be used as a source of bioenergy [17]. Betung bamboo has a calorific value of 5,176 cal/g, relatively higher than bamboo *Wulung* which is only 4,873 cal/g, and *apus* bamboo is 5,025 cal/g [18]. The characteristics of bamboo stems growing around the waters are shown in Table 3.

TABLE III
CHARACTERISTICS OF BAMBOO BIOMASS TYPE OF BETUNG (*Dendrocalamus asper*) WHICH GROWS AROUND WATERS

Sample Plot	**Height (m)**	**Weight (kg)**	**Ratio W/H (kgm^{-1})**	**Diameter (cm)**	**Thickness (cm)**	**Calory ($Kcalkg^{-1}$)**	**Moisture (%)**	**Ash (%)**	**Carbon (%)**
Plot 1	24.0	99.9	4.16	22.7	2.27	3,203.2	44.7	1.4	16.0
Plot 2	19.8	85.1	4.31	18.0	2.30	3,636.3	52.6	1.5	16.0
Plot 3	23.5	80.4	3.43	19.2	1.87	3,677.4	43.3	1.2	15.7
Plot 4	18.2	55.0	3.03	17.2	1.88	3,695.7	40.1	1.4	17.4
Plot 5	21.0	78.0	3.71	12.4	3.10	3,911.6	39.7	1.5	16.8
Plot 6	16.3	61.2	3.75	12.6	1.67	3,413.7	37.6	1.3	17.1
Plot 7	22.2	86.9	3.91	11.7	1.75	3,542.7	35.2	1.7	14.7
Plot 8	15.6	58.1	3.73	11.3	1.87	3,512.3	51.3	1.9	17.6
Plot 9	17.2	42.1	2.45	9.9	1.68	3,498.5	49.4	1.4	16.2

The average height of *Betung* bamboo stems obtained from the study site was 19.7 meters, average fresh weight of 71.9 kg/stem, stem diameter of 15.0 cm, the wall thickness of 2.0 cm, and average stem moisture content of 43.8%. The results obtained show slightly different from some other researchers. Betung bamboo that grows in the Subang West Java Province has an average stem height of 15.8 meters, a stem diameter of 11.5 cm, a fresh stem weight of 39.6 kg, and stem wall thickness of 3.9 cm [19]. Other research shows that bamboo species of *Bambusa vulgaris* that grow in the forests of the Lawachara-Bangladesh reserve have an average stem height of 21.92 m with an average stem diameter of 20.57 cm [20]. Betung bamboo that grows in the village of Tanjung Terdana Bengkulu has a plant height between 6.4 - 10 meters, length of sections 29 - 42 cm, stem diameter 6-9 cm, and thickness of the stem wall 1.5 - 2.0 cm [21]. The research results on *Betung* bamboo in Konawe District showed the results of the stem wall thickness of 1.0 - 2.5 cm and stem moisture content of 42.61% [17].

The calorific value of the stem is influenced by the moisture content it contains. Stem moisture content depends on water intake, tree age (growth phase), substrate and external factors. Thus, stems for energy sources need to be first drained and proper storage before use [22].

The average area of bamboo clumps in the study area is 9.88 m2, and the average number of bamboo clumps in 1 ha is 210 clumps, and the average number of bamboo stands in one clump is 22 stems. Thus the average number of bamboo stands in 1 ha in the study area is approximately 4,620 stems. The average weight of fresh bamboo stems is 71.9 kg/stem. Thus the total potential of fresh bamboo biomass is about 332.2 tons/ha. This study's results are relatively higher than the findings [20], where for bamboo species of *bambusa vulgaris*, the number of bamboo stems per ha is 2,933.33 stems with a total biomass weight of 97.8 tons/ha. The study results of the potential of biomass from *bamboo-blanke* species were only 26.3 tons/ha [23].

Observation results at the study site showed that the average density of bamboo plants in a clump was 2.23 sticks per m2, thus the potential number of bamboo plants was 22,667 sticks per ha. When the study was found, there were only 4,620 bamboo stems per ha; this was due to the very large distance between clumps. The results of other studies indicate that the number of *Betung* bamboo stems is 30.2 stems/clumps, the circumference of the clumps is 8.8 meters, and the plant density is 3.2 stems/meters2 [19]. Research conducted in Thailand shows that intensively managed bamboo plants produce higher biomass yields than bamboo plants that are not well managed [24]. The Kepulauan Mentawai Regency Government plans to manage bamboo plants to meet the raw material for bamboo biomass electricity. If the efficiency of the amount of bamboo stands can be achieved only by 50% of the existing potential, then the actual number of bamboo stands that can be obtained is as much as 11,134 stems per ha or at least 2.4 times the current production. The average weight of *Betung* bamboo plants is 71.9 kg/stem. Thus the potential for fresh biomass of *Betung* bamboo plants is 800.5 tons/ha.

