JOURNAL SYNTAX IDEA
p–ISSN: 2723-4339 e-ISSN: 2548-1398
Vol. 6, No. 02, February 2024

A SYSTEMATIC LITERATURE REVIEW OF TIDAL CURRENT ENERGY IN INDONESIA

Nurhayati[1*], Pebnaldy[2], Hendra Achiari[3]
[1,2,3]Fakultas Teknik Sipil dan Lingkungan, Institut Teknologi Bandung
Email: 25522005@mahasiswa.itb.ac.id[1], pebnaldy@gmail.com[2],
25521007@mahasiswa.itb.ac.id[3]

Abstract

Tidal energy is considered as one of the most promising forms of renewable energy generation due to its environmental friendliness and predictability. The goal of this work is to conduct a thorough literature review on various approaches for optimizing tidal energy output in Indonesia. Tidal current research published between 2014 and 2022 were chosen for further investigation based on literature criteria. The selected primary papers revealed that contemporary tidal energy research focuses on four subjects and trends: resources, numerical modeling, geographic information systems (GIS), and experimental studies. The findings of this study also indicate methodologies that are commonly mentioned and so important in the field of tidal current energy.

Keywords: *tidal current, potential energy, systematic literature review*

INTRODUCTION

The majority of electricity in Indonesia is generated by burning fossil fuels, making the country extremely reliant on foreign imports and consequently vulnerable to oil price fluctuations (Retnasari et al., 2016). Other energy resources, such as renewable energy, must be found to minimize this reliance. Even though Indonesia has a variety of potential renewable energy sources, the proportion of renewable energy in the primary energy mix is now quite low. The development of renewable energy in Indonesia is governed by a Presidential Decree, which says that renewable energy should contribute 17% of the entire national primary energy mix by 2025, including wave and tidal energy (Blunden et al. 2013). The decree further specifies that efforts, including research, should be increased to achieve this goal. This development is also supported by Presidential Regulation Number 18 of 2020 pertaining to the National Mid-Term Development Plan for 2020-2024, which states that one of the national strategic targets is to have a power plant with a capacity of 27,000 MW in order to significantly increase the amount of electricity supply in accordance with the National Mid-Term Development Plan target (Orhan et al., 2017). To attain this purpose, research must be conducted to undertake an

How to cite: Nurhayati, Pebnaldy, Hendra Achiari (2024), A Systematic Literature Review of Tidal Current Energy in Indonesia, *(6) 1,* https://doi.org/ DOI 10.46799/syntax-idea.v6i2.2962
E-ISSN: 2684-883X
Published by: Ridwan Institute

evaluation of ocean energy in Indonesia. The ocean is a massive supply of potential energy resources, and tidal current power conversion has lately emerged as a critical area of sustainable ocean energy. Although modeling approaches have become more developed in recent years and have been performed for many regions around the world to identify prospective locations for tidal stream farms, the lack of reliable data required for the assessments, particularly in more remote areas, has resulted in significant limitations for investigations (Orhan et al., 2015). To increase the dependability of information on the potential of tidal stream resources, resource characterization and rationale for site selection must be improved.

RESEARCH METHODO

Review Method

A systematic approach is chosen for reviewing the literature on tidal current energy. Systematic literature reviews (SLR) is a process of locating, assessing, and interpreting all relevant research data in order to provide answers to specific research questions (Kitchenham and Charters, 2007). This SLR was conducted based on the guidelines by Kitchenham and Charters (2007). SLR is accomplished in three stages: planning, conducting, and reporting the literature review. In the planning process, the need for a systematic review is identified, the review protocol is designed, and the review procedure is reviewed. The current available systematic reviews on potential tidal current energy are then identified and reviewed. The review methodology was created to guide the review and eliminate the likelihood of researcher bias. During the review's conducting and reporting stages, the review protocol was developed, evaluated, and iteratively improved.

Research Question

The research questions (RQ) were designed to keep the review on track. They were created using the Population, Intervention, Comparison, Outcomes, and Context (PICOC) criteria (Kitchenham and Charters, 2007). Table 1 depicts the (PICOC) structure of the research questions.

