International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2013): 6.14 | Impact Factor (2015): 6.391

Identification of Ocean Currents Potential Energy in Lombok Strait Based on Electric Turbine Scenarios

Rizal F. Abida[1], Widodo S. Pranowo[1, 3], Engki A. Kisnarti[2]

[1]Marine and Coastal Data Laboratory, R & D Center for Marine and Coastal Resources, Ministry of Marine Affairs & Fisheries, The Republic of Indonesia, Gedung II BadanLitbang KP, 4th floor, Pasir Putih II, East Ancol, Jakarta, Indonesia

[2]Hang Tuah University, Arif Rahman Hakim 150, Surabaya, Indonesia

[3]Department of Technical Hydrography, Indonesian Naval Postgraduate School (STTAL)
Pantai Kuta V No. 1, Ancol Timur, Jakarta 14430, Indonesia

Abstract: ***Lombok Strait istraversed by the Indonesian Through-Flow (ITF). ITF isa huge volume of seawater mass originated from the Pacific Ocean flowing into the Indian Ocean. An oceanographic mooring is deployed during 2004-2007 to study the ITF. One of the outcome, ocean current data is used for an advance experiment to derive a renewable energy potential.A Matlab Toolbox, called T-Tide, is employed to filtering harmonic and non-harmonic ocean currents.It reveals that Lombok Strait has an optimum velocity of 2.0235 m/s at 45 m depth for hydropower.Energy conversion,using Fraenkel's formula, of its current velocity that using turbine Gorlov's scenario (35% efficiency) can produce a biggest energy (1589,666 kWh). By using scenario of Darrieus turbine (23.5% efficiency) can produce 3,741.99 kWh. Another turbine scenario of In-plane Axis (20% efficiency) can produce 3,184.672 kWh.***

Keyword: ocean currents**,** potential energy**,** Lombok strait, electric turbine scenarios, t-tide**.**

1. Introduction

Electrical Energy is one of the main necessary and it's playan important part in the human life. Until 2006, electrification ratio in Indonesia recently reached 56%, it means that more than 100 million people in Indonesia still not gained and relished the electricity [1]. Geographical conditions of the Indonesian are consist of a thousands islands.Uneven of the deployment electricity center, electricity demand in some areas, costs marginal system development energy supply electricity, and the limited financial capabilities, are the factor problemsin providing energy at national scale. One of the solution to solve the problem by using the renewable energy, such as: solar, wind, water, biomass, etc [2].

Indonesia seas can be used as an alternative energy sources for the electrical energy replacement. Electrical energy Development was derived from the potential elevation tides, the difference temperatures, ocean current, waves, and wind at the coastal. Indonesian seas havestrong ocean currents that potential to be fully utilized to generate electric energy. Indonesia'socean currents andwaves are very potential to be developed. This potential spread in various regions [3]. Indonesia Throughflow (ITF) became one characteristic of the current system in Indonesia. ITF is a system of ocean circulation in Indonesia that brings water masses from the Pacific Ocean to the Indian Ocean. Pacific water mass consists of water masses of the North Pacific and the South Pacific. The ITF mainly due to the difference in sea level between the Pacific Ocean and the Indian Ocean, namely the inner surface of the tropical Pacific Ocean West is higher than in the Indian Ocean at the east, resulting in a pressure gradient resulting flow of current from the Pacific Ocean to the Indian Ocean [4]. Studyareawas chosen based on one of the mooring deployment in ITF pathways. The aim of this study was to calculate the amount of electricity generated potential energy of ocean currents in one stream turbine using Cross Flow Turbine (Gorlov and Darrieus) and Axial Flow (In-plane Axis).

INSTANT Expedition data (2004-2006) has been used too by Ihsan et.al (2015) [5] to calculate the amount of electrical energy from ITF current. This study used data from the same project (INSTANT) but only focus on the Lombok Strait East mooring. The potential energy for electrical energy is calculated more detail and using the available turbine on market. Three turbines has been used in this study each have an area (A) and efficiency (η) different will be produce varies energy.