The moisture content of bamboo stems will decrease with increasing the stems' age, so the old bamboo stems are relatively good to use as an energy source [24]. Comparison of the number of bamboo stems of *Betung* in the age group on a relatively balanced stretch between stems aged 1 year, 2 years, and three years [19]. Bamboo in Indonesia has very promising potential to be put to good use. Bamboo is a quickly developed plant and has a relatively fast life cycle, with a harvest age of 3-4 years [25]. Bamboo has high biomass productivity, can be harvested at the age of 3 years, the trunk is straight, has high strength, is easily processed, and is relatively inexpensive. Betung bamboo has good characteristics and morphology and its chemical component content can be converted into bioenergy [26].

Based on the data potential of fresh biomass of 800.5 tons/ha and the harvest age is 3 years, the harvest potential of *Betung* bamboo is 266.83 tons/ha/year. The need for bamboo biomass for power generation needs is calculated based on the bamboo plant's dry weight. Based on fresh bamboo biomass's potential, dried Betung bamboo's weight potential per hectare per year is estimated at 185.56 tons.

$$DW = \frac{266.83\ kg}{1 + \left(\frac{43.8}{100}\right)}$$

DW = 185.56 ton/ha/year

Bamboo gasification provides excellent prospects for increasing added value and utilizing bamboo as a raw material for generating electricity. Biomass gasification is the main way of biomass energy utilization in Beijing [27]. Not only bamboo stems, but also waste from bamboo processing can also be used for gasification. This encourages a commitment to producing clean electricity from renewable natural resources that can substitute for the use of fossil fuels and reduce operating costs [11].

Every 3-4 kg of fresh biomass from bamboo plants can produce electricity as much as 1 kWh. The potential energy produced is the same as that produced by using as much as 1 liter of diesel [28]. The use of bamboo as an electrification raw material for power capacities <1 MW to 2 MW is very suitable using the "Biomass Power Plant-Gasification System-Pyrolysis". The use of this system will require approximately 1.22 kg of biomass with 15% moisture content to produce electricity of 1 kWe [29].

Some research data relating to the use of biomass as a raw material for electricity generation has been widely published. in Thailand, power plants made from corn cob biomass with a mixture of several types of agricultural waste with a capacity of 150 KW require 224 kg of biomass/hour (approximately 1.49 kg of biomass/KW). Other biomass-based power plants in Thailand with a capacity of 500 KW using raw materials of 60% wood chips and 40% corncobs require raw materials of 5,389 tons/year or approximately 1.23 kg of biomass to produce 1 KW of electricity [30]. Mentawai Prosperity Regional Company Management said that the power plant made from bamboo biomass, which is already owned by the Kepulauan Mentawai Regency, currently requires 1.5 kg of dried bamboo to produce electricity of 1 KWe.

The electricity needed to meet household electrification in the Kepulauan Mentawai Regency in 2020 is 5,283 KVA. If electricity is fully operated for 24 hours per day and 365 days per year, and the power factor (chospi) is 0.8 then in 2020 the electricity needed is 46,279,080 KWh, the need for dried bamboo is 86,773.3 tons/year, and the area of bamboo needed is 467.6 ha.

EPR = 5,283 KVA x 24 hours x 365 days
= 46,279,080 KWh
DBN = 46,279,080 x 1.5 kg x (1/0.8)
= 86,773.3 tons/year.

EPR = Electrical Power Requirements
DBN = Dry Bamboo Needed

The area of bamboo plants needed to meet household electricity needs in 2020 are:

$$Bamboo\ Area\ Plant\ Needed = \frac{86{,}773.3\ ton}{185.56\ ton/ha} = 467.6\ ha$$

The projected need for electrical power to meet household electrification in the Kepulauan Mentawai Regency in 2035 is 8,066 KVA. Using the same assumptions as of 2020, the electricity needed is 70,658,160 KWh, dry bamboo needed is 132,484.1 tons/year, and the required area of bamboo plants is 714 ha.

