Design optimization of hybrid biomass and wind turbine for minapolitan cluster in Domas, Serang, Banten, Indonesia

Erwin Erwin\textsuperscript{1,2}, Tresna P Soemardi\textsuperscript{1}, Adi Surjosatyo\textsuperscript{1}, Julianto Nugroho\textsuperscript{1}, Kurnia Nugraha\textsuperscript{2}, Slamet Wiyono\textsuperscript{2}

\textsuperscript{1} Mechanical Engineering, University of Indonesia, Depok, Indonesia.
\textsuperscript{2} Mechanical Engineering, Sultan Ageng Tirtayasa University, Cilegon, Indonesia.

E-mail: erwin@untirta.ac.id

Abstract. This research aims is to design a renewable energy power plant based on the renewable energy potential in Domas village. Domas is a coastline that has a wind speed is has the potential to develop a wind power plant with enough capacity that can be utilized economically; in addition Domas is also a centre of rice and rice husks producer. Economic activity as a farmers and milkfish breeders and this area is set to be minapolitan area of Serang district. The problem is many of the ponds is placed far from electricity, so it requires another alternative as a source of electrical. Aquaculture requires aeration and lighting to increase fish and shrimp production, to keep the oxygen content dissolved in water. Lighting are required starting at 6 pm to 6 am, and the aerators based on the shrimp and fish life cycle are required to be switched on from 5 pm to 6 am. Wind data is obtained from Homer, meteonorm and NOAA databases, which is then processed in Homer for optimization. Potential data of husk is obtained from ministry of energy and mineral resources of the republic of Indonesia (EMR) database for Serang regency in 2016. For 1 hectare of land with 1.5 tons of fish, total electricity needed 2.4 kWh per day for lighting and 13 kWh per-day for aerator, with peak of 0.385 kW and 1.9 kW. By using the Aeolos 500 wind turbine as non-dispatchable resource and biomass generator as a dispatchable resource, a simulation is performed to get the system that produces the lowest LCOE (Levelized Cost of Electricity) and highest renewable energy (REN) factor for wind turbine. The recommended system is 2 kW Biomass Generator, 10 kW Inverter, 10 kW Rectifier, 24 Battery Trojan L18P 360 Ah capacity with 8 units of Aeolos 500 array. With economic LCOE $0.445 / kWh, and 82.2 % REN factor for wind turbine.

1. Introduction
Sources of renewable energy have become an alternative to the supply of electric energy for remote areas. Domas village located in the Serang district within no more than 20 km from Serang city center. The village is near on Java sea beach. Domas village is a Minapolitan Village with milky fish and shrimp as a main aquaculture. This study aims to design and provide a hybrid system of renewable energy plant to powering the fish and shrimp pond, alternative energy sources that will be used is biomass and wind using local potential characteristic. Recently, research on the fluctuations in energy generated by wind turbines is highly dependent on the intensity of wind turbulence [1] research integration of different renewable energy sources has been
done to improve the sustainability of the supply of electric energy [2-3]. The problem that arises is how to manage this energy source [4], optimization [6-7] and determine the size of each generator [8] for efficient and optimum economical and technical value. Research on hybrid biogass and wind turbine simulations based on real data shows more reliable energy production to produce stabilized at 40 MW in Spain [9]. HOMER software that is issued by NREL was become one alternative in the initial study to conduct a feasibility study [5] the integration of renewable energy sources. Sultan wind turbine is design to meet the specific wind potential behaviour in Serang district [11] and in the future research will used as a main wind turbine in this system. In term of gasification, using sand to prevent agglomeration in gasification with coconut shell and wood pellets [12], using rice husk ash mass effect to sustain pyrolysis process [13]. The development of job creation formation model in renewable energy sector is offered because of the magnitude of renewable energy potential in Indonesia [19]. CFDs are used to analyse and optimize the integrated wind turbine on buildings [20]. This Research focus on developing the optimized of dispatch-able wind power and non-dispatch-able biomass hybrid plant system, that can electrified the aerator and others need in milkfish pond.

2. Method

Hybrid system is more prefered over a single system due to a more stable performance along a year [16]. This research firstly did an investigating of potential renewable energy by collecting data from secondary data such as from Meteonorm database, meteorology station from NOAA website, Homer database for wind speed and ESDM database for biomass potential. This data will be used as an input in optimization designing renewable energy plant using Homer beta 2 Software.