2. Material and Method

2.1 Data

The data thatused in this study wasfromINSTANT Expedition (International Nusantara Stratification and Transport) in 2004-2007, from the Marine and Coastal Data Laboratory, Research & Development Center for Marine & Coastal Resources (P3SDLP). INSTANT Expedition is ainternational coorperation program between five countries: United States of America, Australia, Netherlands, France, and Indonesia. International Program is studying ocean current, temperature, and salinity ITF (Indonesia Throughflow) by deploy theoceanography instruments (mooring) in the location of ITF outflow and inflow at Lombok Strait, Ombai Strait, Timor Passage, Makasar Strait, and Lifamatola Passage. This program was started in 2003 and has two times sailing scientific (*Scientific Cruise*) the Deployment Cruise (2003-2004) and *Rotation Cruise* (2005) [6].

Table 1: Ocean current data on INSTANT expedition in Lombok Strait

No.	Data	Type	Year	Source
1.	INSTANT Expedition ocean current data			Marine and Coastal Data Laboratory
	a. *Deployment* 1	.*Mat.*	2004 - 2005	
	b. *Deployment* 2	.*Mat.*	2005 - 2007	

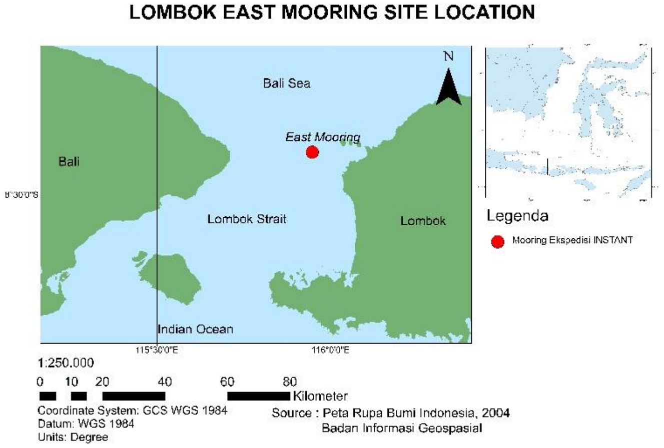

Figure 1: Site Map of East Mooring, Lombok Strait

Turbine data obtained from a research of BalaiBesarPengembanganTeknologiTepatGuna – Indonesian Institute of Science. That will be conducting design water turbine type L C500, to develop water flow turbine, using streams and rivers or irrigation canals. Water turbine serves to change the water flow energy into mechanical energy into shaft rotation. Mechanical energy is then converted into electrical energy using a generator. Flat flow water turbine design refers to the helical turbine that has been developed utilizing the Gorlov turbine tidal currents as an energy source driving the turbine runner. Turbine Gorlov that has been developed using the profile blade in the form of a hydrofoil symmetrical NACA 0015 that works based on the style of the elevator, the turbine proficiency level consists of the main components namely the blade profile NACA 0020, with a chord length of 500 mm, height 1250 mm, and the diameter of 1000mm with the angle of twist of 63 ° and is made of fiberglass blade 3 pieces [7].

2.2 Turbine Efficiency

One of the aims of this research is to analyze catch massive energy in turbine that is any guide, namely on turbine *in the plane axis*, Darrieus turbine, Gorlov Helical. From these three kinds of turbine has a massive energy efficiency catch, different and that affects nor energy produced by in each use turbine. A massive turbine efficiency was influenced by model prefabricated turbine itself. The efficiency turbine shown in Table 2.

Table 2: The efficiency turbine

No.	*Turbine*	*Efficiency*	*Types of turbine*
1.	Gorlov Helical Strands	35%	*CFWT*
2.	Darrieus	23.5 %	
3.	*In the plane axis*	20 %	*AFWT*

Source: Alexander N. Gorban *et al*, 2001[8]

The efficiency value are shown in Table 2 generally lower than that used by Ihsan et.al (2015), but values as shown above is more real and is the result or physical models are available in the market.

