Potential of Edu-Ecotourism Based on OTEC Utilizing Indonesian Post-Operation Offshore Oil/Gas Facilities

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Abstract Indonesia is striving to meet its growing electricity demands in a sustainable way, by moving away from oil and gas sources. The government, particularly in East Kalimantan, is considering the repurposing of the offshore facilities for Ocean Thermal Energy Conversion (OTEC), which not only provides a clean and sustainable electricity, but also offers additional benefits such as agricultural and aquaculture products. This study will look at how OTEC may be integrated into an edu-ecotourism concept, which aims to promote renewable energy technology and create a sustainable economy that benefits local communities and stakeholders. To meet the study's aims, research of the possible use of OTEC as an edu-ecotourism attraction will be conducted, through papers that are reviewed from previous studies to further the understanding and the potential implementation of OTEC for edu-ecotourism. The OTEC itself is planned to have the capability of producing around 20 kW of net power. Therefore, analysis and review of potential uses and benefit of OTEC is crucial to integrate the multi-functionality of OTEC to cater not just to the goal of creating an edu-ecotourism attraction, but also to the various needs of the various stakeholders, that have a part or affected by this project.

Keywords: Edu-ecotourism; decommissioning; sustainable development; ocean renewable energy; OTEC.

1 Introduction

The Indonesian government is currently trying to meet its electricity demand, which is increasing by 4.9% per year, in an environmentally friendly way. The fulfilment of electricity demand in Indonesia, which was previously mostly done with oil and gas fuels, has led to a high number of offshore oil and gas facilities needed to exploit these fuels. The large number of offshore oil and gas facilities creates problems related to decommissioning in the post-operation phase which requires a large amount of sum. At the same time, Indonesia is starting to develop multiple researches for ocean renewable energy with one of them being ocean thermal energy or OTEC [1], [2]. In addition, the Indonesian government is trying to deal with problems related to the large number of abandoned offshore oil and gas facilities, because if left unattended these

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facilities can cause abandoned offshore facilities to cause environmental pollution, disruption of the fishing industry, and also shipping.

One of the efforts made by the government, in this case through the initiative of the Regional Government of East Kalimantan Province, is a study of the utilization of offshore oil and gas facilities in the form of oil and gas export pipelines that are converted to function as pipes carrying cooling water for marine thermal power plants known as Ocean Thermal Energy Conversion (OTEC). This research is a development of technical feasibility studies that have been carried out previously [1], [2]. The advantage of using OTEC systems for power generation is their potential to provide non-intermittent electricity from an environmentally friendly energy source [3]. In addition, OTEC can also provide various derivative products such as agricultural products, aquaculture, and other derivative products that can be attractive because of their benefits to various groups of people with various backgrounds [4].

2 Ocean Thermal Energy Conversion

2.1 OTEC Working Principles

Ocean Thermal Energy Conversion (OTEC) is one of the ocean potentials that can be utilized to provide electrical energy. In OTEC, electrical energy is generated by utilizing the temperature difference between near-surface waters that have higher temperatures and deep waters that have lower temperatures, this temperature difference must have at least a 20°C difference [3]. The higher-temperature surface water is pumped into the system to create a cycle of steam, either by heating another working fluid in an closed cycle OTEC (Figure 1a), or by the hot seawater itself in an open cycle OTEC, which drives the turbine while the lower-temperature deep-sea water is used to cool and re-condense the steam back into liquid, creating a cycle (Figure 1b) [3].