2.1 Wind potential investigation

Annual average wind speed in Domas according to meteonorm 3.18 m/s, also lower than Garissa Kenya [17]. In this research wind data also collected from homer database. Wind velocity data from local meteorological stations are taken in the NOAA database, at an average speed of 3 m/s, in addition to wind speed data also taken from the meteonorm database and the homer database. The village of Domas is located at -5.990 N 106.254 E, in the Meteonorm database has the potential for sunlight and wind throughout the year as shown below.

| Month   | Meteonorm | NOAA       |
|---------|-----------|------------|
| January | 3.6       | 2.225806   |
| February| 2.6       | 2.243333   |
| March   | 3.1       | 2.080645   |
| April   | 2.6       | 1.656667   |
| Mei     | 2.6       | 1.877419   |
| June    | 3.1       | 1.7        |
| July    | 3.1       | 1.682759   |
| August  | 3.6       | 1.432258   |
| September| 3.6     | 1.446667   |
| October | 3.1       | 1.325806   |
| November| 3.6       | 1.34       |
| December| 3.6       | 1.43871    |

2.2. Biomass potential investigation
From ministry of energy and mineral resources, in Serang city, rice husk is a biggest potential of biomass. Domas village with about 50 families, and every family, average have 1 hectare of paddy field, and produce rice 6.15 tons rice per hectare for four times a year, and produce about rice husk 28 tons per year, means every day about 70kg of rice husk for every family. So for biomass have potentially 350 kg daily. In this case biomass will be process to produce biofuel using gasification with max capacity 30 HP, with feeding speed, 30 kg rice husk per hour.

The biomass potential obtained from ministry of energy and mineral resources of the republic of Indonesia (EMR) for 2017, from the table indicates considerable potential and is technically entirely unused, potentially equivalent to a medium-sized generator.

**Table 2. Biomass potential data obtained from EMR report for Serang Banten area**

| District     | Sources           | Industrial Type   | Potential (MWe) | Global | Technical | Optimized | Used |
|--------------|-------------------|-------------------|-----------------|--------|-----------|-----------|------|
| Serang       | Farming           | Husk Farming      | 67.86           | 4.95   | 0         | 0         | 0    |
| Municipal Garbage | Municipal Garbage Potential | 12.2 | 0 | 0 | 0 | 0 |

2.3. Load calculation
To obtain data real electrical energy requirements for a pond then needs to be calculated on the equipment needed and electrical needs, such as aeration tools and magnitude, lighting and other logistic needs.

A pond needs lights for lighting and aerators to keep oxygen levels in the water. Lighting and home appliance are required starting at 6 pm to 6 am, and aerators based on the shrimp and fish life cycle are required to be switched on from 5 pm to 6 am.

Ordinary farmers have up to 2 hectares of ponds, intensive ponds have a distribution capacity of up to 5 tails per m², and it takes 3 waterwheels per plot (0.5 Ha) the load calculation will use a 2 hectare base with 4 pool plots. Overall average electricity required 2.4 KWh per day for lighting and 13 KWh per day for aerator, with peak of 385 watt and 1.9 Kw respectively.

This system is designed for the whole year where the renewable energy potential condition changes by the time and the energy requirement for the pond changes as needed so that the fish grow optimally, and it is expected that the built system will be able to function throughout the year.

After calculating the duration of the aerator during the life cycle of the fish, and the need for lighting of the pond and home appliance, it can be concluded that the required load is like the figure 3, below.

3. Result
3.1. Plant setup
Because of the unstable wind potential and biomass potential, gasification provides a supply of electricity that can support fluctuating electricity to meet demand load. This is also to reduce the carbon footprint in the plant. In this research, wind energy as a non-dispatchable resource, and gasification serves as a dispatch-able resource. Figure 1 show the system of plant setup for simulation.
3.2. Analysis

The use of several windmills with specifications of the same capacity to see some of the possibilities of windmill configuration, setup fees, maintenance that eventually affect the LCOE, here there are 2 types of windmills that will be discussed. From result of simulation with homer got result as follows.

From simulation for optimization has 200 working combination of system for each type of wind turbine, and below is table 3 and table 4 for each 5 best combinations.

Table 3. Best combination for Aeolos 500

| No | A500 | Label (kW) | L16P | Converter (kW) | Initial capital | Operating cost ($/yr) | Total NPC | COE ($/kWh) | Renewable fraction | Diesel (L) | Label (hrs) |
|----|------|------------|------|----------------|----------------|----------------------|----------|------------|-------------------|------------|-------------|
| 1  | 9    | 2          | 24   | 10             | $9,900         | 1,721                | $31,894  | 0.447      | 0.86              | 430        | 705         |
| 2  | 9    | 2          | 22   | 10             | $9,700         | 1,740                | $31,948  | 0.448      | 0.85              | 460        | 770         |
| 3  | 8    | 2          | 26   | 10             | $9,600         | 1,751                | $31,984  | 0.449      | 0.83              | 488        | 786         |
| 4  | 9    | 2          | 26   | 10             | $10,100        | 1,716                | $32,031  | 0.449      | 0.87              | 408        | 657         |
| 5  | 10   | 2          | 22   | 10             | $10,200        | 1,711                | $32,074  | 0.45       | 0.89              | 388        | 663         |

3.2.1. Aeolos 500 wind turbine (wind 1)

Providing the largest power supply compared to other configurations, with the number of turbines 9 units.

