier life condition can be expected.

Information. More chances to access information will improve the knowledge of villagers. They can exchange data and facts of experiences through public telecommunication.

Improvement of living standard. Direct and indirect influence of the availability of WECS electrification to income, health, education and information access for the rural community will in turn improve the standard of living of the community and will improved social structure gradually.

5.3. Prospect of WECS Utilization

Wind energy in several locations has been measured and some have a good to excellent wind energy potential especially at eastern part Indonesia.
A stand alone systems are suitable for small island with small energy demand,.

The prospect for utilization WECS of small size are huge especially to adding the existing electricity generating that usually used diesel oil. As demand increase, this small WECS can be extended by adding another wind turbine. Such a hybrid system has a good prospect in many islands in eastern part of Indonesia.

The feasibility studies at several locations show that there are a prospect to implement a large size wind turbine that connected to the local grid.

Jenebara village at Batangmata subdistrict - at Selayar Island - South Sulawesi has average wind speed of 6.8 m/s annually at 50 height. A yearly measurement was taken during November 2005 until October 2006. The evaluation at 80 meter hub height, this wind resource gives energy as big as 144,423 MWh electric per year. At this height, the WASP simulation show a possibility to implement 25 wind turbines of 1.5 MW each make a total capacity of 45 MW.

5.4. Barriers on WECS Utilization.

There is a deadlock situation, that is the market for wind power in isolated area has not been developed because the product is not there, while in turn the product has not been developed because the market is not exist.

Some of the main barriers are:

- lack of project preparation in the previous pilot projects,
- lack of human resources at the recipient side and local institutional support,
- lack of report on experiences from the previous installed WECS (type and size) that has been adapted successfully in the remote community and no information about WECS cost efficient, and
- lack of guidelines based on the real experiences.

6. CONCLUSION AND RECOMMENDATION.

- Wind resource assessment is one of the main program that has been performed in cooperation with several institutions, national and international to produce wind map of Indonesia It made based on the available wind energy data from various locations, existing topographical information and evaluation that use a certain extrapolating technique

- The national program for development of WECS is directed to provide electricity in the rural and isolated areas in order to extend the local grid by hybrid wind-diesel system or implementing a larger WECS that interconnected to the existing grids.
- Further Research & Development is required to obtain a suitable WECS that able to operate in average low wind speed for various conditions in Indonesia.
- Wind turbine provides a clean alternative resource of electricity for remote areas that has not been covered by PLN.
- Various pilot project in Indonesia show that wind energy has been very useful to improve standard of living in remote areas.
- Several sites have been identified and some of them have a good prospect for implementing WECS.

However, some considerations are needed for a successful project, those are:

- Need to use the update versions of relevant international standards – including the one for decentralized power systems with other renewable energy systems
- Need to make the best practice guidelines for project implementation that covers a relevant experience from the previous and recent projects.
- Need to document the proven approaches, for example to repeating and/or downscaling a successful demonstration system.
- Need to document the proven WECS, which may have been develop from filtering down from the large scale WECS and any technological approach adapted to successful smaller systems.
- Need to include a wind power project for the isolated system as a part of national and international program rather than an individual project
- Need to simplify the procedure to apply a small to medium size WECS.
- Need to test and to document the previous test result thoroughly before the system is installed at rural remote communities.
- Need to define the ownership to make sure future investment when needed.
- Need to involve and to get back up from the relevant national or regional knowledge centre or to establish a local team for future implementation, operation and maintenance.
- Need to have a sufficient detailed feasibility study before WECS implementation.
- Need to have the local wind energy data and methodology applied that will be used to consider the WECS selection, and all the hardware status wheater they available locally or should be imported.
- Need to sustain funding for technological development, experimental facilities in the institute who in charged in developing WECS and to provide engineering tools for customizing the WECS.

For future development of a wind power project in the isolated areas, detailed information on users demands such as local priorities in the energy development is needed in advance. Hopefully, the dissemination of WECS can be made wider in Indonesia.

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