Wave Energy Reviews In Indonesia

by Muh Yusuf

International Journal of Mechanical Engineering and Technology (IJMET)
Volume 8, Issue 10, October 2017, pp. 448–459, Article ID: IJMET_08_10_049
Available online at http://www.iaeme.com/IJMET/issues.asp?JType=IJMET&VType=8&IType=10
ISSN Print: 0976-6340 and ISSN Online: 0976-6359

WAVE ENERGY REVIEWS IN INDONESIA

Denny Nugroho Sugianto, Kunarso, Muhammad Helmi, Inovasita Alifdini, Lilik Maslukah, Siddhi Saputro, Muh. Yusuf
Department of Oceanography, Faculty of Fisheries and Marine Sciences,
Diponegoro University Indonesia

Denny Nugroho Sugianto, Kunarso, Muhammad Helmi, Inovasita Alifdini
Coastal Disaster Mitigation and Rehabilitation Studies (CoRem) Diponegoro University,
Center of Excellence Science and Technology (PUI)

Hadi Endrawati
Department of Marine Science, Faculty of Fisheries and Marine Sciences,
Diponegoro University Indonesia

ABSTRACT

Indonesia is a maritime country that has vast ocean. Some coastal parts in Indonesia has wave energy potential to develop for renewable energy. In some researches that were conducted, the potential parts were consisted of western of Sumatera Island, Southern of Java Bali Nusa Tenggara and Northern of Papua Island. Those regions have various results of wave characteristics and an estimation of generated electrical energy. Others factors that we have to concern to implement this energy were costs, transmissions from sources to users and maintenace of devices. The strategic plans should be arranged for the commercial developments.

Keywords: wave energy, marine renewable energy, Indonesia

Cite this Article: Denny Nugroho Sugianto, Kunarso, Muhammad Helmi, Inovasita Alifdini, Lilik Maslukah, Siddhi Saputro, Muh. Yusuf and Hadi Endrawati, Wave Energy Reviews in Indonesia, International Journal of Mechanical Engineering and Technology 8(10), 2017, pp. 448–459.
http://www.iaeme.com/IJMET/issues.asp?JType=IJMET&VType=8&IType=10

1. INTRODUCTION

Renewable energy is generally defined as harnessed energy from alternative resources to replace natural gas, oil and coal, which are non-renewable [1]. Ocean wave energy is one of the most promising renewable [2] and clean energy sources which can be called as “Blue energy”[3]. The ocean energy sources are an untapped resource that is able to produce a significant contribution to renewable and clean energy generation [4].

One of sorts of ocean renewable energy is wave energy. Wave-energy-characteristics are inexhaustible, predictable and non-pollutant [5]. Wave energy and the associated potential power production from wave energy converters holds great pledge as an abundant, carbon neutral source of electricity generation to generation [6]. Ocean waves are a more predictable resource with a higher energy density compared to solar and wind [7]. Energy production from ocean waves is Non Polluting that can supply mega capability from the vast-ocean-water-body [8].

Some prototypes to harness wave energy have been implemented in other countries. There are plenty kinds of wave energy devices, such as oscillating water column (OWC) device [9], wave energy raft [10], wave energy pendulum [11], nodding duck [12], overtopping device [13] and point absorber [14]. Those devices can be classified into two categories: the fixed device and the floating device [15]. Performance of a sea wave energy conversion device depends on many technical factors such as converting energy efficiency [16]. Some of the devices passed through the commercialization stage and have been built and deployed, for instance Pelamis, Oyster, OWC, etc [17].

Indonesia is the largest archipelago state in the world [18] comprising 17,480 islands, with a maritime territory measured nearly by 6 million square kilometres [19]. Indonesia also as an archipelago nation which has lots of maritime space [20], triggering inter-continental maritime connections [21] and fishing ground areas [22] that is related to Pacific and Indian Ocean [23]. Due to many promising potentions from the sea, it will be good harnessing of renewable energy from it. The need for alternative energy sources is capable of providing conversion in a sustainable manner has prompted a significant scientific and operational interest [24].

2. INDONESIAN ENERGY PROBLEM

2.1. Current Conditions and Problems of Energy

Based on forecasts in 2013 by EIA, world energy consumption will increase by 56% between 2010 and 2040. The energy market will expand [25] which is amplified by international energy trade [26]. The generally stronger convergence with respect in oil-related emissions until 1991 conditional on gross domestic product per capita is compatible with situation where the rising oil prices [27] caused a strong transformation in the interest of countries [28].

Indonesian energy problems today are fossil energy reserves continue to decrease and more difficult to be accessed by undeveloped people, remote and bordered areas [29]. In terms of reserves, declining oil production and increasing fuel demand (BBM) will cause higher crude oil and fuel imports [30]. The increase of final energy consumption per sector occurred annually in the period of 2000 to 2014, except in 2005 and 2006. The average of annual growth over the period of 2000-2014 was 3.99% per year from 555.88 million BOE in 2000 to 961.39 million BOE in 2014 [31]. If it is assumed that no new energy reserves are found, based on the R / P ratio (Reserve / Production) of 2014, the petroleum will be run out in 12 years, 37 years of natural gas, and 70 years of coal. This reserve will be faster to run out because of the increasing trend of fossil energy production [32].

