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Tarikh

: 31<sup>st</sup> May 2013

*\*Potong yang tidak berkenaan*

MANAGING THE TRANSITION OF FOSSIL FUELS TO RENEWABLES ENERGY:  
APPLICATION OF OCEAN THERMAL ENERGY CONVERSION


OOI BUN JIAN

Laporan ini dikemukakan sebagai nenebuhi sebahagian daripada syarat penganugerahan  
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## **DEDIKASI**

Untuk keluarga, pensyarah dan rakan-rakan tersayang

## **PENGHARGAAN**

Penulis ingin merakamkan penghargaan ikhlas kepada penyelia, Dr. Chew Boon Cheong atas bimbingan dan dorongan yang diberi sepanjang menjalani Projek Sarjana Muda ini.

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## ABSTRAK

Dunia kita mengalami kesuntukkan minyak mentah pada hari ini. Namun, teknologi tenaga diperbaharui menjana elektrik yang bersih dan mampan berbanding dengan tenaga fosil. Ini telah menarik perhatian pakar sains untuk mengkaji dan belajar dalam tenaga yang boleh diperbaharui. *Ocean Thermal Energy Conversion (OTEC)* wujud dalam dekad lepas telah dibina pada tahun 1930 oleh *Georges Claude*, selepas konsep tenaga haba lautan telah dicadang oleh *Arsene Jacques D'Arsonval* pada tahun 1881. Walau bagaimanapun, teknologi tersebut telah terhenti dari dibangunkan untuk komersial teknologi tersebut. Bumi kita dilindungi oleh lautan dengan lebih 70% di permukaan bumi, ini menjadikan lautan menjadi pengumpul suria terbesar di dunia. *OTEC* menjana elektrik dengan suhu perbezaan dalam air laut dan prosesnya tidak mengakibatkan isu persekitaran. Dalam kajian ini, Kota Kinabalu, Sabah telah dipilih sebagai lokasi utama untuk menyiasat kriteria geografi, penerimaan sosial dan teknikal *OTEC* sebagai penjana tenaga. Kajian ini menggunakan kaedah *mixed method* untuk data penumpulan dan data analisis. Kajian ini membuktikan bahawa penggunaan *OTEC* di Sabah membawa banyak manfaat seperti penerimaan sosial, kemampanan dan kecekapan tenaga dibandingkan dengan bahan api fosil. Kesimpulannya, *OTEC* berpotensi menjadi salah satu sumber tenaga utama bagi orang-orang yang tinggal di Sabah. Peralihan dari fosil kepada tenaga yang boleh diperbaharui, terutamanya aplikasi *OTEC* boleh berkembang dan umum, untuk menghasil tenaga yang bersih dan mampan di kawasan-kawasan pantai seluruh dunia.

## ABSTRACT

Nowadays, the world is awakening by the fear of peak oil. Since the renewable energy is clean sources of energy that are sustainable and lower environment impact than fossil energy, the renewable energy has been attracting the world scientists, which are worth to be developed and studied further. Ocean Thermal Energy Conversion (OTEC) existed in last decade was built in 1930 by Georges Claude, after the thermal energy of the ocean was tapped by Jacques Arsene D'Arsonval in 1881. However, the technology was put on-halt and discontinued from being developed wisely for realistic application. Since ocean cover more than 70% of earth surface, this makes them as the world largest solar collectors for thermal energy creation. The technology generates energy by using the difference of temperature in an ocean with least environment impact and high sustainability. In this case study, Kota Kinabalu, Sabah has been selected as main location to investigate the geographical criteria, social acceptance and the technical of OTEC as energy generator and feasibility. The research used mixed method for both data collection and data analysis. This study proved that the application of OTEC in Sabah brings a lot of benefits such as social acceptance, sustainability and energy efficiency compare to fossil fuels. As a conclusion, the OTEC might become one of the main energy sources for people living in Sabah. Transition from fossil to renewable energy, particularly the application of OTEC could be expanded and generalized, to harvest more energy at the coastal areas of all places around the world.