Table 1. Summary of PICOC

Population	Tides in Indonesia, tidal current energy, tidal energy, tidal power,
Intervention	Tidal current energy, numerical modelling, energy resources,
Comparison	n/a
Outcomes	Accurate numerical modelling for potential tidal current energy in Indonesia
Context	Study location in Indonesia, 2D or 3D modelling

The research questions and motivation addressed by this literature review are shown in Table 2.

Table 2. Research question

ID	Research Question	Motivation
RQ1	Which journal is the most influential in the field of tidal current energy?	Identify the most influential journals in potential tidal current energy field
RQ2	Who are the most active and influential researchers in the tidal current energy field?	Identify the most active and influential researchers who have made significant contributions to tidal current energy research
RQ3	What kind of research topics are selected by researchers in the tidal current energy field?	Identify research topics and trends in tidal current energy
RQ4	What kind of methods are used to analyze the potential tidal current energy?	Identify opportunities and trends for tidal current energy method

The main focus of this study is guided by RQ3, while RQ1, RQ2, and RQ4 serve to provide context. RQ3 aims to summarize existing research on tidal current energy. To address RQ1, RQ2, and RQ4, an initial study was conducted to identify relevant research. The collected data was then analyzed and classified based on the research questions. A visual representation of the systematic literature review's fundamental mind map is presented in Figure 1.

Figure 1. Basic Mind Map of the SLR on Tidal Current Energy Research

Study Selection

A set of criteria for inclusion and exclusion were utilized to select primary studies. The specifics of these criteria can be viewed in Table 3.

Table 3. Inclusion and Exclusion Criteria

Inclusion Criteria	Studies in academic or project area
	Studies related to tidal energy conducted in Indonesia
	The papers were published between 2014 and 2023
	If a study is published more than once, only the most recent and comprehensive version will be considered.
	Papers not written in English

Exclusion Criteria	Research on tidal energy conducted outside of Indonesia.

The search process involves a variety of activities such as selecting digital libraries, creating a search query, conducting a preliminary search, refining the search query, and obtaining a list of primary studies from digital libraries. To ensure the search process is successful, it is crucial to choose appropriate databases to increase the possibility of finding highly relevant articles. For this study, the Mendeley digital library was utilized, and the search strings were developed following Wahono's (2015) process, which includes identifying search terms based on the PICOC framework, refining them based on the research question, and reviewing relevant titles, abstracts, and keywords to add more search terms to the query. The search was carried out using titles, keywords, and abstracts, with publications from 2014 to 2022, and only English publications were considered. The study selection process involved two stages, including the exclusion of primary studies based on the title and abstract and then the exclusion of primary studies based on the full text. The final list of selected primary studies after the first stage contained 52 primary studies. After evaluating the full texts of the 52 primary studies, similar papers by the same authors in other journals were excluded, leaving 52 primary studies. The process of screening the literature is depicted in Figure 2.