Peningkatan konsumsi energi nal per sektor selalu terjadi setiap tahun pada periode 2000–2014, kecuali pada tahun 2005 dan 2006. Rata–rata pertumbuhan tahunan selama periode 2000-2014 adalah 3,99% per tahun dari 555,88 juta SBM pada tahun 2000 menjadi 961,39 juta SBM pada tahun 2014

2.2. Energy Availibility and Demand

Indonesia has several potential fossil energy resources including petroleum, natural gas and coal. In 2014, proven petroleum reserves of 3.6 billion barrels, natural gas of 100.3 TCF and coal reserves of 32.27 billion tons. By 2050, the utilization of electricity has increased by almost 6.1 times for the basic scenario and has become more than 7.5 times higher for the high scenario. This is caused by electricity-based technology continues to grow rapidly and dominantly used in almost all sectors, especially in the household and commercial sectors. The abolition of fuel and electricity subsidies led to a decrease in energy subsidies from 315 trillion rupiah in 2014 to 119 trillion rupiahs by 2015 used for infrastructure and social development [30].

2.3. Electrical Energy in Indonesia

An electrical power supply is one of the most important and fundamental elements for suistanable economic growth [33]. It is implemented with the issuance of Presidential Decree (Decree) No. 4 2016 on accelerating the development of electricity infrastructure [34]. The rise of climate change issue and the energy crisis makes the building must perform energy saving to reduce the adverse effects on the environment [35]. PLN's power plant capacity still dominates with a share of more than 76% (39.3 GW), power plant of IPP at 15% (7.9 GW), and the rest is filled with PPU power plants and IO non-fuel power plants with a share of 9% (4.7 GW).

Indonesia has several types of power plants, namely PLN, IPP, PPU and IO non BBM. The capacity of PLN's power plant has a market over than 76% (39.3 GW), IPP power plant at 15% (7.9 GW), while PPU power plants and IO non-fuel power plants have a market of 9% (4.7 GW). Approximately 74% of the total capacity of the national power station is located in Java-Bali, 16% in Sumatra, 3% in Kalimantan and in other islands (Sulawesi, Maluku, NTB-NTT, Papua) [30].

The Electricity consumption in the period of 2000-2014 has an average growth of 6.8% per year, while in 2014-2050 it grows by an average of 5.3% per year. The decrease in electricity contribution is caused by many tools that have used the principle of energy savings. In 2014, the national electrification ratio was 84.4% or an increase of 3.9% from 2013. The role of electricity in 2050 still dominates up to 74% of the total energy needs. Nevertheless, per capita power consumption in Indonesia is still low if compared to some ASEAN countries. Electricity consumption in Indonesia is 798 kWh / capita, Thailand (2,471 kWh / capita), Malaysia (4,512 kWh / capita), Singapore (8,840 kWh / capita) and Brunai Darussalam (9704 kWh / capita) [30].

3. WAVE ENERGY HISTORY AND ASSESSMENT

Indonesian maritime continent which consists of five large islands (Papua, Kalimantan, Sumatera, Sulawesi and Java) [36] has increasingly serious shortages of conventional energy such as coal and oil. The entire coastal in Indonesia estimated can produce more than 2 ~ 3 TW electrical equivalents, assuming 1% of the Indonesian coastline (~ 800 km) can supply a minimum of ~ 16 GW equivalent to Indonesia's electricity supply in 2005 [37]. However, resources categorized as recoverable as sources of energy derived from the ocean such as wave energy, tidal, wind and OTEC have not been further utilized [38].

Previous reports produced a great contribution to the design of wave energy converters and applied for many patents. Development of ocean energy in Indonesia remained not to be implemented properly because there are still many inhibiting factors [39]. Advanced of comprehensive wave energy evaluation and application systems are still scarce in the primitive state of wave energy evaluation [40]. The trials of sea wave power plants have been conducted in Parang Racuk (Gunung Kidul) of Yogyakarta Special Province (DIY). The plant was tested using Oscillating Water Column (OWC) technology by BPPT and BPDP. The trials which do until now have not been able to achieve the expected results because the OWC prototype has mechanically operational difficulties [41].

The cost of investments based on trials in some industrialized countries is around 9 cents / kWh to 15 cents / kWh [39]. According to PT PLN (Persero), every one kilo meter of transmission requires 3-4 towers. For transmission of 500 kV and 150 kV, each of towers requires 25x25 square meters of land and 15x15 square meters [30]. Based on the results of financial analysis, construction of power plants from marine resources assessed that have the opportunity to be developed is the energy of ocean currents, sea waves and tides. The electricity tariff per kWh generated is considerable to compete with the non-subsidized electricity cost sold by PLN for IDR 1,163 / kWh, which is IDR 1,268 / kWh for ocean current energy, IDR 1,709 / kWh for sea wave energy and IDR 2,048 / kWh for tidal energy. Meanwhile, electricity tariffs generated by energy from the difference in sea water temperature (OTEC) have a high cost, reaching at IDR 4,030 / kWh, which tends not to compete with conventional electricity tariffs that are approximately four times cheaper [42].