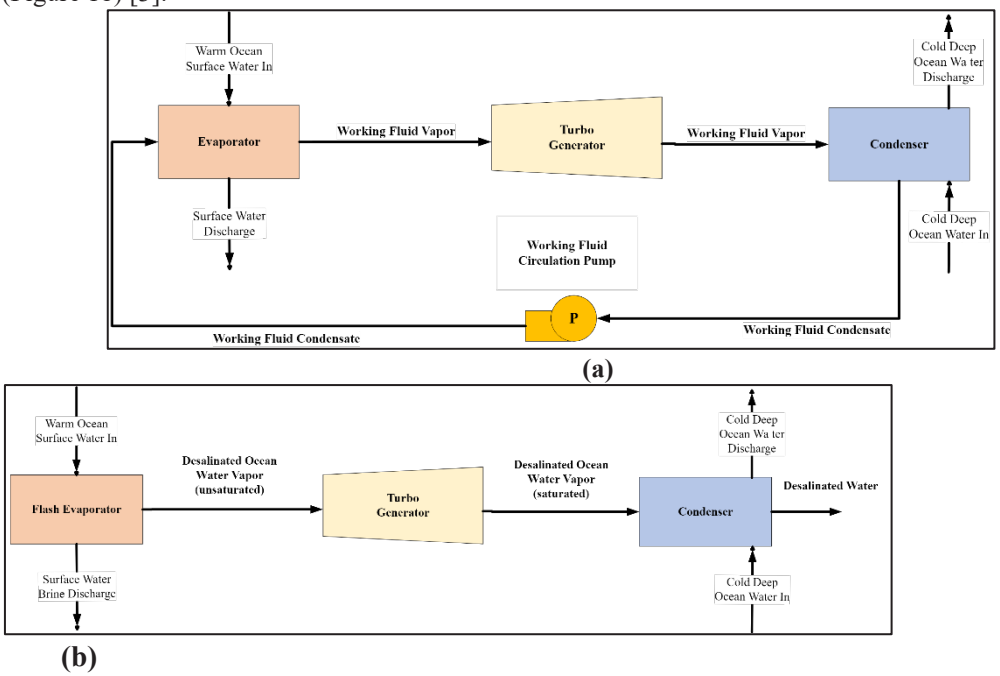


Figure 1. (a) Closed Cycle OTEC Principle (b) Open Cycle OTEC Principle **[3]**

One example of an OTEC currently in operation is a closed-cycle OTEC in Kumejima, Okinawa, Japan with a generating capacity of 100 kW The advantage of using OTEC systems as power plants is their potential to provide electricity on a continuous (non-intermittent) basis [3]. Another advantage the utiliziation of an OTEC system (Figure 2) is the potential of OTEC to provide cooling for the generating system independently as well as clean fresh water (directly for Open Cycle OTEC or through a desalination system for a Closed Cycle OTEC) in addition to providing electricity, thus making OTEC a viable alternative energy sources for coastal areas or remote islands that are off the grid or have a lack of clean water for human consumption, wether for the OTEC plant staff or the community. In addition to its fresh water production, cold water from the deep sea that are utilized in an OTEC system also brought additional benefits such as nutrients that are

critical and can be used in aquaculture, not to mention its potential to provide a natural air conditioning system for buildings and community through a method termed as Sea Water Air Conditioning (SWAC).

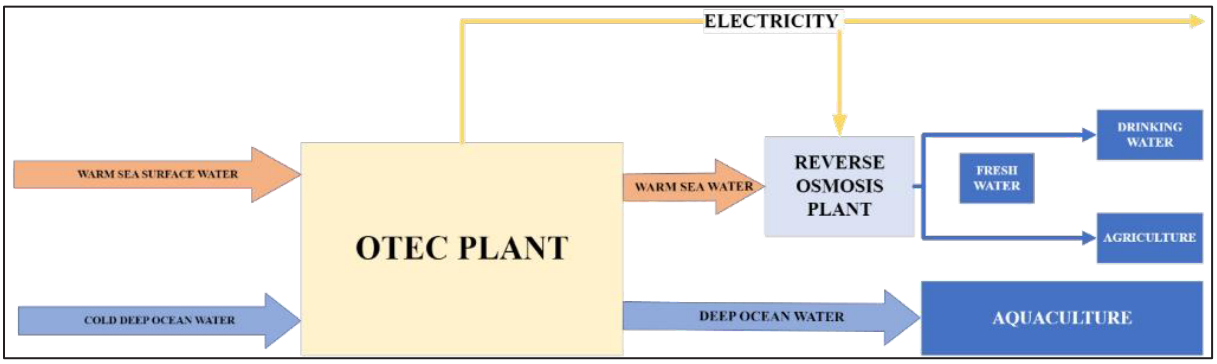


Figure 2. Multifunctionality of an OTEC system adapted from **[3]**

2.2 Multifunctionality of OTEC

OTEC has a distinct advantage over other marine renewable energy sources especially for utilization in the tropics. As mentioned in the researches that have been published, OTEC have an ability to produce electricity constantly while also having the capability of producing additional products that can be utilized by mankind [5]. With a stable temperature gradient between the surface and deep water in the tropics, OTEC plants could produce stable and continuous electricity throughout the year. In addition, OTEC could also produce additional by products and services (Figure 2). For example:

2.2.1 Aquaculture

In its operational state an OTEC plant utilized large amounts of Deep Ocean Water (DOW) for its electricity generation. These DOW contains large amounts of nutrients while also generally being relatively clean either from pathogens or other contaminants such as microplastics or industrial wastes [6] (Figure 3). These characteristics of a clean and nutrient rich water source are what the aquaculture industry such as for those who breeds oysters; clams; prawns; and other species are needs in their industry. By utilizing the DOW that are already being pumped to the surface by the OTEC plants, the Aquaculture industry could produce such products at a lower cost by lowering the need to purchase chemical enrichments and water treatment products.

