DEPLOYMENT OF MARINE CURRENT ENERGY IN INDONESIA

Rohit Ramachandran, GPSS-GLI, 47-136841
Advisor: Professor Ken Takagi
Co-advisor: Project Associate Professor Hirotaka Matsuda

ABSTRACT

Marine Current Energy Generation (MCEG) is a new technology that harnesses the velocity of sea currents to produce emission-free electricity. This technology has the potential to greatly contribute toward climate change mitigation. While MCEG is a clean and renewable energy technology, in order to be sustainable, it must also be economically affordable and socially acceptable. While much attention is paid to the technical, economic, and environmental aspects of this technology, an assessment that collectively analyzes the interactions between these three aspects is necessary. Moreover, current studies focus on developed countries like the United Kingdom, the United States, and Canada. However, developing countries, such as Indonesia and Brazil, also have high potential for adapting MCEG to meet increasing energy demands. Bearing this in mind, this research aims to collectively analyze the environmental, economic and social impacts of MCEG in the context of a developing country. By placing a high degree of importance on stakeholder input, this research explores the acceptability and sustainability of MCEG compared to the current methods of electricity generation. This research aims to offer the most appropriate course of actions for introducing MCEG in a developing country.

For this research a field site has to be selected that is part of a developing country that has an increasing need for additional electricity, and, most importantly, that has favorable

conditions for MCEG installation. Indonesia, although home to one of the fastest growing economies in the world, has a great need for additional electricity generation capacity, with close to 50 million people still with no access to electricity. Many locations within Indonesia exist where sea current flows are concentrated due to constraining topography, such as straits between islands, providing ideal sea conditions for MCEG installation. Considering the large size of the country and the numerous feasible MCEG sites, further narrowing of the research site is necessary. After looking at the marine current velocities, surrounding population and power demands, water depths, strait widths, presence of major shipping lanes, electricity grids, the states of infrastructure, and availability of data, Larantuka strait in Flores Timur Regency is selected as the research area.

For sustainability assessment and decision-making, the framework suggested by Santoyo-Castellazo and Azapagic (2014) is adapted and used for this research. The framework is made up of the following steps: (1) Selection of environmental, economic and social indicators for measuring sustainability, (2) Selection and specification of technologies to be compared, (3) Development of scenarios based on selected technologies, (4) Environmental, economic and social impact assessment, and (5) Integration of sustainability indicators using Multi-Criteria Decision Analysis (MCDA) to determine the most sustainable option for future. Literature survey, field observation, interviews and focus group discussions with various stakeholder groups aided in the identification of the sustainability indicators. The two environmental indicators selected for this research are Carbon Emissions and Disturbance to Biodiversity. Electricity Tariff and Cost of Fuel for Production of electricity are the two economic indicators, and the two social indicators are Public Acceptance and Security and Diversity of Supply. Currently Flores Timur Regency only uses diesel generators for electricity production, so this research compares between MCEG and diesel electricity generation. Based on estimated future energy demands three scenarios are developed that are assessed for their sustainability. In scenario 1, 6 MW of electricity generation capacity comes from diesel generators; in scenario 2, 3 MW capacity comes from diesel generators and 3 MW capacity from MCEG; and in scenario 3, MCEG provides the entire 6 MW capacity. With these scenario options, MCDA is conducted thrice using Analytic Hierarchy Process (AHP).

In MCDA 1 the stakeholders are asked to make pair-wise comparisons between each criteria and sub-criteria based on their experience and judgment. The results identify the most preferred scenario for each group of stakeholders along with the weights each stakeholder group places on each criteria and sub-criteria. But, MCDA 1 is based on personal experience and judgment so lacks scientific data and, thus, can include error in the decision. MCDA 2 is conducted using scientific data and treats all criteria and sub-criteria equally. However, in reality, all the criteria and sub-criteria are not of equal importance to the different stakeholder groups. MCDA 3 takes this into account and is conducted with the weights elicited from MCDA 1, along with the scientific data that contributed to MCDA 2.

All stakeholder groups prefer Scenario 3 the most and scenario 1 the least in MCDA 1. MCDA 2 shows similar results as MCDA 1, though with a different degree of preference. However, results vary in the final MCDA 3, in which three out of the five stakeholder groups prefer scenario 3 most while the two other groups most prefer scenario 2. Overall, Disturbance to Bio-Diversity and Public Acceptance are the two most important indicators. The relatively expensive electricity tariff of MCEG is a hindrance to the selection of MCEG overwhelmingly over other scenarios as the most preferred future energy generation choice. Reduced emissions, although an important factor in the promotion of renewables, are considered to be of extremely low importance according to the public. A lack of information regarding the impacts of MCEG on marine biodiversity in tropical waters is another factor contributing to the low preference for MCEG.

Based on the findings, it can be concluded that it is vital to conduct studies on the types of biota in the waters of Larantuka strait and assess the impacts on this ecosystem by monitoring the strait for a long period of time. Efforts should also be made to lower the electricity tariff of MCEG, either by developing the technology further or by availing subsidies as currently enjoyed by diesel. A favorable Feed-in-tariff (FIT), like the FIT for solar PV, can also be helpful for making the electricity from MCEG affordable. Finally, public awareness should be increased to ensure the successful deployment of MCEG. The benefits of fuel-free electricity generation, and the importance of emission-free electricity have to be highlighted to the people. These courses of actions can help lead towards sustainable deployment of MCEG in Indonesia, and the deployment of a renewable energy source to quench the growing need for electricity in developing countries.

Keywords: Marine Current Energy, Indonesia, Sustainability Assessment, Multi-Criteria Decision Analysis