The potential of electricity generated from marine energy in Indonesia has been widely studied and calculated by various parties [30], one of which is the calculation issued by the Association of Marine Energy of Indonesia - ASELI [43]. Some areas with wave heights of more than 2 meters and a 10-second period are potential waves for renewable energy development [44]. Potential of wave energy in the area reaching at 1200 MW with plant capacity of 0.5 - 2 MW [45]. The development of researches on wave energy in Indonesia is presented in Table 1.

Tabel 1 The Development of Some Wave Energy Researches in Indonesia

Source	Formulation	Location	Data Used	Findings
Mehlum (1991) [25]	Norwave's Tapered Channel (TAPCHAN) Technology	Indonesia	Unknown	An installed capacity appoximation is 1.5 MW. The annual production will be some 10 GWh with expected cost of energy is 6 cents (US) per kWh.
Barstow *et al*. (1998) [46]	Wave power from an estimation using a set of direct relationships between significant wave height and energy period.	Indian Ocean in the coastal area of Indonesia	2 years analysis of satellite altimeter data from the Topex/Poseidon mission (launched in 1992)	Electrical capacity is from 5 to 20 kw/m.
Cornett (2008) [47]	Wave power per unit width transmitted by irregular waves	Indian Ocean in the Coastal area of Indonesia	Wave climate predictions by WAVEWATCH-III (NWW3) wind-wave model spanning the 10 year period from 1997 to 2006.	20 – 30 kW/m capacity
Irhas and Suryaningsih	Oscillating Water Column Technology	South Coast of Yogyakarta	Wave data from metrology,	The air pressure efficiency of the wave power plant uses 1

Source	Formulation	Location	Data Used	Findings
(2014) [48]			climatology, and geophysics agency of Indonesia	large pipe which is equal to wave power plant that uses 17 small pipes.
BPPT (2014) [32]	unknown	Indonesian Waters	Unknown	Wave energy potency : theoretical potency of 510 GW, technical potency of 2 GW and the practical potency of 1,2 GW
Mukhtasor *et al.*, (2015) [49]	Pendulum System PLTGL-SB 20 kW	unknown	Unknown	Increasing the capacity to be 3500 W with generators produced by LIPI
Anggraini *et al.*, (2015) [50]	Oscillating Water Column (OWC) converter	Some Indonesian Waters Areas	Significant wave height data obtained from Meteorology, Climatology and Geophysics Agency (BMKG) of Indonesia	The greatest power is located in Aru Islands and Arafuru Sea which reached out 313 kW and had a minimum value of 55 kW. The median powers were located in the south coast of Central Java, Timor Sea and Banda Sea which had maximum value of 198 kW and minimum value of 20 kW.
Alifdini *et al.* (2016) [51]	Oscillating Water Column *fixed on-shore*	Sungai Suci Beach, Bengkulu	Wave data from ECMWF (2011-2015)	Electrical energy that can be produced using this technology in Sungai Suci Beach was 7.703 MW/year.
Alifdini *et al.* (2016)b [52]	Oscillating Water Column *floating type*	Pulau Baai Beach, Bengkulu	Wind data (speed and direction) from ogimet.com in 2000-2016	Power output of OWC was 1.9 GW/year (using 3 chambers)
Sugianto *et al.* (2017) [53]	Oscillating Water Column *fixed on-shore*	Sungai Suci Beach, Bengkulu	Hindcasting wave using 17 years wind data (2000-2016)	The capacity of power that could be generated was 1.0073 MW and categorized as small hydro
Azhari *et al.*, (2017) [54]	Pico-Scale Wave Energy Converter	South Coast of Yogyakarta	Wave data from Metrology, Climatology and Geophysics Agency in Indonesia (BMKG) during period from 2000 to 2010.	A quasi-flat LPMG (Linear Permanent Magnet Generator) which was designed could produce output power of 725.78 Wp for each phase, with electrical efficiency of 64.5%.

4. STRATEGIC PLANS

A strategic plan is needed to accomplish purposes. It is important to reach the goals systematically and clearly. Strategic plan can be obtained through analysis of some resources challenges and availability. Ocean energies are identified as a potential commercial-scale source of renewable energy [55]. Renewable energy development especially in the wave energy area is a challenge for Indonesia. Both commercial readiness and market viability are required for successful entry into and survival in the energy market [56]. Through the large investment cost, which is not comparable with the profit gained, make Indonesia rethink to develop this type of energy. Therefore, it is necessary to design any strategies about how to keep this energy in order to be able to be developed given the potential energy of these waves in some coastal areas and sea in Indonesia. Situation analysis by looking at various options in long-term energy development needs to be done to achieve the target set [30].

4.1. The Challenges of Wave Energy Development in Indonesia

Indonesia is the archipelago state surrounded by the Indian and Pacific Ocean in several areas. With the coast and ocean areas that have potential for the development of this renewable energy, it should be able to put good use of the existing energy potential. However, several things to note are the challenges of renewable energy development [57]. The electricity production cost of the wave energy generator is relatively higher so that in some locations the application is less competitive than the production cost of electricity from conventional power plants. This is due to the need for adequate infrastructure and some equipment components that are still imported. As a result, the interest of investors who want to invest becomes limited. In addition, the limited human and budgetary resources [58] to manage and maintain the wave energy power plant makes this energy development a little hampered. The availability of energy that is not fully 24 hours, it is also a consideration for the construction of wave energy facilities.