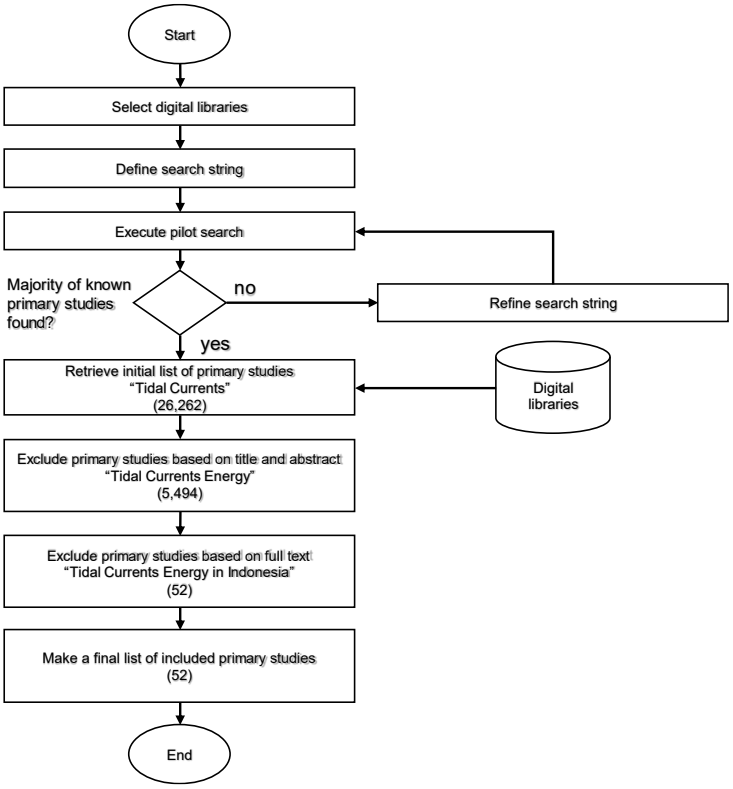

Figure 2. Literature Screening

RESULTS AND DISCUSSION

1. Significant Journal Publications

This study includes 52 primary research that analyze the potential tidal current energy in Indonesia. The distribution through time is shown to illustrate how interest in the tidal current energy field has varied over time.

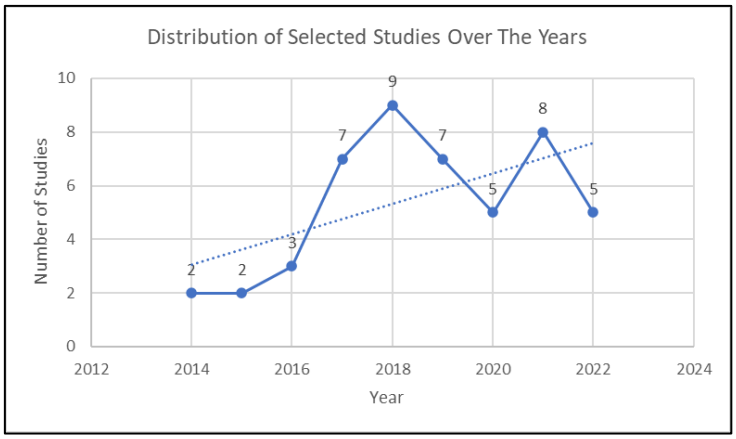

Figure 3. Distribution of Selected Studies over the Years

Figure 3 depicts a brief overview of the distribution studies conducted over the years. Since 2017, more papers have been published, indicating that more recent and relevant investigations are included. Based on the graph, the topic of tidal current energy research is still relevant today. Figure 4 depicts the most important tidal current energy journals based on the selected primary papers.

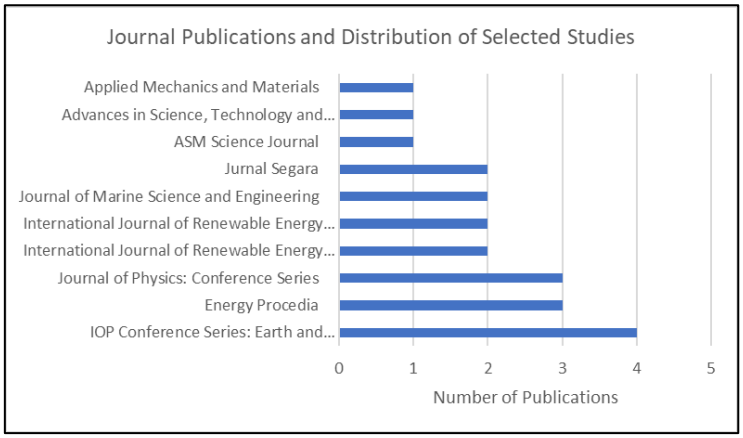

Figure 4. Journal Publications and Distribution of Selected Studies

2. Influential Researchers

Researchers who contributed significantly and are engaged in the field of tidal current energy research were studied and recognized in the selected primary papers. Figure 5 depicts the most active and significant researchers in Indonesia's tidal current energy field. Active researchers in the field of tidal current energy are Kadir

Orhan, Adi Purwandana, Harman Ajiwibowo, Roberto Meyerle, Ulung Jantama Wisha, and Agustinus Ribal.