Axial Flow Water turbine (AFWT) is a turbine that spins in parallel defendants toward ocean current and need control or a profitable to rotor to follow the ocean current, in an effort to improve it's power conversion was arrested by turbine. Conversely if *AFWT* will turn perpendicular to have the ocean current, but in different with Cross *Flow Water turbine* (*CFWT*). *CFWT* is turbine that can spin with movements from various directions, so that it does not require a profitable higher compared with *AFWT*. This type of turbine has several benefits, but more complicated in design and the prediction of the movement hydrodinamics. A massive catches ocean current in Darrieus turbine of 0.88125 m^2 of overall cross section of 3.75 m^2, with the efficiency of 23.5 %,Gorlov turbine of 1.3125 m^2 of overall cross section of 3.75 m^2, with the efficiency of 35 %, *turbine In -plane axis* (axis) of horizontal 0.75m^2 , from broad cross section as a whole was 3.75 m^2, with the efficiency of more than 20 percent.

Figure 2 . is illustration of models and the massive energy efficiency catches in each turbine, is *AFWT* and *CFWT*.

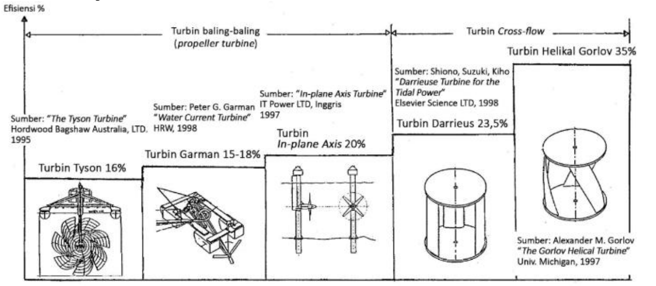

Figure 2: A comparison performance (efficiency) in various turbine ocean currents [8].

2.3 Conversion of Ocean Current to Electricity

Development of technology extraction energy ocean currents are usually adopting from the principle technology wind energy that has been developing countries, namely kinetic energy to change the ocean currents to energy rotation and electrical energy. The power that was produced by the ocean currents turbine is bigger than wind turbine, because the density of sea water is more dense than air masses. Capacity that can be counted on approach produced a mathematical formulate a passing through a surface or widespread, then the formula general is formulation Fraenkel [9] are:

$$P = 0.5\ \rho\ A\ \eta\ V^3$$

$P = power\ (Kwatt)$;

$\rho = water\ mass\ (1025\ kg/m^3)$;

$A = area\ (m^2)$ Vary depending on the turbine that is used.

$\eta = turbine\ efficiency\ (\%)$ Vary depending on the turbine that is used.

$V = current\ speed\ (m/s)$.

Formulationaboveoccursin kineticenergytotheprocessof conversion electricity power generating systems at sea water

3. Results and Discussion

3.1 Ocean Current Characteristics in Lombok Strait

INSTANT Data in Lombok Strait consists of 2 deployment mooring (see Table 1). Each deployment depth produces a different ocean current measurements. There are three measurements of ocean current velocity, which are the maximum, minimum, and it's range value.

The ocean current velocity in mooring deployment 1 is between 0 m/s to 1.6495 m/s, for the specific value in each depth can seen in Table 3.