4.2. Strategic Plans that Indonesia has done

Policies from various agencies related to electrical and renewable energy development continue to emerge. Some of them are the National Energy Council (DEN) that has been socializing the draft of National Energy Policy (KEN) which contains of the target of electricity needs in the period of 2010-2050. In addition, The Directorate General of Renewable Energy and Energy Conservation (DG EBTKE) has issued a discourse to achieve a higher share of renewable energy in the national energy mix of 25% by 2025, otherwise known as the 25/25 energy vision. BPPT has also released Indonesia Energy Outlook which contains projected needs and energy supply for the long term. In addition, PT PLN (Persero) has issued the Electricity Supply Business Plan of PT PLN (Persero) 2011-2020, called RUPTL which provides an overview of PLN's power supply business plan throughout Indonesia in 2011-2020 which will be used as reference in the preparation of long-term corporate plans and as a guide in the preparation of annual work programs [59].

The developing strategic plan for the development of renewable energy development is based on Nawa Cita (priority agenda) [60]. The policy and strategic direction that have been formulated are to increase the role of renewable energy in the energy mix by formulating the appropriate incentives and prices to encourage investment. In addition, renewable energy is being developed in order to increase the accessibility of electrical supply for Indonesia's outermost areas. Increasing efficiency in the use of energy through energy-efficient campaigns is also necessary [61].

Directorate General of EBTKE together with The Ministry of Finance, provides incentives in the form of a feed-in tariff mechanism for investors to develop renewable energy [62]. Some programs that have been developed for renewable energy development are [57]:

1. Prepare the Regulation and Policy

   This needs to be done to accelerate the achievement of renewable energy utilization rate in the national primary energy mix.

2. Creating Markets

   The market can be created through the assignment of PT PLN (Persero) to buy electricity from ocean renewable energy.
3. Preparing SNI

   Indonesian National Standard (SNI) related to renewable energy generating equipment needs to be arranged in order to create the utilization of renewable energy safety.
4. Create Feed-In Tariff and Ceiling Price

   The publication of ESDM regulates the fit and ceiling price of electrical energy from power plants using renewable energy.
5. Building Energy Infrastructure

   Infrastructure of renewable energy should be allocated funding through APBN, APBD and DAK by utilizing renewable energy potential in local area.
6. Improving International Cooperation

   International cooperation can be done with some countries that have experienced in the development of ocean renewable energy. This is necessary in order to be a reference and learning for Indonesia to be able to develop renewable energy potential in the future independently.

4.3. Future Plans

Some of the strategies that Indonesia needs to do now are to take several policy-making steps such as energy conservation, energy diversification and energy intensification. Energy conservation is an effort to use energy by not reducing the development of growth rate [63] by using equipments that more efficient to energy users [37]. Energy conservation is conducted with the aim of improving energy efficiency on the supply and demand sides of industrial, transportation, household and commercial sectors [57]. Meanwhile, energy diversification is an effort to reduce the dependence of petroleum [63] by diversifying the use of non-petroleum energy [37] such as renewable energy [57]. Energy intensification is a search for new energy sources in order to increase energy reserves as utilization of electric power [39]. Intensification efforts are done through increased survey activities and exploration of energy resources to determine its potential economically [41].

In the development of marine renewable energy, several strategies that have been developed by the International Energy Agency (IEA) include [62]:

1. Improving and Aligning Agencies & Policies

Indonesia's energy policy is experiencing a lot of difficulties because the large number of institutions and agencies which involved with overlapping roles. The above conditions ultimately make policy targets that are sometimes too ambitious and more reflective of political priorities than targets that may be achieved.

2. Improving The Legal Framework and Regulations

In the field of legal and regulatory framework there are still many things to improve. Many published regulations are contradicted to the existing policies and / or in direct contradiction with applicable law. The need to establish an independent institution or at least two key units are in an independent government or not having direct responsibility for the ministry - especially in the field of regulation in upstream and downstream sector of oil and electricity sector. The Corruption Eradication Commission (KPK) can serve as an example of an organization of independent institutions but remains part of state institutions.

3. Improving and Expanding Infrastructure

Plans for increasing renewable energy production depend heavily on the huge investment in transmission and investment networks on the development of geothermal power plants, solar energy and wind energy. Indonesia has actually identified the needs of this infrastructure project in its policies and plans but is often delayed and its sources of funding are unclear. Investment projects, whether financed by the public or private sector are often delayed due to unclear land tenure and poor land acquisition procedures for projects that are the top priority.

4. Ensure the Sustainability of the Energy Sector

Efforts to improve sustainability in the energy sector are critical to ensuring that Indonesia is able to achieve its greenhouse gas (GHG) reduction targets. It also requires the use of new and more efficient technologies in the transportation and power generation sectors. Environmental protection also needs to be upgraded, especially at the local level where forest and biodiversity degradation in Indonesia is to be stopped.