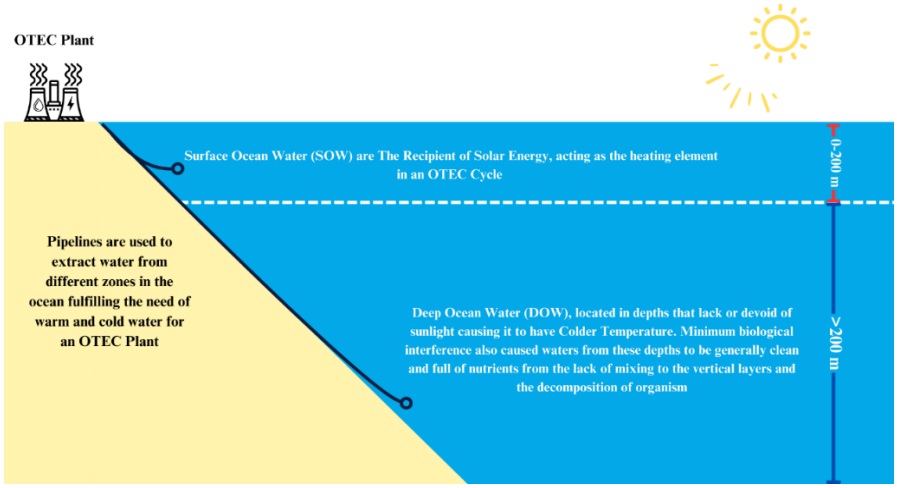


Figure 3. Contents of Deep Ocean Water adapted from **[15]**

2.2.2 Desalinated Water

According to research, an open-cycled or hybrid OTEC plant can directly produce desalinated water by converting seawater vapour that have seperated from its salt content that is produced during it's electricity generating cycle to drinkable fresh water. A 1 MW hybrid OTEC could be taken as an example where it has the ability to generate around 4500 m^3 of drinking water daily [5]. Meanwhile a closed cycle OTEC system

would have to introduce a dedicated desalination facilities which needs additional powers to convert its seawater intake due to its seawater cycle lack of change in its material state as its stays as liquid thus retaining its salt water content througout the loop. Economically speaking, it's production cost and the quality of produced drinking water, would have similar characteristics to its conventional counterparts thus making it quite economically and technically feasible especially since its raw resource (i.e., pumped water from the ocean for the operation of an OTEC plant).

2.2.3 Agriculture

In the agricultural sectors, fresh waters produced by an OTEC system could be used to supply waters that could be used to water fresh produce. This could be beneficial in coastal area where clean supply of fresh waters are limited and agricultural products remains as one of the main source of income [5]. Other than the usage of fresh waters, DOW could also help cultivate plants or produce usually grown in a more temperate climate, in areas with warmer temperature such as the tropics and subtropics. In this utilization, the DOWs are used to decrease the temperatures of the soil where the plants are planted. This method is known as refrigerated soil agriculture, where normally other methods of refrigeration are used to decrease the temperature of the soil and that can be costly when viewed in a technological aspect or from its electricity consumption alone.

3 Edu-Ecotourism

Edu-ecotourism is a form of sustainable tourism that have an highlight in it's educational value. Thus, it consist of two main aspect which are Ecotourism and Edutourism.

3.1 Ecotourism

Ecotourism is a type of tourism that focuses on environmentally friendly and responsible travel to natural areas. The goal of an ecotourism is to protect the environment, improve the well-being of local residents, and provide an educational experience for travellers. Ecotourism involves activities related to nature, such as observing and appreciating natural landscapes, wildlife, and local cultures. It also emphasizes the importance of minimizing environmental impacts, supporting local communities, and promoting conservation efforts [7].

In a sustainable development strategy for increasing tourism in a specific area, ecotourism is a viable strategy due to its having this following aspects:

- Have minimal negative impacts on the natural resources of an area;
- Involvment of multiple stakeholders (individuals, communities, tourists, operators, and government agencies) in the planning, development, implementation, and monitoring phases;
- Respect local cultures and traditions;
- Creates sustainable income for local communities and stakeholders;
- Creates revenue for the conservation area;
- Educate all stakeholders on their role in conservation.

3.2 Edutourism

An educational tourism activity emphasizes the development of knowledge, added value to the economy, and brings long-term socio-economic benefits in the form of entertaining and interesting tourism activities. Taken from the book titled "Managing Educational tourism", age, gender, income, and occupation are one of the many key factors of a succsessfull educational tourism that influences a tourist attraction in certain areas or activities [8]. The book also explained some components of an edu-tourism, first of all there are a primary ccomponent which are:

- Attractions and activities that provide the means of providing learning experiences (e.g. parks, historical sites, natural environments);
- Resource Specialists responsible for delivering the learning component of tourism activities (Such as curators, lecturers, researchers, academics);
- Tour Planners who are responsible for planning and developing learning programs for tourists (such as conservation organizations, universities, interest groups);
- Tour Operators who have responsibility for packaging and marketing tours to tourists.