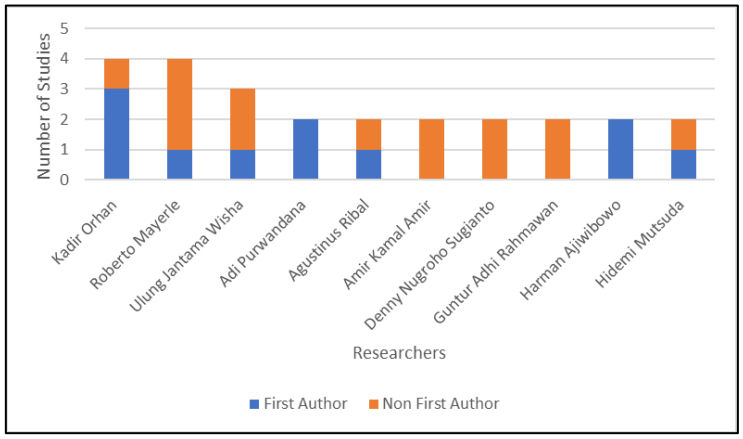

Figure 5. Influential Researchers and Number of Studies

3. Research Topics in Tidal Current Energy

According to the findings of the selected primary studies, recent tidal currents energy research focuses on four areas:

1. Using Geographic Information System (GIS) approach, search for areas with potential for producing energy from tidal currents.
2. Employ numerical modeling (Numerical Modelling) to analyze hydrodynamic models and possible energy from tidal currents.
3. Perform an experimental study to explore the progress of tidal currents for technologies generating renewable energy (Experimental Study).
4. Investigate energy resources originating from tidal currents (Resources).

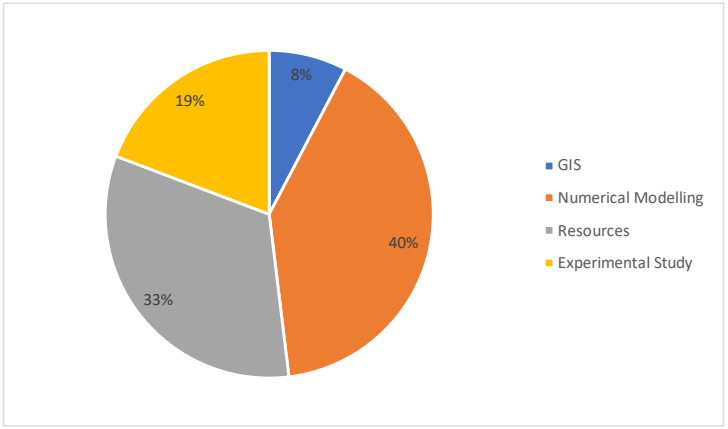

Figure 6. Distribution of Research Topics

Figure 6 depicts the total distribution of tidal current energy research subjects in Indonesia from 2014 to 2022. 40% of the research engages are involved with numerical modeling, 33% are concerned with tidal energy resources, and 19% are

concerned with experimental study. GIS-related research subjects receive barely 8% coverage.

4. Methods Used in Analyzing Tidal Current Energy

Since 2014, several methods that have been used to analyze the energy of tidal currents in Indonesia have been applied and proposed as the best method. Figure 7 depicts the most often used methods in tidal current energy.