Some suggested recommendations including to improve coordination in energy regulation and policy development are by increasing the energy investment framework to accelerate decision-making processes and open up market-based on energy sector mechanisms. Establish a special unit of the Investment Coordinating Board to facilitate infrastructure investment in renewable energy. In addition, the government is expected to provide advice and support investors to obtain the necessary licenses [62]. It is also important to fix things related to social and cultural aspects. Public awareness of the importance of switching to renewable energy sources needs to be built early [58].

5. CONCLUSION

Nationally, the use of new and renewable energy (EBT) in Indonesia has not been optimal because with low fossil energy prices, high EBT investments will make it difficult for EBT to enter into the competition of energy utilization. With the development of 35 GW program which is a short-term program listed in Nawacita makes the use of EBT more limited because to achieve the goal Nawacita is required large-scale energy-fueled fossil.

Wave energy development as a source of renewable energy in Indonesia is still deepening in research. There are some experimental tests of wave energy devices, but still experiencing some obstacles. Some stategic plans should Indonesia do to implement wave energy for a source of electricity, so, Indonesia can overcome energy crisis in the future due to lack of fossil energies.

ACKNOWLEDGEMENTS

We would thank to Oceanography Department Diponegoro University, LPPM Diponegoro University, WCU Program Diponegoro University, Center for Coastal Disaster Mitigation and Rehabilitation Studies (CoRem) Diponegoro University, Center of Excellence Science and Technology (PUI) Diponegoro University and Ministry of Research Technology and Higher Education (Ristek Dikti) Republic of Indonesia for funding our research.

REFERENCES

[1] Tan, W. C., K. W. Chan and H. Ooi. 2017. Study of the Potential of Wave Energy in Malaysia. AIP Conference Proceedings 1865: 1 – 5.

[2] Wang, L., J. Isberg and E. Tedeschi. 2018. Review of Control Strategies for Wave Energy Conversion Systems and Their Validation: The Wave-to-Wire Approach. Renewable and Sustainable Energy Reviews 81 (1): 366-379.

[3] Li, X., J. Tao, J. Zhu and C. Pan. 2017. A Nanowire based Triboelectric Nano generator for Harvesting Water Wave Energy and Its Applications. APL Materials Open Access 5 (7): 1 - 6. Article number 074104.

[4] Alonso, R., M. Jackson, P. Santoro, M. Fossati, S. Solari and L. Teixeira. 2017. Wave and Tidal Energy Resource Assessment in Uruguayan Shelf Seas. Renewable Energy 114, Part A, 18-31 pp.

[5] Almeida, J.P.P.G and Lopes de. 2017. REEFS: An Artificial Reef for Wave Energy Harnessing and Shore Protection – A New Concept towards Multipurpose Sustainable Solutions. Renewable Energy 114, Part B: 817 - 829.

[6] Robertson, B., Y. Jin, H. Bailey and B. Buckham. 2017. Calibrating Wave Resource Assessments through Application of the Triple Collocation Technique. Renewable Energy 114, Part A: 166-179.

[7] Lehmann, M., F. Karimpour, C. A. Goudey, P. T. Jacobson, M.-R. Alam. 2017. Ocean Wave Energy in the United States: Current Status and Future Perspectives. Renewable and Sustainable Energy Reviews 74: 1300-1313.

[8] Arulappan, S.S. 2017. New Green Energy: Ocean Wave Energy Conversion Physical Turbine Models and Designs Photos Presentation and Explanations for Large Scale Manufacturing. International Journal of Mechanical and Production Engineering Research and Development (IJMPERD) 7 (4): 425-430.

[9] The Queen's University of Belfast. 2002. Islay LIMPET Wave Power Plant (Publishable Report). 1-62 pp.

[10] Zheng, S. and Y. Zhang. 2017. Analytical Study on Hydrodynamic Performance of A Raft-Type Wave Power Device. Journal of Marine Science and Technology: 1 - 13.

[11] Gu, Y., L. Zhao, J. Huang and B. Wang. 2012. The Principle, Review and Prospect of Wave Energy Converter. Advanced Materials Research 347 – 353: 3744-3749.

[12] Wilson, C. 2013. Wave Energy Roots. Marine Technology 50 (3): 87-88.

[13] De Andres, A., E. Medina-Lopez, D. Crooks, O. Roberts and H. Jeffrey. 2017. On the Reversed LCOE Calculation: Design Constraints for Wave Energy Commercialization. International Journal of Marine Energy 18: 88 - 108.

[14] Göteman, M. 2017. Wave Energy Parks with Point-Absorbers of Different Dimensions. Journal of Fluids and Structures 74: 142-157.

[15] Wu, B., T. Chen, J. Jiang, G. Li, Y. Zhang and Y. Ye. 2018. Economic Assessment of Wave Power Boat Based on The Performance of Mighty Whale and BBDB. Renewable and Sustainable Energy Reviews 81 (1): 946-953.

[16] Chiu, S.F.., J.J. Wang, S.C. Wang and S. D. Chao. 2017. Enhancing Sea Wave Potential Energy with Under-Sea Periodic Arrays of Cylinders. Proceedings of the 2017 IEEE International Conference on Applied System Innovation: Applied System Innovation for Modern Technology, ICASI 2017, 213-216 pp.

[17] Yurchenko, D. and P. Alevras. 2018. Parametric Pendulum based Wave Energy Converter. Mechanical Systems and Signal Processing 99: 504 - 515.