Table 4. Best 10 combination for Sunnily

| No | Sunnily | Label (kW) | L16P | Converter (kW) | Initial capital | Operating cost ($/yr) | Total NPC | COE ($/kWh) | Renewable fraction | Diesel (L) | Label (hrs) |
|----|---------|------------|------|----------------|----------------|----------------------|----------|------------|-------------------|------------|-------------|
| 1  | 12      | 2          | 24   | 10             | $11,400        | 2,393                | $41,986  | 0.589      | 0.62              | 931        | 1,464       |
| 2  | 4       | 2          | 5    | 10             | $5,500         | 2,858                | $42,023  | 0.59       | 0.22              | 2,024      | 4,168       |
| 3  | 12      | 2          | 28   | 10             | $11,800        | 2,372                | $42,127  | 0.591      | 0.63              | 882        | 1,374       |
| 4  | 12      | 2          | 22   | 10             | $11,200        | 2,421                | $42,154  | 0.591      | 0.62              | 966        | 1,548       |
| 5  | 12      | 2          | 26   | 10             | $11,600        | 2,392                | $42,181  | 0.592      | 0.63              | 919        | 1,436       |

Deficiency, the relative price per unit is expensive compared to other wind turbines and is rare to find in market. 8 units arranged in this 3 x 3 matrix requires an area of 45.9 m x 45.9 m. Providing the largest power supply compared to other configurations, with the number of turbines 8 units.
3.2.2. Sunily wind turbine (wind 2)
Providing a large power supply with a total of 12 units of turbines arranged in a 4 x 3 matrix requires an area of 51 m x 74 m. Due to a number of units more than wind 1 then LCOE (*Levelized Cost Of Electricity*) system is higher than the system that uses wind 1.

3.3 Recommended design
From the result of optimization by Homer, the system that can be recommended is shown in table 5 below.

| Table 5. Configuration of renewable energy plant |
|-----------------------------------------------|
| Renewable Configuration | wind 2 | Wind 1 |
| Wind turbine            | 12 Units | 9 Units |
| Generator 1             | 2 kW | 2 kW |
| Battery                 | 24 Trojan L16P | 24 Trojan L16P |
| Inverter                | 10 kW | 10 kW |
| Rectifier               | 10 kW | 10 kW |

The cost and price of electricity that arise from the sistem and renewable energy factor for wind turbines shown in table 6.

| Table 6. Economic result of renewable energy plant |
|-----------------------------------------------|
| Wind 2 | Wind 1 |
| Total net present cost | $41,986 | $31,894 |
| Levelized cost of energy | $ 0.589/kWh | $ 0.447/kWh |
| Operating cost | $ 2,393/yr | $ 1,721/yr |
| REN Factor | 0.62 | 0.86 |

Figure 2 shows that in some months from August to January the REN factor of the Aeolos 500 wind turbine exceeds 90%. In figure 3, in the months from August to January the REN factor of the Sunily wind turbine is only about 80%.

4. Discussion
Optimization of solar power system has been done in Sleman Java, for aeration of fish pond and managed to get the appropriate system [21]. Evaluation of hybrid plants between solar and wind turbines has also been done for aeration ponds in Thailand [22]. Departing from the success of previous research is the author tries to make a hybrid generator between biogas and windmills for milkfish pond in Domas.

Comparison of several types of wind turbines and REN factor produced indicate that wind turbines in accordance with wind conditions will result in higher renewable energy factor [23]. In this study
showed that the Aeolos 500 wind turbines is more suited and more optimum result to wind conditions at Domas, than the Sunily wind turbines. The two best design is feasible according to economic for area isolated from electricity such as milkfish pod in Domas.

For a capacity of 40 MW wind park hybrid with biomass gasification, Pérez-Navarro offers the concept of biomass gasification using syngas storage so that if the combustion process in the gasification reactor produces excessive syngas it can be stored, which can then be used when load needed is increased [9].

![Proposed hybrid system of biomass gasification generator and array Wind Turbine](image)

**Figure 3.** Proposed hybrid system of biomass gasification generator and array Wind Turbine

5. **Conclusion**

From the study that has been done, the recommended system of new renewable energy generation wind power using several wind turbines are feasible to build and have advantages and disadvantages of each. For overall electricity demand is 2.4 KWh per day for lighting and 13 KWh per day for aerators, with peak of 385watt and 1.9KW respectively.

It can be seen that *Aeolos 500* in economic analysis, is cheaper and have higher the production rate of electricity than *Sunily* because of to the different power curve owned by each wind turbine. The more characteristic of the power curve at low wind velocity will be higher REN Factor value and will decrease the LCOE (Levelled Cost Of Electricity).

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