In addition, the secondary component consists of supporting services consisting of:

- Transportation such as cruise, bus, train or other modes of transportation that play a role in bringing tourists to and from tourist sites.
- Hospitality services such as the provision of meals, recreation, social activities, and accommodation options.
- Travel Services such as travel agents and insurance providers.
- Marketing Organizations that operate on a national, regional or local scale to promote educational tourism to tourists.

4 OTEC Based Edu-Ecotourism

4.1 Worldwide Example of OTEC Based Edu-Ecotourism

Around the world a couple of OTEC demonstration plants have been built as a pilot project not just to promote the usage of OTEC as a new source of renewable energy, but also as a model on how the multifunctionality of OTEC could be harnessed to benefit the local community. Such examples are as follows:

4.1.1 Okinawa Deep Ocean Water Research Center (ODRC)

The ODRC in Kumejima, Okinawa, Japan had created a pilot project in the form of a 100 kW OTEC plant that aims to not just produce electricity but also utilize it's multifunctionality under the name the "Kumejima Model" [9]. The "Kumejima Model" is an innovative approach by utilizing Deep Ocean Water (DOW) and Ocean Thermal Energy Conversion (OTEC) technologies for sustainable development on Kumejima Island. This model integrates multiple uses of DOW, allowing it to be utilized not just in power generation, but also in the local aquaculture, agriculture, and even cosmetics industry, thereby maximizing resource efficiency and minimizing waste. For instance, after being used for OTEC power generation, the cold DOW can be repurposed for cooled-soil agriculture and aquaculture, demonstrating its versatility and potential for reuse up to four times or more depending on the application.

Kumejima itself have the target of achieving 100% renewable energy by 2040, with OTEC expected to supply a large portion of the island's electricity needs. The projected installation of a 1MW-class OTEC facility is predicted to provide approximately 15% of Kumejima's electricity supply, which is crucial given the island's current reliance on diesel power generation for its day to day electricity generation. Furthermore, the local economic impact of DOW industries has been notable, with revenues increasing from roughly 20 million USD in 2011 to 24 million USD in 2016, highlighting the economic benefits of integrating these technologies that support additional products from an OTEC plant into the community.

The OTEC plant in Kumejima is utilized for various applications and not just power production. One significant use is in aquaculture, where the cold deep ocean water (DOW) is utilized to produce healthy baby prawns free from polutants at the Okinawa Kuruma Prawn Hatchery, ensuring a stable supply throughout the year. Additionally, DOW is used in the farming of sea grapes, that's already an established local produce, which now benefits from the nutrient-rich and temperature-controlled environment provided by the ocean water.

Moreover, the Kumejima Model integrates DOW for chilled-soil agriculture, where fresh water is cooled using DOW in heat exchangers, allowing for temperature regulation near plant roots, which is essential for growing foods and food coloring extracts from sensitive plants. The cosmetics industry also use DOW, as local companies use desalinated DOW as a base for their products, benefiting from its low-cost access to minerals and bacteria-free quality [9]. The companies manufactures a range of cosmetic products using desalinated DOW as a base, which allows them to incorporate local ingredients and minerals into their formulations, providing a consistent and bacteria-free resource for production. This approach not only enhances the quality of their products but also offers marketing advantages due to the unique properties of DOW. Additionally, there's also an ongoing development of bioreactor systems within typhoon-resistant greenhouses, which support the commercialization of chilled-soil agriculture techniques, further integrating DOW into the local industries These approaches in multi-produce utilization of OTEC not only enhances local industries but also promotes sustainable development on the island.

4.1.2 Cozumel Island OTEC Ecopark

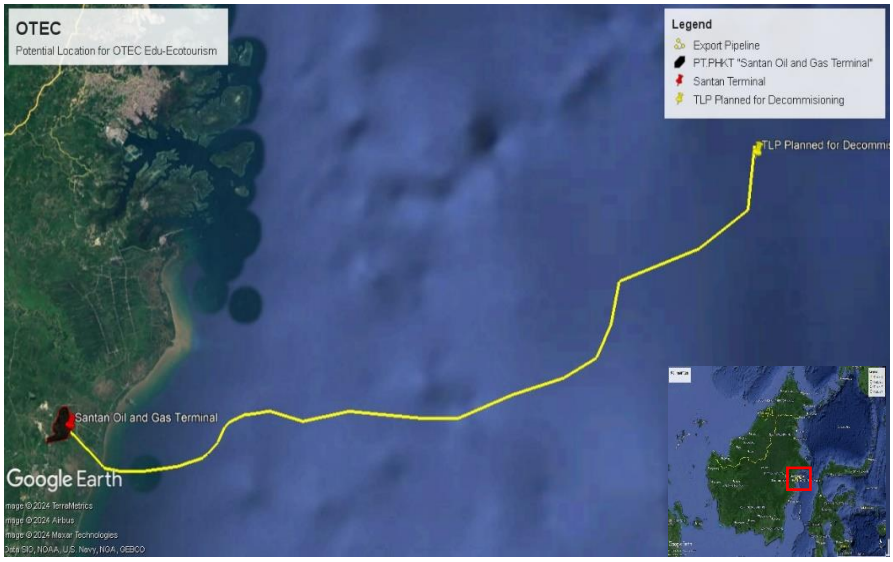
The Ocean Thermal Energy Conversion (OTEC) Ecopark proposed off Cozumel Island aims to address the local needs for water, energy, and food in coastal communities [10]. This system is designed to produce 60 MW of base load power, which is expected to be integrated into the local electrical grid through the Chankanaab electrical node, located around 44 km away. In addition to energy generation, the OTEC system will also produce over 77,000 m³ of desalinated water daily, sufficient to meet the needs of a population of 730,000.Furthermore, the desalination submodule will generate 3 million m³ of nutrient-rich deep ocean water (DOW) each day, which can be utilized for sustainable aquaculture, particularly in cultivating Ulva spp. seaweed.