[18] Brotosusilo, A., I.W.A. Apriana, A.A. Satria and T. Jokopitoyo. 2016. Littoral and Coastal Management in Supporting Maritime Security for Realizing Indonesia as World Maritime Axis. IOP Conference Series: Earth and Environmental Science 30 (1): 1 – 6.

[19] Febrica, S. 2017. Maritime Security and Indonesia Cooperation, Interests and Strategies. Taylor & Francais eBook. 1 - 1065 pp.

[20] Satiawan, P R. 2017. The Sea is Not an Empty Space. IOP Conf. Series: Earth and Environmental Science 79: 1 – 6.

[21] Kusuma, P., N. Brucato, M. P. Cox, T. Letellier, A. Manan, C. Nuraini, P. Grangé, H. Sudoyo and F.-X. Ricaut. 2017. The Last Sea Nomads of the Indonesian Archipelago: Genomic Origins and Dispersal. European Journal of Human Genetics 25: 1004–1010.

[22] Edyvane, K. S., S. S. Penny. 2017. Trends in Derelict Fishing Nets and Fishing Activity in Northern Australia: Implications for Trans-Boundary Fisheries Management in the Shared Arafura and Timor Seas. Fisheries Research 188: 23-37.

[23] Deckker, P.D. 2016. The Indo-Pacific Warm Pool: Critical to World Oceanography and World Climate. Geoscience Letters 3 (1): 1 – 12.

[24] Lucero, F., P. A. Catalán, Á. Ossandón, J. Beyá, A. Puelma, L. Zamorano. 2017. Wave Energy Assessment in the Central-South Coast of Chile. Renewable Energy 114, Part A: 120-131.

[25] Mehlum, E. 1991. Commercial Tapered Channel Wave Power Plants in Australia and Indonesia. Oceans (New York) 1 : 535-538.

[26] Zhang, J.C., R. Zhong, P. Zhao, H.W. Zhang, Y. Wang and G.Z. Mao. 2016. International Energy Trade Impacts on Water Resource Crises: An Embodied Water Flows Perspective. Environ. Res. Lett. 11: 1 – 12.

[27] Batten, J. A., H. Kinateder, P. G. Szilagyi and N. F.Wagner. 2017. Can Stock Market Investors Hedge Energy Risk? Evidence from Asia. Energy Economics 66 : 559-570.

[28] Acar, S. and M. Lindmark. 2017. Convergence of CO_2 Emissions and Economic Growth in The OECD Countries: Did The Type of Fuel Matter ? Part B: Economics, Planning and Policy. Energy Sources 12 (7) : 618-627.

[29] Lasabuda, R. 2013. Regional Development in Coastal and Ocean in Archipelago Perspective of The Republic of Indonesia. Jurnal Ilmiah Platax I-2 : 92 – 101.

[30] BPPT. 2016. Indonesia Energy Outlook. Ed: Sugiyono, A., Anindhita, L.M.A. Wahid. and Adiarso. Center for Technology of Energy Resources and Chemical Industry. Jakarta: Agency for the Assessment and Application of Technology.

[31] ESDM. 2014. Handbook of Energy and Economic Statistics of Indonesia (HESSI). Jakarta: Ministry of Energy and Mineral Resources (ESDM) Republic of Indonesia.

[32] BPPT (Badan Penelitian dan Penerapan Teknologi). 2014. BPPT - Outlook Energi Indonesia 2014. Jakarta: Pusat Teknologi Pengembangan Sumberdaya Energi (PTPSE), Badan Pengkajian dan Penerapan Teknologi (BPPT).

[33] Sambodo, M.T., H. Morohosi and T. Oyama. 2017. Developing a Green Path Power Expansion Plan in Indonesia by Applying a Multiobjective Optimization Modeling Technique. Journal of Energy Engineering 143 (3): 1 – 12.

[34] Rompas, P T D., H. Taunaumang and F. J. Sangari. 2017. A Numerical Model of Seawater Volume and Velocity Dynamic for Marine Currents Power Plant in the Bangka Strait, North Sulawesi, Indonesia. IOP Conference Series: Materials Science and Engineering 180 (1): 1 - 7.

[35] Anisah, I., F.X.N Inayati, R. Soelami and Triyogo. 2017. Identification of Existing Office Buildings Potential to become Green Buildings in Energy Efficiency Aspect. Procedia Engineering 170: 320-324.

[36] Yamanaka, M. D. 2016. Physical Climatology of Indonesian Maritime Continent: An Outline to Comprehend Observational Studies. Atmospheric Research 178 – 179: 231-259.

[37] Sugiyono, A. 2004. Perubahan Paradigma Kebijakan Energi Menuju Pembangunan yang Berkelanjutan. Presented in Seminar Akademik Tahunan Ekonomi I, Pascasarjana FEUI & ISEI, December 8-9, 2004, Nikko Hotel, Jakarta. 1 – 12 pp.

[38] Dahuri, R. 2003. Paradigma Baru Pembangunan Indonesia dalam Berbasis Kelautan. Ringkasan Orasi Ilmiah. Bogor. Bogor: Institut Pertanian Bogor. 4 – 64 pp.