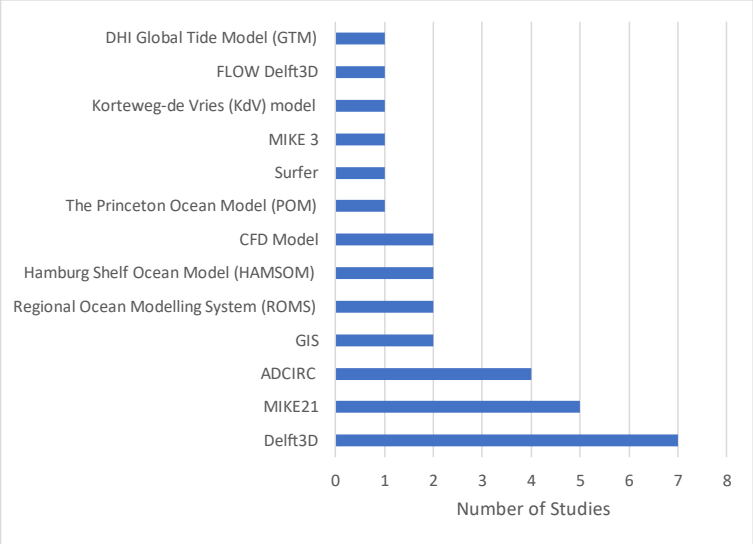

Figure 7. Methods Used in Analyzing Tidal Current Energy

The most widely used model for assessing tidal potential energy is the Delft3D approach. This method is used by Ajiwibowo and Pratama (2022) to determine the hydrodynamic model. This approach can also be used to choose a location. In the case of Hermawan and Gunawan (2018), it is used in research that employ a 2-dimensional numerical model of ocean tide speed. HANSOM has been utilized in various studies to determine sea level, salinity, and temperature near the open ocean's boundary (Orhan et al., 2017). Furthermore, Delft3D can generate high-resolution three-dimensional baroclinic models by simulating tidal currents with the FLOW module of the Delft3D modeling system (Orhan & Mayerle, 2020).

Amiruddin et al. (2019) employed a two-dimensional, depth-integrated Advanced Circulation (ADCIRC) model to simulate tidal elevation and barotropic tidal current. This method can identify very promising areas for harvesting tidal current energy (Ribal et al., 2017). Another numerical solution was provided that made use of the Princeton Ocean Model (POM) using topography and tide forecast data as initial conditions (Brown et al., 2019). The results of the water elevation were compared to real-time data. Validations indicate good agreement for the water elevation phase and satisfactory agreement for the water elevation amplitude (Rahmawati et al., 2016).

Hydrodynamic variables paired with Geographic Information Systems (GIS) technology can identify regions with varied levels of potential to generate electricity

from the water. The method employed is to examine the most recent technology capabilities as well as the features of currents, wind, waves, and tides (Purba, 2015).

MIKE 3 is used for hydrodynamic numerical modeling to simulate the velocity distribution surrounding each area in order to find the optimal places for tide-induced tidal current power harvesting (Ajiwibowo et al., 2018). Other software, such as Delft3D (Orhan & Mayerle, 2020), ROMS (Work et al., 2013), FVCOM (Rahman et al., 2015), and MIKE (Nugraha et al., 2018), has been used in similar investigations. The global model's resulting current velocities will become boundary conditions in the local model, which has a more detailed mesh surrounding the area of interest.

CONCLUSION

The goal of this review is to undertake a thorough evaluation of the literature on various methods to tidal energy research in Indonesia. Based on literature criteria, tidal current research published between 2014 and 2022 was chosen for further analysis. This literature review was conducted in the form of a systematic literature review. According to the major publications chosen, current tidal energy research focuses on four topics and trends: resources, numerical modeling, geographic information systems (GIS), and experimental studies. The study's findings also point to approaches that are frequently highlighted and important in the field of tidal current energy. According to the total distribution of tidal current energy, 40% of the research is focused with numerical modeling, 33% with tidal energy resources, and 19% with experimental studies. GIS-related research receives only 8% coverage. In Indonesia, numerous approaches have been employed to analyze the energy of tidal currents. Delft3D, Mike 21, ADCIRC, POM, and ROMS are the most often used approaches.

BIBLIOGRAPHY

Ajiwibowo, H., & Pratama, M. B. (2022). Hydrodynamic model and tidal current energy potential in lepar strait, indonesia. *International Journal of Renewable Energy Development*, *11*(1), 15–25. https://doi.org/10.14710/ijred.2022.37028

Ajiwibowo, H., Lodiwa, K. S., Pratama, M. B., & Wurjanto, A. (2018). Identification of potential sites for harvesting tidal current power in Kelian Cape, Kelabat Bay, and Larantuka Strait. *International Journal of GEOMATE*, *14*(42), 103–111. https://doi.org/10.21660/2018.42.27939

Amiruddin, Ribal, A., Khaeruddin, & Amir, A. K. (2019). Preliminary estimation of tidal current energy for three straits in the vicinity of Bali and Lombok islands. *International Journal of Renewable Energy Research*, *9*(4), 1637–1649. https://doi.org/10.20508/ijrer.v9i4.9910.g7812

Blunden, L. S., Bahaj, A. S., & Aziz, N. S. (2013). Tidal current power for Indonesia? An initial resource estimation for the Alas Strait. *Renewable Energy*, *49*, 137–142. https://doi.org/10.1016/j.renene.2012.01.046