EPR = 8.066 KVA x 24 hours x 365 days
= 70.658.160 KWh
DBN = 70.658.160 x 1,5 kg x (1/0,8)
= 132.484,1 ton/year

The area of bamboo plants needed to meet household electricity needs in 2035 are:

$$Bamboo\ Area\ Plant\ Needed = \frac{132{,}484.1\ ton}{185{,}56\ ton/ha} = 714\ ha$$

In the Kepulauan Mentawai Regency Spatial and Regional Planning for 2015 - 2035, it is stated that it will develop 300 hectares of bamboo for each island. Mentawai Islands Regency consists of 4 large islands, thus the government has targeted there will be the development of bamboo plants on an area of 1,200 ha by 2035.

IV. CONCLUSIONS

The projected number of households in the Kepulauan Mentawai Regency until the end of 2020 and 2035 are 22,534 units and 28,639 units, respectively. In 2020 there were still 11,819 households that had not yet received electricity, and by the end of 2035, there were an estimated 17,924 household units that would need electricity. If each household needs 450 VA of electricity, then electricity is still needed for households in 2020, and by the end of 2035, each is 5,283 KVA and 8,066 KVA. In order to meet the electricity needs of the aforementioned household, the Kepulauan Mentawai Regency Government is using electricity made from bamboo biomass. Bamboo biomass needed to meet the electricity power in 2020 and at the end of 2035 is 65,777.3 tons/year and 132,484.1 tons/year, respectively. To meet the bamboo biomass needs, there must be bamboo plantation land for 2020 and at the end of 2035, covering 467.6 ha and 714 ha, respectively.

REFERENCES

[1] BPS-Statistics of Kepulauan Mentawai Regency, "*Kepulauan Mentawai Regency in Figures 2019*", ISSN : 2654-9603, catalog : 1102001-1301, p. 346, 2019.

[2] Aisman, "Basic study of the potential of bamboo biomass-based electrical energy in the Kepulauan Mentawai Regency", *Journal of Agroindustry*, Vol. 6, No. 2, pp. 65-72, Nov. 2016.

[3] State Electricity Company [PLN] of Kepulauan Mentawai Regency, "*Annual Report PLN of Kepulauan Mentawai Regency in 2019*", not published.

[4] S. Yokoyama, Ed., "Guide to Biomass Production and Utilization", Project Assistance for Asian Cooperation for Environmental Conscious Agriculture. *The Japan Institute of Energy*, 2008.

[5] Arhamsyah, Utilization of Wood Biomass as a Renewable Energy Source. *Research Journal of Forest Product Industry* Vol. 2, No.1, pp. 42– 48, Juni 2010.

[6] R. Li, "Study of China's biomass power generation technology". IOP Publishing, Series: *Earth and Environmental Science* **300** (2019) 042045 doi:10.1088/1755-1315/300/4/042045.

[7] S. Makridakis, S.C. Wheelwright, and V.E. McGee, *Forecasting: Methodes and Applications.* Second edition, Jhon Wiley & Sons, New York, p. 926, 1983.

[8] J.L. Bowyer, R. Shmulsky, and J.G. Haygreen, *Forest Product and Wood Science: an Introduction*, 5 th edition, Blackwell Publishing, p. 576, May 2007.

[9] N.P.E. Wiratmini. (2019), Biomass Power Plant Investment in Mentawai Reaches Rp. 145 billion. [Online] Avalable: https://ekonomi.bisnis.com/read/20190917/44/1149532.

[10] D. Yoesgiantoro, D.A. Panunggul, D.E. Corneles, and N.F. Yudha, "The Effectiveness of Development Bamboo Biomass Power Plant (Case Study: Siberut Island, The District of Mentawai Islands)". IOP Publishing, Series: *Earth and Environmental Science* 265 (2019) 012001 doi:10.1088/1755-1315/265/1/012001.

[11] J.M.O. Scurlock, D.C. Dayton, and B. Hames, B., "Bamboo: an overlooked biomass resource?", *Biomass and Bioenergy* 19 (2000), pp. 229-244.

[12] H.P. Putri, M. Mokodompit, and A.P. Kuntari, "Study the characteristics of briquettes made from bamboo waste using glue of rice". *Journal of Technology*, Vol. 6 No. 2, pp. 116-123, Dec. 2013.

[13] D.A. Himawanto, "Optimization of pyrolysis conditions of bamboo waste in order to get the greatest energy". *Buana Science* Vol. 12 No. 2: pp. 35-38, 2012.