[39] Lubis, A. 2007. Energi Terbarukan dalam Pembangunan Berkelanjutan. J. Tek.Ling 8 (2): 155-162.

[40] Zheng, C.W., Z.S. Gao, Q.F. Liao and J. Pan. 2016. Status and Prospect of the Evaluation of the Global Wave Energy Resource. Recent Patents on Engineering 10 (2): 98-110.

[41] Sugiyono, A. 2010. Pengembangan Energi Alternatif di Daerah Istimewa Yogyakarta: Prospek Jangka Panjang. Proceding of Call for Paper Seminar Nasional VI Yogyakarta University of Technology. 1 – 13 pp.

[42] Luhur, E. S., R. Muhartono and S. H. Suryawati. 2013. Financial Analysis of Developing Ocean Energy in Indonesia. J. Sosek KP 8 (1): 25 – 37.

[43] Erwandi. 2011. Pengembangan Regulasi, Standarisasi dan Sertifikasi Penetapan Teknologi Energi Laut. Bahan Presentasi dalam Workshop Arus Laut (Presentation) 2011.

[44] Twidell, J. dan T. Weir. 2006. Renewable Energy Resources. New York: Taylor & Francais Group.

[45] Mukhtasor. 2012. Pengembangan Energi Laut di Indonesia. Jakarta: Asosiasi Energi Laut Indonesia.

[46] Barstow, S., O. Haug and H. Krogstad. 1998. Satellite Altimeter Data in Wave Energy Studies. Proc. Waves'97, ASCE 2: 339 - 354.

[47] Cornett, A. M. 2008. A Global Wave Energy Resource Assessment. Proceedings of the Eighteenth, International Offshore and Polar Engineering Conference Vancouver, July 6-11 2008. 318 – 326 pp.

[48] Irhas and R. Suryaningsih. 2014. Study on Wave Energy into Electricity in the South Coast of Yogyakarta, Indonesia. Energy Procedia 47: 149 – 155.

[49] Mukhtasor, Z. Arif, I. Syarif, Prastianto and R. Walujo. 2015. Status Pengembangan Pembangkit Listrik Tenaga Gelombang Laut Sistem Bandulan PLTGL-Sb 20 kW. ITS-Proceeding.

[50] Anggraini, D., M. I. Al Hafiz, A. F. Derian and Y. Alfi. 2015. Quantitative Analysis of Indonesian Ocean Wave Energy Potential using Oscillating Water Column Energy Converter. International Journal of Science and Technology 1 (1): 228-239.

[51] Alifdini, I., Y.O. Andrawina, D.N. Sugianto, A.B. Widodo and A. Darari (2016). Technology application of oscillating water column on the Sungai Suci Beach as solutions for make a renewable energy in coastal Bengkulu, Indonesia. Proceeding of 3rd Asian Wave and Tidal Energy Conference (AWTEC) Volume 2, Singapore. 52 p.

[52] Alifdini, I., D N Sugianto, Y. O. Andrawina and A. B. Widodo. 2017. Identification of Wave Energy Potential with Floating Oscillating Water Column Technology in Pulau Baai Beach, Bengkulu. 2nd International Conference on Tropical and Coastal Region Eco Development 2016. IOP Conf. Series: Earth and Environmental Science 55: 1 - 11.

[53] Sugianto, D. N., Purwanto, G. Handoyo, I. B. Prasetyawan, Hariyadi and I. Alifdini. 2017. Identification of Wave Energy Potential in Sungai Suci Beach Bengkulu Indonesia. ARPN Journal of Engineering and Applied Sciences 12 (17): 1-10.

[54] Azhari, B., W. Prawinnetou and D. A. Hutama. 2017. Design of A Quasi-Flat Linear Permanent Magnet Generator for Pico-Scale Wave Energy Converter in South Coast of Yogyakarta, Indonesia. Renewable Energy Technology and Innovation for Sustainable Development AIP Conf. Proc. 1826 : 020024-1 – 020024-12.

[55] López, M., F. T.-Pinto and P. R.-Santos. 2017. Numerical Modelling of The CECO Wave Energy Converter. Renewable Energy 113: 202-210.

[56] Babarit, A., D. Bull, K. Dykes, R. Malins, K. Nielsen, R. Costello, J. Roberts, C. B. Ferreira, B. Kennedy, J. Weber. 2017. Stakeholder Requirements for Commercially Successful Wave Energy Converter Farms. Renewable Energy 113: 742 - 755.

[57] Hutapea, M. 2016. Solusi Listrik Off-Grid Berbasis Energi Terbarukan di Indonesia: Kerangka Regulasi dan Program. Presentation. Kementerian Energi dan Sumber Daya Mineral, Direktorat Jenderal Energi Baru Terbarukan dan Konservasi Energi. Ruang Grand Duke Lantai 17, Marquee Cyber 2 Tower, Jakarta, 4 Februari 2016.

[58] Ariantara, B. 2016. Pentingnya Pengurangan Penggunaan Sumber-Sumber Energi Tak Terbarukan, Kapita Selekta Teknik Mesin 2016 (Clean Energy). Depok: Universitas Indonesia.

[59] Sugiyono, A. 2012. Outlook Kelistrikan Indonesia 2010-2030: Prospek Pemanfaatan Energi Baru dan Terbarukan. Proceding of Seminar Nasional Pengembangan Energi Nuklir V, 2012. 87 – 94 pp.