The integration of OTEC technology not only provides clean energy but also supports the local economy by creating opportunities in the blue economy sector. Not to mention, the cultivation of "*Ulva* spp." is projected to yield approximately 69.75 tons per day, contributing to food security and carbon sequestration efforts.. Overall, the OTEC Ecopark represents a comprehensive approach to enhancing the resilience and sustainability of coastal communities in Mexico, while also addressing the challenges posed by climate change and resource scarcity.

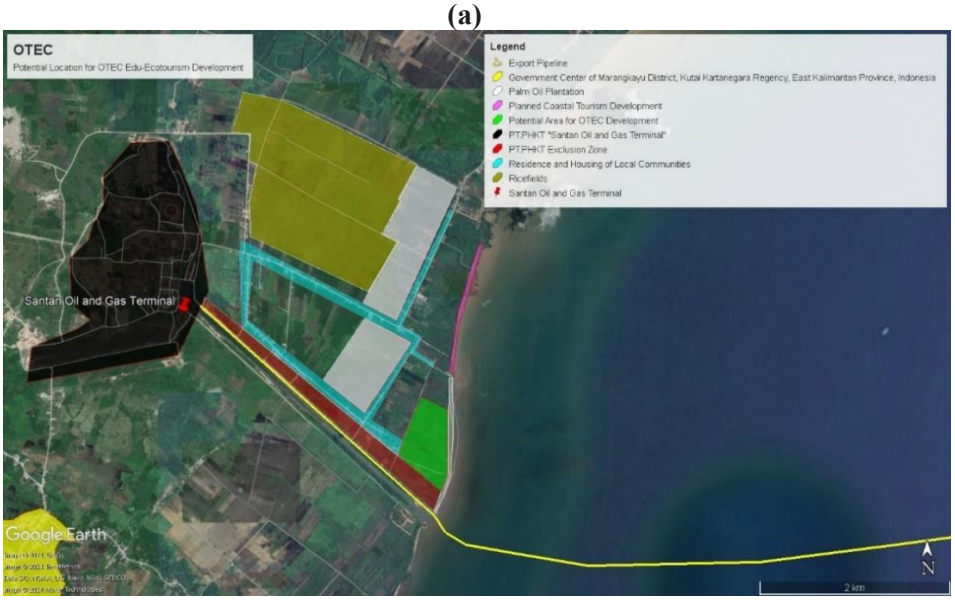
4.2 OTEC Based Edu-Ecotourism Potential in Indonesia

A study had been conducted in Indonesia regarding the utilization of Post-Operation oil and gas facilities located in East Kalimantan [1]. The results of the study indicate that reusing post-operation offshore oil and gas pipelines (POGP) as cold-water pipes (CWP) for a 20 kW Closed-Cycle Ocean Thermal Energy Conversion (OTEC) systems could significantly reduce investment costs, as the POGP has a remaining service life of over 20 years, making it a viable option for such applications . The analysis revealed that the temperature of cold seawater in the CWP could increase by approximately 3 to 6°C due to exposure to ambient temperatures along the 60 km pipeline length . This temperature change is deemed as critical, as it affects the performance of the OTEC system, particularly in the condenser where the working fluid interacts with the cooling medium. The study emphasizes the importance of conducting a comprehensive assessment of the temperature changes in the cold seawater flowing through the CWP, as these changes can impact the efficiency of the OTEC system.

The findings suggest that careful design and feasibility studies are essential to optimize the efficiency of the OTEC system while utilizing the existing POGP infrastructure. Overall, the potential for cost reductions in both decommissioning and OTEC development presents a viable potential for the reutilization of POGP in Indonesia's energy transition efforts by utilizing as a part of the OTEC System. The location chosen are taking into account the 200 m, exclusion zone of PT.Pertamina Hulu Kalimantan Timur (PHKT) which forbids any construction inside or near the pipeline canal and also the planned Coastal Tourism Development Plan of Semangko Village. The location and also nearby Zone of Interest (ZoI) of a potential OTEC Edu-Ecoutourism could be seen in Figure 4, where each colored zone represent a different ZoI located in Semangko Village, Marangkayu District, Kutai Kartanegara Regency, East Kalimantan, Indonesia.



