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Experience in Oceanographic Surveys for Designing 100 kW Tidal Current Energy Conversion Systems

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ABSTRACT

Nowadays tidal current energy conversion system (TCECS) is being developed with a capacity of 100 kW for Indonesian waters. The design process is based on the results of field measurements, i.e., ocean currents, tides, ocean waves, and bathymetry. This paper aims to explain the experiences when collecting oceanography data in a potential site for TCECS. The survey method is that the equipment placed on the seabed will emit signals that can record flow and wave data according to the desired time and depth. The survey process, especially for the tidal current energy application, requires good preparation so as not to fail. The results of this paper explain the challenges and highlight the steps. These are technical, environmental, and survey permits. The technical aspects are tool stability, buoyancy effects, visualization tools with an underwater camera system, seawater brightness, and sedimentation. Environmental aspects are big waves, strong currents, and weather. The survey permit aspects are destruction and conservation area. Therefore, before the survey, safety procedures or documents must be made in the form of HIRA (Hazard Identification and Risk Analysis). The experiences of this survey are a novelty consideration for other surveyors in the tidal current energy aspect.

Keywords: *Tidal energy; TCECS; Oceanography survey; HIRA; Renewable energy*

1. INTRODUCTION

Indonesia has a good potential for marine and coastal human needs [1]. Indonesia's marine potential is contained in various forms, such as ocean currents, tides, waves, and others. Ocean current is the water mass movement towards an equilibrium which causes horizontal and vertical displacement of water masses. The movement results from several forces acting and some factors influencing it.

Ocean current is a mass movement of water and sea from one place to another, either vertically (upward motion) or horizontally (sideways movement). According to Junianto et al. [2], the current impulse is caused by wind movement, movement of thermohaline, tide flow, turbulence, tsunami, and another wave. There was also potential for another source, the tidal wave. These environmental conditions may use to classify a potential site, e.g., utilization of tidal current for a power plant [3]. According to Xie et al. [4], tides are a phenomenon of the movement of rise and fall of the water level sea periodically caused by a combination of gravity and the gravitational pull of astronomical objects, primarily by the sun, earth, and moon. The influence of other celestial bodies is negligible due to greater or lesser distances.

Research on waves and tidal currents has been widely implemented in Indonesia to determine its potential. Oceanographic surveys mostly use an Acoustic Doppler Current Profiler (ADCP) [4-6]. The equipment is mostly placed under the vessel. For example, this was used to measure tidal current conditions at a depth of 35.94 to 50.94 m and obtained an average speed of 40.51 cm/sec with a southwest direction. ADCP is one of the main tools used to determine the value of the speed and direction of tidal currents in a body of water. Its use was already beneficial for human needs in various depths. Oceanographic surveys are rarely carried out for tidal current energy conversion system (TCECS) applications, so information on constraints and opportunities is rarely found in references. With the potential of the sea in this remarkable, this paper will discuss the identification and challenge of TCECS oceanographic survey in Indonesia and the opportunity to develop TCECS surveys.

2. POTENTIAL OF TIDAL CURRENT SURVEYS

A tidal current survey was conducted in the potential site using AWAC Nortek 400 kHz which was used to measure tidal current parameters. Tidal currents are measured with AWAC at a depth of 24 m, measured at 24 layers/cell, which has a size of 1 m for each layer. These measurements coincide with tidal measurements so that the relationship between changes in water depth and velocity can be determined. The measurement produces tidal current velocity data and tidal current direction for more than 30 × 24 hours. For the total measurement, 2870 recorded current data have been collected.

Measurement of tidal currents using AWAC can determine the character of tidal currents at the observation point. AWAC provides data on the velocity of tidal currents in each layer (depth point) so that later it can be seen that the potential for high tidal currents is in which layer. After knowing the location of the potential velocity of tidal currents, the turbine positions will be adjusted to the location of the potential velocity to produce high energy. The results of this measurement can also decide the supporting structure to be used according to the position of the potential tidal current velocity at what depth, whether the supporting structure to be used is a floating type, a kite type, or a fixed type on the seabed.

In Hydro-Oceanographic survey work, there are various activities performed besides tidal current survey, such as bathymetry survey (mapping the shape of the seabed), ocean tidal measurement, measurement control nets (Benchmark), sampling of seawater and seabed sediments, and others. Hydro-Oceanographic surveys are usually done in various jobs in coastal areas or offshore. The needs of the instrument/measurement tool used also vary due to the measurement results to be obtained from measurement:

1. Bathymetry can use a Single Beam Echo Sounder (SBES) or a Multibeam Echo sounder (MBES).
2. The tides can use the palm of tidal / Tide Staff or Tide Gauge.
3. The ocean waves can use Automatic Water Level Recorder (AWLR) or Wave Recorder.

One of the main types used in its application to the surveys is AWAC 400 kHz (Figure 1). AWAC with a pressure of 0-100 m depth and accuracy capability of up to 1.5 Hz pulse wave and current measurements can be the velocity and direction. These specifications are explained in Table 1.