[60] PPR. 2009. Peraturan Presiden Republik Indonesia No. 82 Tahun 2016 Tentang Strategi Nasional Keuangan Inklusif.

[61] RPJMN. 2015. Buku I Agenda Pembangunan Nasional, lampiran Peraturan Presiden RI Nomor 2 Tahun 2015 tentang RPJMN 2015-2019. Jakarta: Indonesian Government.

[62] IEA. 2015. Indonesia 2015 (Ringkasan Pelaksanaan). Paris: International Energy Agency. 1 – 9 pp.

[63] Manan, S. 2009. Energi Matahari, Sumber Energi Alternatif yang Effisien, Handal dan Ramah Lingkungan di Indonesia. Gema Teknologi: 31 – 35.

[64] Nadine Nabeel Abu Shaaban, Construction Industry on the Renewable Energy Bandwagon. International Journal of Management, 7(4), 2016,pp. 51-60.

[65] Gopala Reddy K, Akshatha. K, Bhushith. M. K, Meganashree. H. R, Hybrid Power Generation Using Renewable Energy Sources for Domestic Purposes, International Journal Of Electrical Engineering & Technology (IJEET), Volume 5, Issue 8, August (2014), pp. 141-147

[66] Arya Ramachandran, Sreethumol M V, High Step-Up Converter with Diode Capacitor Technique for Renewable Energy Applications, International Journal of Electrical Engineering & Technology (IJEET), Volume 5, Issue 12, December (2014), pp. 289-294

[67] M.Saisesha, V.S.N.Narasimharaju, R.Madhu Sudanarao and M.Balaji, Control of Power Inverters in Renewable Energy and Smart Grid Integration, International Journal Of Electrical Engineering & Technology (IJEET), Volume 4, Issue 1, January- February (2013), pp. 200-207

[68] M. Zikra, H. Ikhwani, N. Syahroni and Silvianita, Wave Energy Assessment in Indonesia Seas Based on Era-Interim Reanalysis, International Journal of Civil Engineering and Technology (IJCIET) Volume 8, Issue 6, June 2017, pp. 380-387.

Phytoplankton community structure and it's relationships

ORIGINALITY REPORT

20%	14%	13%	5%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	www.science.gov Internet Source	2%
2	eprints.ums.ac.id Internet Source	2%
3	aip.scitation.org Internet Source	1%
4	www.researchgate.net Internet Source	1%
5	R. Satish, K. Murugabhoopathy, N. Rajendhiran, V. Vijayan. "Technology strategy for improved safety management in steel industry", Materials Today: Proceedings, 2020 Publication	1%
6	autodocbox.com Internet Source	1%
7	scitepress.org Internet Source	1%
8	cyberleninka.org Internet Source	1%

9	www.eurekaselect.com Internet Source	1 %
10	Bijun Wu, Tianxiang Chen, Jiaqiang Jiang, Gang Li, Yunqiu Zhang, Yin Ye. "Economic assessment of wave power boat based on the performance of “Mighty Whale” and BBDB", Renewable and Sustainable Energy Reviews, 2018 Publication	1 %
11	www.grdspublishing.org Internet Source	1 %
12	www.tandfonline.com Internet Source	1 %
13	Alfred Boediman, Raden Aswin Rahadi, Bagus Aditya Nugraha. "An Overview of Indonesian Renewable Energy Studies and Its Investment Opportunities", Indonesian Journal of Energy, 2021 Publication	1 %
14	Submitted to University of Stirling Student Paper	1 %
15	E. Mehlum. "Commercial Tapered Channel Wave Power Plants in Australia and Indonesia", OCEANS 91 Proceedings, 1991 Publication	1 %
16	Submitted to University of San Diego Student Paper	

1%

17	Bayu Rudiyanto, Tri Ajeng Kusuma Wardani, Saiful Anwar, Lutfi Al Jamali et al. "Energy and Exergy Analysis of Steam Power Plant in Paiton, Indonesia", IOP Conference Series: Earth and Environmental Science, 2019 Publication	1%
18	Bryson Robertson, Yuhe Jin, Helen Bailey, Bradley Buckham. "Calibrating wave resource assessments through application of the triple collocation technique", Renewable Energy, 2017 Publication	1%
19	oseanografi.fpik.undip.ac.id Internet Source	1%
20	www.zbw.eu Internet Source	1%
21	Felipe Lucero, Patricio A. Catalán, Álvaro Ossandón, José Beyá, Andrés Puelma, Luis Zamorano. "Wave energy assessment in the central-south coast of Chile", Renewable Energy, 2017 Publication	1%
22	Submitted to Imperial College of Science, Technology and Medicine Student Paper	1%

Exclude quotes	On	Exclude matches	< 1%
Exclude bibliography	On		

Phytoplankton community structure and it’s relationships

GRADEMARK REPORT

FINAL GRADE

/0

GENERAL COMMENTS

Instructor

PAGE 1

PAGE 2

PAGE 3

PAGE 4

PAGE 5

PAGE 6

PAGE 7

PAGE 8

PAGE 9

PAGE 10

PAGE 11

PAGE 12