Table 3: OceanCurrentVelocityin Deployment 1

Depth (*m*)	Max (m/s)	Min (m/s)	Range (m/s)
100	1.068	0.000624	1.067376
260	1.6495	0.003	1.6465
272	1.6085	0.002828	1.605672
284	1.7142	0.001414	1.712786
296	1.6303	0.003	1.6273
308	1.5391	0.001	1.5381
320	1.4173	0.002	1.4153
332	1.1185	0.001	1.1175
344	0.95754	0.00283	0.95471
350	0.4609	0	0.4609
356	0.9142	0.002	0.9122
368	0.8403	0.001	0.8393
380	0.796	0.002236	0.793764
392	0.7707	0.002829	0.767872
404	0.7558	0.001	0.7548
416	0.6932	0.002	0.6912
428	1.3142	0.002	1.3122
440	0.9293	0.001414	0.927886
450	0.5021	0.011	0.4911
452	0.6571	0.001	0.6561
464	0.5869	0.001	0.5859
476	0.6397	0.002236	0.637464
488	0.6236	0	0.6236

The current velocity in deployment 1 has a vary values, it is because the instrument that used to measure in mooring deployment 1.Current velocity mostly decrease within increasing of the depth(See Table 3). The maximum current velocity in the depth of 100 m was 1.06737 m/s while in the 488 m is 0.6236 m/s.

The ocean current velocity in mooring deployment 2 is between 0 m/s to 2.0285 m/s, for the specific value in each depth can seen in Table 4.

Table 4: Ocean Current Velocity in Deployment 2

Depth(*m*)	Min (m/s)	Max (m/s)	Range (m/s)
45	2.0285	0.005	2.0235
61	1.9587	0.002828	1.955872
77	1.9587	0.002	1.9567
93	1.4865	0.001414	1.485086
104	0.734	0.001951	0.732049
109	0.9998	0	0.9998
125	1.0973	0.001414	1.095886
248	0.6353	0	0.6353
354	0.6675	0	0.6675
433	0.5515	0.011	0.5405

Table 4 shows that ocean current velocity in mooring deployment 2 has a vary values in each depth. It is has a same result with the mooring deployment 1 (Table 3), that the current velocity mostly decrease within the increasing of the depth. The maximum current velocity in depth of 45 m was 2.0235 m/s and in 433 m was 0.5405 m/s.

In a study that carried out by Ihsan et.al (2015) only data on deployment 2, and at this point measurement tools depth that makes data in publication was less than office although presented as a whole mooring station in the expedition INSTANT. This matter was influential in the speed findings suggest that, in comparison to speed ocean current maximum on or before around 0,162 m/s to 0,618 m/s, by using methods that period but with a data that is different from that in this research displaying data that more of it, which is in the depth of 45m with a high speed between 0.005 m/s to 2.0285 m/s. The difference is quite significant.

3.2 Estimation of Electrical Energy

Energy Conversion of the movement of ocean current to power that was produced by turbine. For converting the energy was used by the Fraenkel formation that had an objective as an approach from development of technology in changingthe kinetic energy ocean currents into thepower plant [9].Turbine that is used as a model in this research on turbine Gorlov, turbine Darrieus turbine, and in-plane axis. The result of energy conversion from theocean current measuringshown in Table 5, with the unit kilowatt hour.

Based on the result conversion energy ocean current thatusedFraenkel formula, using several scenarios that turbine turbineGorlov, turbine Darrieus, and in-plane axis turbine as a reference for the result as shown above turbine power that could get in. With the acquisition is greatest power in the depth of 45 m with great power of 1589.666 *kWh*.

With great power that was obtained from the result of the research plan target compared to General National Energy that is taken from the sea of 6,000 MW, then the ratio between these research results to the target energy that, at the end of 2050 to 0.00014 percent.