(a)



(b)

Figure 4. (a) General Area of the Planned OTEC in East Kalimantan, Indonesia. (b) Location of Planned OTEC site, Marangkayu, East Kalimantan. Image adapted from Google Earth.

If we based the potential of OTEC, in East Kalimantan, that have been researched for a development of an OTEC Plant, to the OTEC utilization concept developed around the world. The development of OTEC in said location will not only help the electricity demand of the area in a sustainable manner, but also can be utilized to develop the local community (Figure 5).

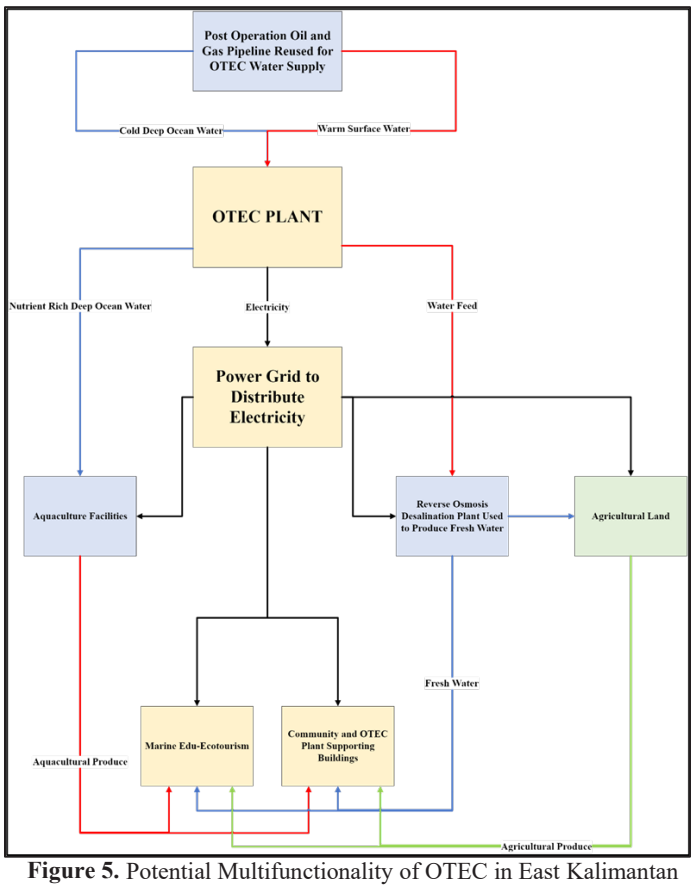


Figure 5. Potential Multifunctionality of OTEC in East Kalimantan

4.2.1 Aquacultural Products

Based on a report from the Marine and Fisheries Service of the Province of East Kalimantan, the report showed that farming and aquaculture of Tiger Prawns and Seaweeds remained as one of the main sources of income for the local communities as per seen in Table 1 [11]. Tiger Prawn as a species is quite sensitive to Water Quality [12]. As per the research done by Pantjara et al, the lack of a supperior seed in addition to inferior water quality could lead to the decrease in survival and growth rate of juvenile tiger prawns. This study is also supported by assessment done by the local community, where the heavily physical parameters of the water used in prawn farming either due to the high content of sediments or other pollution such as parasite has declined the existence of prawn farming in Marangkayu. As proven in Kumejima, Japan, DOW can be utilized to enrich the waters used for aquaculture in place of chemical enrichments, thus providing a sustainable and environmentally friendly method of increasing the production of aquaculture products such as prawn and seaweeds.

Table 1. Recapitulation of Fishery Activities in Marangkayu, East Kalimantan [11].

No	Fishery Activities	Investment Criteria			Profit Month
		NPV	IRR	Net BCR	
1	Dogol	87,549,442	99%	5.11	Rp2,593,271.00
2	Bubu	35,039,057	89%	4.64	Rp1,075,833.00
3	Fishing	41,881,943	87%	4.54	Rp1,549,000.00
4	Gill Net	48,591,959	91%	4.6	Rp1,770,583.00
5	Gondrong	58,964,216	94%	4.85	Rp2,116,083.00
6	Spear Fishing	37,892,102	84%	3.91	Rp1,437,063.00
7	Rakkang	21,365,208	50%	2.88	Rp1,100,417.00
8	Bagan	295,529,738	89%	4.62	Rp4,925,496.00
9	Bandeng Presto	60,817,821	108%	5.29	Rp2,078,333.00
10	Salted Fish Production	28,016,508	90%	4.41	Rp1,020,333.00
11	Prawn Aquaculture	421,450,773	80%	4.11	Rp11,779,106.00
12	Seaweed Aquaculture	275,924,762	88%	4.59	Rp10,148,958.00