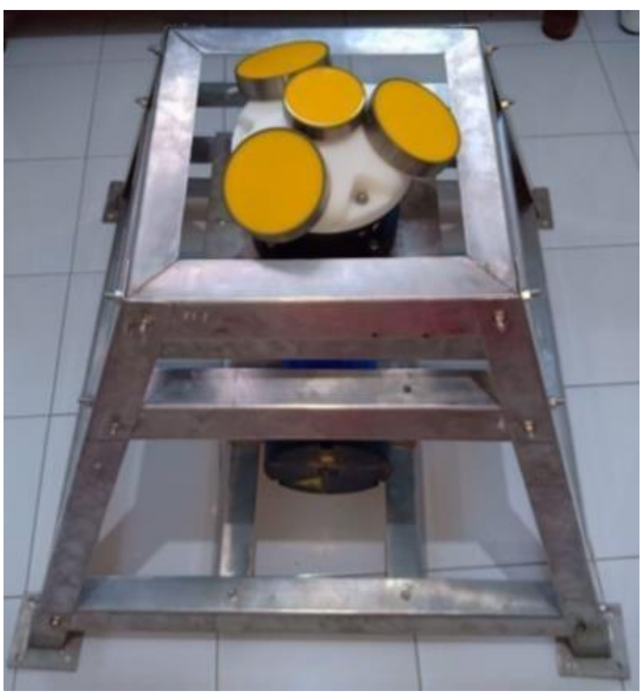

Figure 1. AWAC 400 kHz

Table 1. Instrument specifications [4]

Water velocity measurements	
Maximum range profiling	100 m
Cell size	1.0-8.0 m
Number of cells	Typical 20-40, max. 128
Velocity range	±10 m/s horizontal, ±5 m/s along beam
Accuracy	±1% of measured value ±0.5 cm/s
Maximum output rate	1 Hz
Internal sampling rate	2 Hz
Wave measurement option (AST)	
Maximum depth	100 m
Data types	Pressure, one velocity on each beam, AST
Sampling rate velocity (output)	0.75 Hz
Sampling rate AST (output)	1.5 Hz
No. of samples per burst	512, 1024 or 2048

3. CHALLENGES OF OCEANOGRAPHIC SURVEY

In energy conversion, tidal currents can be used as an alternative energy source by utilizing the kinetic energy stored in each water current. Research on tidal currents aims to know the characteristics of tidal currents in each layer of water depth, the correlation of wind and current movements,

Figure 2. Survey Vessel with A Size of about 30 GT

Figure 3. AWAC Web Frame

and how much alternative energy potential (power density) is. The current is recorded simultaneously and continuously at each depth layer at one point location [7]. Several challenges must be considered during the measurement process for further survey activities.

3.1 Technical Obstacles

The many uncertain conditions strongly influence an oceanographic survey in very different conditions. Therefore, preparation and monitoring are essential to support to get a feasible output. Some technical barriers are caused by the stability of the ship. These make a reduction or removal of the tool.

In eastern Indonesia, the survey vessel was a vessel with a size of about 30 GT (Figure 2). The ship was originally a fishing vessel with a pulley, which was used to roll the rope to lift the instruments. These on the ship were not stable because of the wave height. Therefore, the instrument of AWAC was framed to make it stable. AWAC web frame (Figure 3) was useful to provide additional weight effect that the position of AWAC did not change because of the conditions in the sea floor.

3.2 Non-technical Obstacles

The seabed has more calm condition than the surface. However, predictions of current velocity and direction (Figure 4) in the bottom area have a challenge that must be handled at the time of the survey, not only from current velocity and direction but also from other challenges from other surveys. Therefore, it is necessary to safety various requirements for the survey.