Brown, A. J. G., Lewis, M., Barton, B. I., Jeans, G., & Spall, S. A. (2019). Investigation of the modulation of the tidal stream resource by ocean currents through a complex tidal channel. *Journal of Marine Science and Engineering*, *7*(10). https://doi.org/10.3390/jmse7100341

Hermawan, S., & Gunawan, H. (2018). High spatial grid resolution of hydrodynamic numerical modeling for sea current energy site selection in Indonesia. *Journal of Telecommunication, Electronic and Computer Engineering*, *10*(2–3), 163–167.

Kitchenham, B.A & Charters, S. (2007). Guidelines for performing systematic literature reviews in software engineering. *Technical Report, Ver. 2.3 EBSE Technical Report. EBSE*, *1*, 1–54.

Nugraha, R. B. A., Erwandi, E., Syahputra, H., & Nurman Mbay, L. O. (2018). The Analysis of Tidal Current in Suramadu Bridge Pier for Marine Power Generation Test Site. *Jurnal Segara*, *14*(2). https://doi.org/10.15578/segara.v14i2.6644

Orhan, K., & Mayerle, R. (2020). Potential hydrodynamic impacts and performances of commercial-scale turbine arrays in the strait of Larantuka, Indonesia. *Journal of Marine Science and Engineering*, *8*(3). https://doi.org/10.3390/jmse8030223

Orhan, K., Mayerle, R., & Pandoe, W. W. (2015). Assesment of Energy Production Potential from Tidal Stream Currents in Indonesia. In *Energy Procedia* (Vol. 76, pp. 7–16). Elsevier Ltd. https://doi.org/10.1016/j.egypro.2015.07.834

Orhan, K., Mayerle, R., Narayanan, R., & Pandoe, W. (2017). INVESTIGATION OF THE ENERGY POTENTIAL FROM TIDAL STREAM CURRENTS IN INDONESIA. *Coastal Engineering Proceedings*, (35), 10. https://doi.org/10.9753/icce.v35.management.10

Purba, N. P., Kelvin, J., Sandro, R., Gibran, S., Permata, R. A. I., Maulida, F., & Martasuganda, M. K. (2015). Suitable Locations of Ocean Renewable Energy (ORE) in Indonesia Region-GIS Approached. In *Energy Procedia* (Vol. 65, pp. 230–238). Elsevier Ltd. https://doi.org/10.1016/j.egypro.2015.01.035

Rahman, A. A. A., Yahaya, N. A., Bahsan, R., & Ahmad, U. K. (2015). Energy harvesting from cooling tower by vertical axis wind turbine (VAWT). *Jurnal Teknologi*, *76*(5), 37–41. https://doi.org/10.11113/jt.v76.5533

Rahmawati, S., Mutsuda, H., Yoshitomi, E., & Doi, Y. (2016). Numerical estimation for tidal-current energy resources in Indonesia. In *Proceedings of the International Offshore and Polar Engineering Conference* (Vol. 2016-January, pp. 519–527). International Society of Offshore and Polar Engineers.

Retnasari, A., Istiqomah, A., & Fauzi, A. (2016). Economic Analysis of "Ocean Current" Potential as Power Plant to Support Community Development (Case Study in Nusa

Penida Strait). *Applied Mechanics and Materials*, *839*, 1–5. https://doi.org/10.4028/www.scientific.net/amm.839.1

Ribal, A., Amir, A. K., Toaha, S., Kusuma, J., & Khaeruddin. (2017). Tidal current energy resource assessment around Buton Island, Southeast Sulawesi, Indonesia. *International Journal of Renewable Energy Research*, *7*(2), 857–865. https://doi.org/10.20508/ijrer.v7i2.5682.g7066

Wahono, R. S. (2015). A systematic literature review of software defect prediction. *Journal of software engineering*, 1(1), 1-16.

Work, P. A., Haas, K. A., Defne, Z., & Gay, T. (2013). Tidal stream energy site assessment via three-dimensional model and measurements. *Applied Energy*, *102*, 510–519. https://doi.org/10.1016/j.apenergy.2012.08.040