4.2.2 Fresh Water Production

According to research, sustaining a clean water supply remains as one of the problem faced in East Kalimantan [13]. Based on research conducted in 2020, the local water service cannot fulfil the total needs in Balikpapan alone, thus opening the potential for a new freshwater production source in East Kalimantan. OTEC through either Open Cycle flash evaporation or the usage of reverse osmosis desalination, for a closed cycle OTEC, could prove to be one of the steady supplier of fresh waters, due to its 24/7 operational capability all year long. This will prove beneficial to the community, especially those in coastal areas where a steady supply of clean fresh water might be difficult to be provided.

4.2.3 Agricultural Product

In 2021, a research have been conducted on the agricultural needs and land development in the Marang Kayu, Sub-district [14]. Said research has shown that agricultural and plantations are the second most common land usage in the area, after fisheries and aquaculture (Table 2). This has meant that other than being a fishery-based community, Semangko Village, in Marangkayu District was also an agricultural one. The potential of OTEC in not only supporting the local energy demands, but also in providing a way to support its agriculture industry are one of the untapped potentials from developing an OTEC plant in the region. From Figure 8, we could see those agricultural lands of paddy fields (Dark Greenish-Yellow), located north-east of The Santan Oil and Gas Terminal encompass an area of around 240 Ha. Currently the paddy fields and it's farmers are facing a decline due to either flooding in rainy season or the lack of fresh water during drought based on observation and interview done towards the local community. As proven in Kumejima and also the research

done for the planned OTEC plant in Cozumel Island, OTEC could benefit the agricultural sector by providing a steady supply of fresh water, especially during drought, and also in the diversification of local produce, that otherwise needed more temperate temperatures.

Table 2. Land Usage in East Kalimantan [14].

Space Pattern	Slope					Grand Total
Sub-District	**<2%**	**2-8%**	**16-25%**	**26-40%**	**40%**	
Bontang Selatan		**204.60**	**406.31**		**197.79**	**808.70**
Protection Forest		166.68	257.46		151.37	575.51
Corversion Production Forest		8.08	97.90			106.06
Plantation		27.51	50.87		46.42	124.80
Settlement		2.33				2.33
Marangkyu	**10,659.14**	**12,830.09**	**37,124.25**	**11,280.53**	**13,858.76**	**85,752.77**
Protection Forest	137.26	1,240.40	380.83		57.29	1,815.78
Conversion Production Forrest	565.74	844.46	269.65		229.41	2,909.26
Permanent Production Forest	154.54	6,301.41	22,868.55	7,768.01	4,630.64	41,723.35
Fisheries Area	4,206.37	204.96				4,411.33
Plantation	1,786.33	1,374.69	10,296.08	3,434.01	7,183.62	24,073.73
Settlement	879.69	1,657.29	2,896.62	78.51	756.59	6,268.60
Food crops and Horticulture	2,929.21	1,206.68	412.62		1.01	4,549.72
Muara Kaman			**602.79**	**366.94**	**15.47**	**985.20**
Permanent Production Forest			598.38	3,694.00	11.63	976.95
Nature Reserve Area			4.41		3.84	8.25
Sangatta Satan		**173.31**	**900.98**	**773.11**	**1,631.93**	**3,479.33**
Nature Reserve Area		173.31	900.98	773.11	1,631.93	3,479.33
Teluk Pandan	**396.14**	**5,832.48**	**16,400.17**	**10,206.24**	**30,378.89**	**63,218.92**
Protection Forest	315.95	227.54	245.76		7,121.37	7,910.62
Conversion Production Forrest	68.83	487.55				556.38
Permanent Production Forest		451,151.00	11,785.68	7,018.81	16,362.60	39,676.60
Nature Reserve Area		605.45	4,378.72	3,187.43	6,867.01	18,038.61
Plantation	11.36	0.43	0.01		22.91	34.71
Grand Total	**11,055.28**	**19,040.48**	**55,444.50**	**22,666.82**	**46,077.84**	**154,244.92**
Percentage	**7%**	**30%**	**36%**	**15%**	**12%**	

4.2.4 Edu-ecotourism Attraction

A pilot project or OTEC facilities, such as those in Kumejima, Japan could increase visitors from outside of the region, either for academical reasons or tourism. The potential for said OTEC plant in attracting visitors can be predicted in a couple of ways, for one the OTEC plant itself could prove as a pilot project of the viability and benefit of OTEC as a source of renewable energy in Southeast Asia and the Tropics, and also shows that a transition from fossil based fuels to renewable energy could be done in an economically beneficial method. Currently the local government are committed to find a way to utilize planned or already decommissioned oil and gas facilities, so that it could be utilized for the transition to renewable energy, while also serving as an Edu-Ecotourism attraction by creating a pilot plant and an energy transition museum.