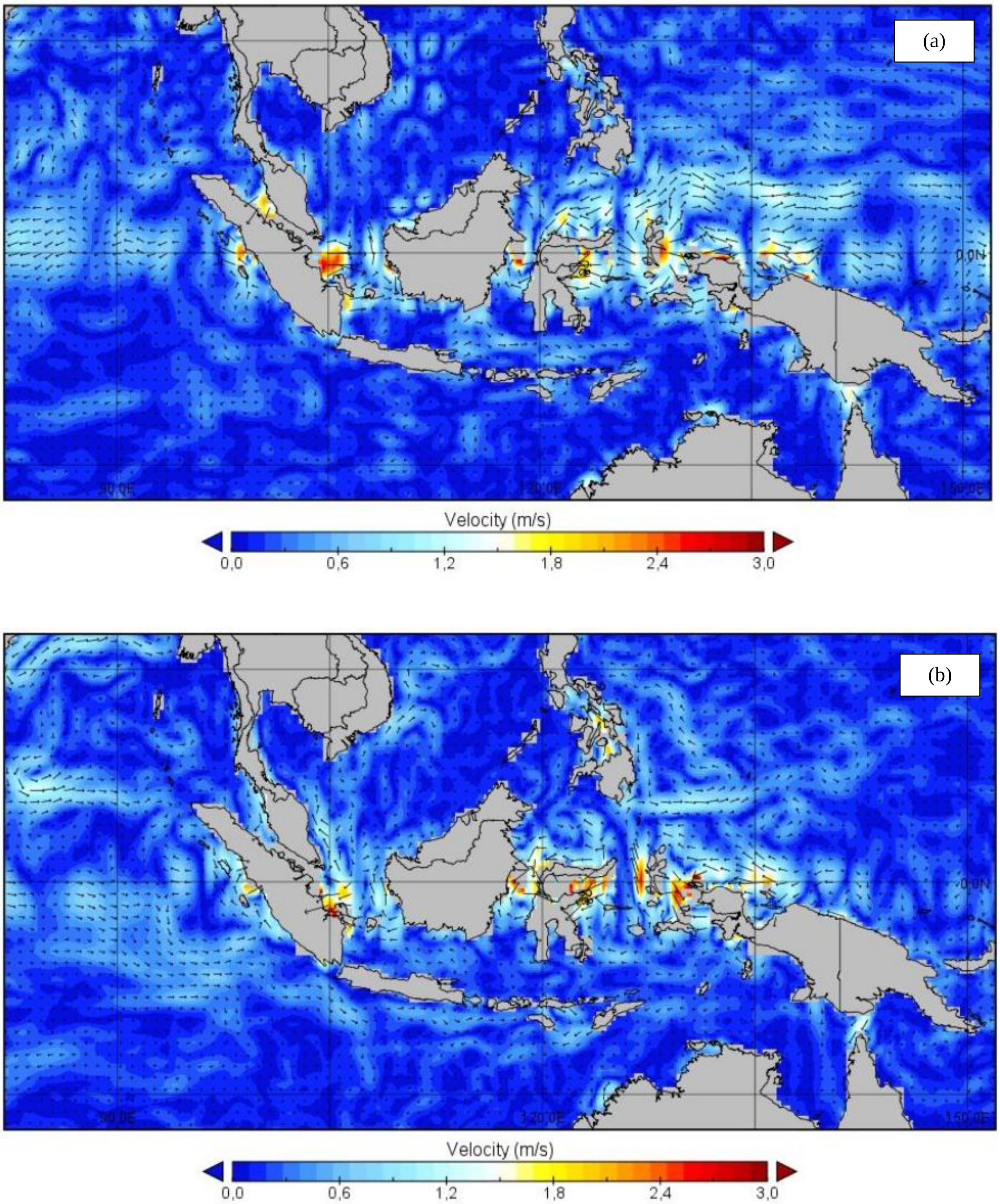

Figure 4. Indonesia Ocean Surface Current Velocity and Direction in Northwest Monsoon (a) and Southeast Monsoon (b) [8]

Table 2. List of Identifying Hazards that could Potentially Occur in the Survey [4]

No	Hazard	Risk	Mitigation
Mobilization/Demobilization			
1	Instruments get stolen	Instruments lost	Attaching Keys and security cover Guarding along the travel
2	Instruments get Slammed	Broken instruments	Packing with a safety toolbox and selecting the suitable vehicle
Instruments Deployment			
1	Overcapacity boat	The boat gets sunk	Using qualified boat
2	Broken rope while installing the instrument	Instruments lost	Using qualified rope Employ qualified winch operator
3	Flipped by the strong current	Badly measured data	Using ballast and anchor, develop a stable frame, deploy at the weak current period, checking with underwater camera
Data Recording			
1	Insufficient power	Bad/lost measured Data	Using new battery
2	Vandalism	Buoy/marker lost	Monitoring periodically, using sling wire attached to the buoy, and Guarding 24 hour.
3	Struck by fishing net	Instruments flipped	Guarding 24 hour, two 24-hour stand-by guarding the boat
Data Acquisition			
1	Broken rope when lifting the instrument	Instrument lost	Using qualified rope and employing a qualified winch operator
2	Download failure	Incomplete data	Using the required battery set, using a high-grade data cable, and avoiding hard impact

4. DISCUSSIONS

The safety of personnel and equipment is an important thing to be maintained to ensure the sustainability of the survey. Hazard identification and risk are necessary to prevent personnel and instruments from any risk. This process is necessary to anticipate the risks that may hinder the activities of the survey. Table 2 shows a list of identifying hazards that could potentially occur in the survey.

The explanation of activity during the survey in the potential area in the previous section shows that the risk of this survey is relatively large. Therefore, planning for these surveys is inseparable from these risks. These reports in this survey are used to mitigate in the next survey, especially in technical and non-technical handling.

Health and Safety (HS) can be explained that all workers are entitled to health and safety services regardless of the status of the formal or informal sector, company size, and type of work. Both the development and growth of the industrial sector are always accompanied by a huge problem of workplace accidents and occupational diseases [9].

5. CONCLUSIONS

Oceanographic survey for TCECS may be carried out quite well by considering several aspects. These aspects include technical and non-technical conditions. This paper has presented the preparation in every aspect of the survey and may be used as mitigation in carrying out further surveys. These have more complex environmental conditions, especially sea level conditions where breaking waves have not occurred. The survey equipment must be more advanced and tested for its strength to guarantee data security, safety, and quality. These things are important to note in this paper.

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