[14] I.N. Sukarta, and P.S. Ayuni, "Proximate analysis and heat value in biosolid pellets combined with bamboo waste biomass". *Journal of Science and Technology* Vol. 5, No. 1, pp. 728-735, April 2016.

[15] D.S. Nawawi, A. Carolina, T. Saskia, D. Darmawan, S.L. Gusvina, N.J. Wistara, R.K. Sari, and W. Syafii, "Chemical characteristics of biomass for energy". *J. Tropical Wood Science and Technology* Vol. 16 No. 1, pp. 44-51, Jan. 2018.

[16] M. Mentari, T. Mulyaningsih, and E. Aryanti, "Identification of bamboo in the Kedome East Lombok watershed and alternative benefits for river border conservation", *Journal of Watershed Management Research* Vol. 2 No. 2, pp. 111-122, Oct. 2018.

[17] N. Pujirahayu, "Study of the physical properties of several types of bamboo in Tonggauna District, Konawe Regency", *AGRIPLUS*, Vol. 22 No. 03, pp. 224-230, Sept. 2012.

[18] S. Suluh, P. Sampelawang, N. Sirande, "An analysis of the use of local bamboo as an alternative energy source", IOP Publishing, Series: *Materials Science and Engineering* 619 (2019) 012006 doi:10.1088/1757-899X/619/1/012006.

[19] Sutiyono and M. Wardani, "Characteristics of bamboo petung (*Dendrocalamus Asper* Back.) in the lowlands of Subang, West Java", in *Proc. Biology Seminar* Vol 8, No 1, pp. 51-62, 2011.

[20] Sohel MSI, Alamgir M, Akhter S, Rahman M. Carbon storage in a bamboo (Bambusa vulgaris) plantation in the degraded tropical forests: Implications for policy development. Land Use Policy [Internet]. Elsevier BV; 2015 Dec;49:142–51. Available from: http://dx.doi.org/10.1016/j.landusepol.2015.07.011

[21] R.W. Haastuti, A.P. Yani, and I. Ansori, "Study of bamboo species diversity in the village of Tanjung Terdana, Central Bengkulu", *J. Biology Education and Learning* 2 (1), pp. 96-102, 2018.

[22] D.P. Miasik, and Rabczak, "The use of forest waste in the energy sector", IOP Publishing, Series: *Materials Science and Engineering* 603 (2019) 052092. doi:10.1088/1757-899X/603/5/052092.

[23] B. Suprihatno, R. Hamidy, and B. Amin, "Analysis of biomass and carbon reserves of bamboo belangke (Gigantochloa Pruriens)", *J. Enviromental Science of Riau University* 6 (1), pp. 82-92, 2012.

[24] A. Darabanta, M. Haruthaithanasana, W. Atklaa, and T. Phudphonga, "Bamboo biomass yield and feedstock characteristics of energy plantations in Thailand", in *Energy Procedia* 59-2014, pp. 134 – 141, 2014.

[25] E. Arsad, "Teknologi pengolahan dan manfaat bambu", *J. Forest Product Industry Research* Vol.7, No.1, pp. 45–52, Jun. 2015.

[26] S. Yusuf, F.A. Syamani, W. Fatriasari, and Suyakto, "Review on bamboo utilization as biocomposites, pulp and bioenergy" in IOP Publishing, Series: *Earth and Environmental Science 141* (2018) 012039 doi :10.1088/1755-1315/141/1/012039.

[27] H.Z. Zhang, and B.R. Huang, "Sustainable development strategies of biomass energy in Beijing", in IOP Publishing, Series: *Earth and Environmental Science* 86 (2017) 012007 doi :10.1088/1755-1315/86/1/012007.

[28] J. Wahono, "Increasing the electrification ratio of rural communities / remote islands with bamboo biomass", Paper at the National Seminar on Sustainable Energy Independence, Tuapejat Mentawai, August 20, 2015.

[29] H. Al Rasyid, "Biomass generation technology for reliable off grade areas", Paper at the National Seminar on Sustainable Energy Independence, Tuapejat Mentawai, August 20, 2015.

[30] C. Sritong, A. Kunavongkrit, and C. Piumsombun, "A study of raw material management innovation problems in biomass power plants". *International Journal of e-Education, e-Business, e-Management and e-Learning*, Vol. 2, No. 4, pp. 319-322, August 2012.