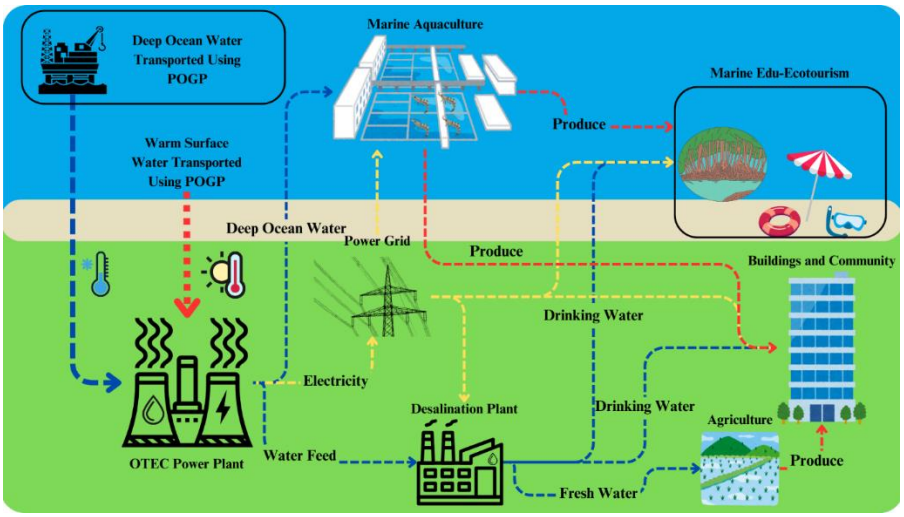


Figure 6. Illustration of an OTEC Edu-Ecotourism Concept in East Kalimantan

As an Edu-Ecotourism concept, OTEC could provide an integrated area where various products and electricity could be produced sustainably (Figure 6). While mainly the area is used for research purposes regarding an OTEC Pilot Projects that attracts researchers and visitors, as per seen in Kumejima the various products that are produced from the multifunctionality of OTEC could support the local community and tourism. Where electricity could be produced sustainability and continuous, desalination plants could produce fresh waters both for drinking and agriculture, and various marine produces from aquacultures can be used to feed tourist and be sold to generate additional income all integrated into one another. This new and unique method of an integrated multifunctional facility in South East Asia, could potentially boost visitors that aims to research the OTEC and it's multifunctionality while also attracts visitors for recreational reason to experience the uniqueness of the produce and it's production method, to enjoy the natural landscape of its coastal area, and even learn regarding on how OTEC could be utilized to sustainably produce electricity and it's other products as a method of transitioning from oil and gas so that the nature could be safeguarded. In addition, local knowledge and cultural centre could also be established as a way to increase awareness and spread knowledge regarding conservation efforts and local cultures. This concept of sustainable tourism while also providing a way of improving one's knowledge and awareness are exactly what made an OTEC as a potential Edu-Ecotourism attraction, which are by utilizing its uniqueness as a power plant that have various capabilities and also providing integration with local resources to promote sustainable tourism.

Other than that, the given improvement of road access and local infrastructures needed to support OTEC plant will also prove beneficial in the long term for the community, even after the plant have been built by improving road access to the region and developing the various local infrastructures and facilities. Thus this proposed method of sustainable tourism could co-exist and support the planned increase of Marine Ecotourism planned by the local government to improve the tourism rate in Semangko Village, Marangkayu District, Kutai Kartanegara Regency, East Kalimantan as per shown by the pink area *coastal area* in Figure 5.

4 Conclusion

In conclusion, the integration of Ocean Thermal Energy Conversion (OTEC) technology into Indonesia's energy landscape presents a unique opportunity for sustainable development. The potential to repurpose decommissioned offshore oil and gas facilities for OTEC systems not only addresses the growing electricity demands in a sustainable manner, but also offers significant economic benefits to local communities through the production of fresh water, aquaculture, and agricultural products. The successful examples of OTEC implementation in places like Kumejima, Japan, demonstrate the viability of such projects, showcasing their ability to generate clean energy while simultaneously supporting local industries and promoting eco-tourism.

Moreover, the establishment of OTEC facilities can serve as educational and ecotourism attractions, enhancing public awareness and appreciation for renewable energy technologies. This dual focus on energy production and community engagement aligns with global sustainability goals, making OTEC a promising endeavour for Indonesia's transition towards a greener economy. Overall, the the importance of strategic planning and stakeholder involvement in harnessing the full potential of OTEC for the benefit of both the environment and local communities and also the technical analysis of OTEC and it's multifunctionality if developed in East Kalimantan remains paramount for future research.

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