Table 5: The resultofenergyconversionbased onGorlov,Darrieusand In the plane AxisTurbine as Scenarios

Depth (m)	Gorlov (*in kWh*)			Darrieus (*in kWh*)			In the plane Axis (*in kWh*)		
	Max	Min	Range	Max	Min	Range	Max	Min	Range
45	1589.666	726.499	8819.106	1067.347	487.792	5921.400	908.381	415.143	5039.489
61	1133.533	606.352	6741.235	761.086	407.122	4526.258	647.733	346.487	3852.134
77	627.302	377.707	3936.022	421.189	253.603	2642.758	358.458	215.833	2249.156
93	380.461	350.898	2923.840	255.452	235.603	1963.150	217.406	200.513	1670.766
104	266.000	0.000	263.884	178.600	0.000	177.179	152.000	0.000	150.791
109	672.253	0.000	672.253	451.370	0.000	451.370	384.144	0.000	384.144
125	888.729	0.000	885.297	596.718	0.000	594.414	507.845	0.000	505.884
248	172.476	0.000	172.476	115.806	0.000	115.806	98.558	0.000	98.558
260	3018.910	0.000	3002.468	2026.982	0.000	2015.943	1725.091	0.000	1715.696
272	2799.345	0.000	2784.603	1879.560	0.000	1869.662	1599.626	0.000	1591.202
284	3388.267	0.000	3379.889	2274.979	0.000	2269.354	1936.153	0.000	1931.365
296	2914.713	0.000	2898.652	1957.021	0.000	1946.238	1665.550	0.000	1656.372
308	2452.413	0.000	2447.636	1646.620	0.000	1643.413	1401.379	0.000	1398.649
320	1915.043	0.000	1906.947	1285.815	0.000	1280.379	1094.310	0.000	1089.684
332	941.242	0.000	938.719	631.977	0.000	630.283	537.852	0.000	536.411
344	590.560	0.000	585.339	396.519	0.000	393.013	337.463	0.000	334.480
350	65.859	0.000	65.859	44.219	0.000	44.219	37.634	0.000	37.634
354	200.054	0.000	200.054	134.322	0.000	134.322	114.317	0.000	114.317
356	513.945	0.000	510.580	345.078	0.000	342.818	293.683	0.000	291.760
368	399.113	0.000	397.690	267.976	0.000	267.021	228.065	0.000	227.252
380	339.260	0.000	336.409	227.789	0.000	225.874	193.863	0.000	192.234
392	307.928	0.000	304.550	206.752	0.000	204.484	175.959	0.000	174.029
404	290.412	0.000	289.260	194.991	0.000	194.218	165.949	0.000	165.292
416	224.062	0.000	222.129	150.442	0.000	149.143	128.036	0.000	126.931
428	1526.784	0.000	1519.824	1025.126	0.000	1020.453	872.448	0.000	868.471
433	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
440	539.835	0.000	537.374	362.461	0.000	360.809	308.477	0.000	307.071
450	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
452	190.848	0.000	189.978	128.141	0.000	127.557	109.056	0.000	108.559
464	135.983	0.000	135.289	91.303	0.000	90.837	77.705	0.000	77.308
476	176.085	0.000	174.245	118.228	0.000	116.993	100.620	0.000	99.569
488	163.122	0.000	163.122	109.525	0.000	109.525	93.212	0.000	93.212

4. Conclusions

A massive catches ocean current in Darrieus turbine of 0.88125 $m^2$of overall cross section of 3.75 m^2 blades, with the efficiency of 23.5%, Gorlov turbine of 1.3125 m2 of overall cross section of 3.75 m^2 blades, with the efficiency of 35%, turbine In the plane axis of 0.75 m^2, from broad cross section as a whole was 3.75 m^2 blades, with the efficiency of more than 20%.

Energy conversion of ocean currents in Lombok Strait that using scenario turbine Gorlov's has a biggest energy in the depth of 45 meters with the energy 1589,666 kWh. While for scenario Darrieus turbine produce energy of 3,741.99. And the energy that produced by turbine in the plane axis of 3,184.672 kWh in the same depth of 45 m. It is more effective and typical efficiency than the previous scenario, which is in the depthof 104m.

5. Acknowledgement

Processing and data analysis mostly done in the Marine and Coastal Data Laboratory, Research & Development Center for Marine & Coastal Resources(P3SDLP), Agency for Research and Development of Marine and Fishery, in Jakarta (2014/2015). The preparation and publishing the article was financed by DIPA State Budget (APBN) for 2016 in Research & Development Center for Marine & Coastal Resources (P3SDLP),dedicated to the Research Group on Climate Change Policy.

References

[1] M. Nizam,“Pembangkit Listrik Terdistribusi (Distributed Generation) Sebagai Upaya Pemenuhan Kebutuhan Energi Listrik di Indonesia,” Jurnal Kanika, XVII (1), 2008.

[2] Anonym,“PengembanganEnergiTerbarukanSebagaiEnergiAditif di Indonesia,” http://www.energi.lipi.go.id/utama.cgi?artikel&1101089425&9, 2015.

[3] S. Hadi,“EnergiListrikAlternatifBerbasisArusLaut Indonesia,” ITBNews.

[4] M. Safitri, S.Y. Cahyarini, M.R. Putri, “Variasi Arus Arlindo dan Parameter Oseanografi di Laut Timor sebagai Indikasi Kejadian Enso,” Jurnal Ilmu dan Teknologi Kelautan Tropis IV (2), 2012.

[5] Y.N. Ihsan, A. Tussadiah, N. Pridina, R.M. Utamy, K.M. Astriandhita, Arnudin, K. Nurhasanah, “Renewable Energy form Ocean Currents on the Outflow ITF Pathway, Indonesia,” Energy Procedia (65), pp. 131-139, 2015.

[6] W. S. Pranowo, A. R. Tisiana Kuswardani, T. L. Kepel, U.R. Kadarwati, S. Makarim, S. Husein, “Ekspedisi

INSTANT 2003-2005: Menguak Arus Lintas Indonesia," Pusat Riset Wilayah Laut & Sumberdaya Non Hayati Badan Riset Kelautan dan Perikanan Departemen Kelautan dan Perikanan, 2005.
[7] Novrinaldi, A. Haryanto, U. Hanifah, "Rancang Bangun Turbin Heliks Aliran Datar Tipe LC500," In Proceedings SNapp201, 2011.
[8] N. Gorban, Alexander, A.M. Gorloy, V.M. Silantyey, "Limits of the Turbine Efficiency for Free Fluid Flow," Journal of Energy Resources, 2001.
[9] Fraenkel P. L, "Power from Marine Curents,"Journal Power and Energy (216), 2002.

Author Profile

Rizal Fadlan Abida received the S.T. SarjanaTeknik in Indonesia (Bachelor of Engineering)in Marine Engineering (Oceanography) Hang Tuah University in 2010 - 2015. Afterward, he is work in Marine and Coastal Data Laboratory, in Research & Development Center for Marine & Coastal Resources, under the Ministry of Maritime Affairs and Fisheries, the Republic of Indonesia. He is, one of the person, in charge in the development of Information System for Fisherman (SINP). Since 2016, he is strongly involve in the several experimental project on hydro-oceanographic and scientific survey and cruises.

Widodo S. Pranowo is now as Head of Marine and Coastal Data Laboratory, in Research & Development Center for Marine & Coastal Resources, under the Ministry of Maritime Affairs and Fisheries, the Republic of Indonesia. He is also active as a lecturer at the Department of Technical Hydrographic, Indonesian Naval Postgraduate School (STTAL). Since 2016, he is also as a guest lecturer in the Indonesian National Armed Forces Commander's School (SESKO TNI). During 2003-2007, he's strongly involve in the multinational oceanographic research project "International Nusantara Stratification and Transport (INSTANT)".

Engki A. Kisnarti is an active lecturer in the Department of Marine Engineering, Hang Tuah University, Surabaya, Indonesia. Her strong background/ competence is in Physical Oceanography. She was one of the cruise participant during the INSTANT expedition (Leg-4)July 16 - 25, 2005 with RV. Baruna Jaya I for the deployment and recovery mooring in Lifamatola Passage. She is a principal advisor for the bachelor thesis project of Rizal Fadlan Abida.