## CONTENT

CHAPTER	TITLE	PAGE NUMBER
	<i>PENGAKUAN</i>	ii
	<i>DEDIKASI</i>	iii
	<i>PENGHARGAAN</i>	iv
	<i>ABSTRAK</i>	v
	ABSTRACT	vi
	CONTENT	vii
	LIST OF TABLES	xii
	LIST OF FIGURES	xiii
	LIST OF SYMBOLS	xv
	LIST OF APPENDIX	xvi
<b>CHAPTER 1</b>	<b>INTRODUCTION</b>	1
	1.1 Background of the study	1
	1.2 Research Question	2
	1.3 Objectives	3
	1.4 Scope	3
	1.5 Limitation	4
	1.6 Importance of the Project	5
	1.7 Summary	5
<b>CHAPTER 2</b>	<b>LITERATURE REVIEW</b>	6
	2.1 Introduction	6
	2.2 Overview of Ocean Thermal Energy Conversion and Fossil Fuels	7



<b>CHAPTER</b>	<b>TITLE</b>	<b>PAGE NUMBER</b>
	2.2.1 Ocean Thermal Energy Conversion	7
	2.2.2 Fossil Fuels	11
	2.2.3 Technical Criteria Comparison between Ocean Thermal Energy Conversion and Fossil Fuels	14
	2.3 Social Acceptance	16
	2.4 Social Acceptance framework	17
	2.5 Challenges of OTEC	17
	2.6 Theoretical Framework	19
	2.7 Summary	20
<b>CHAPTER 3</b>	<b>RESEARCH METHOD</b>	21
	3.1 Introduction	21
	3.2 Research Design	22
	3.3 Mixed Method Research	23
	3.4 Primary and Secondary Data Sources	25
	3.5 Location of Research	25
	3.6 Method of Primary Data Collection	26
	3.7 Validity, Generalizability and Reliability	26
	3.7.1 External Validity	27
	3.7.2 Internal Validity	28
	3.7.3 Construct Validity	28
	3.7.4 Reliability	29
	3.8 Summary	30
<b>CHAPTER 4</b>	<b>DATA ANALYSIS AND DISCUSSION</b>	31
	4.1 Introduction	31
	4.2 Investigate Technical Criteria of OTEC compare with Fossil Fuels	32
	4.2.1 Technical Criteria of Ocean Thermal Energy Conversion	32

CHAPTER	TITLE	PAGE NUMBER
	4.2.1.1 Efficiency of OTEC	33
	4.2.1.2 Environment Impacts of OTEC	34
	4.2.1.3 Plant Design of OTEC	36
	4.2.1.4 Temperature Gradient	38
4.2.2	Technical Criteria of Fossil Fuels	40
	4.2.2.1 Efficiency of Fossil Fuels Power Station	41
	4.2.2.2 Environment Impact of Fossil Fuels	42
	4.2.2.3 Effectiveness of Fossil Fuels as Energy Sources	44
4.3	Social Acceptance of OTEC Compare with Fossil Fuels	45
	4.3.1 Social Concern Level	45
	4.3.2 Measure of Awareness in Energy Field	49
	4.3.3 Adoption and Utility Level	52
	4.3.4 Social Perception Analysis	55
	4.3.5 Experts View on Social Acceptance	59
4.4	Innovative Solution to Overcome the Challenges of OTEC	60
	4.4.1 Challenges of OTEC	60
	4.4.1.1 Economic in Cost Competitive	60
	4.4.1.2 Organism Entrainment and Impingement	62
	4.4.1.3 Seawater Discharge	62
	4.4.1.4 Durability of OTEC Plant	63
	4.4.2 Innovative Solution for OTEC Challenges	64
	4.4.2.1 Economic Challenge	65

<b>CHAPTER</b>	<b>TITLE</b>	<b>PAGE NUMBER</b>
	4.4.2.2 Organism Entrainment and Impingement Challenge	66
	4.4.2.3 Seawater Discharge Challenge	67
	4.4.2.4 Durability of OTEC Plant Challenge	69
<b>CHAPTER 5</b>	<b>CONCLUSION</b>	70
	5.1 Introduction	70
	5.2 Overview on Technical Criteria for OTEC and Fossil Fuels	71
	5.2.1 Technical Criteria of OTEC	71
	5.2.1.1 Efficiency of OTEC	71
	5.2.1.2 Environment Impact of OTEC	72
	5.2.1.3 Plant Design of OTEC	73
	5.2.1.4 Temperature Gradient of OTEC	73
	5.2.1.5 Conclusion on Technical Criteria of OTEC	74
	5.2.2 Technical Criteria of Fossil Fuels	74
	5.2.2.1 Efficiency of Fossil Fuels as Energy Sources	75
	5.2.2.2 Environment Impacts of Fossil Fuels	75
	5.2.2.3 Effectiveness of Fossil Fuels as Energy Sources	76
	5.2.2.4 Conclusion of Technical Criteria of Fossil Fuels	76

<b>CHAPTER</b>	<b>TITLE</b>	<b>PAGE NUMBER</b>
	5.2.3 Conclusion on Technical Criteria for OTEC and Fossil Fuels	77
5.3	Overview on Social Acceptance of OTEC	77
	5.3.1 Concern Level of Sabah Residents	78
	5.3.2 Awareness Measurement in Energy Development	79
	5.3.3 Adoption and Utility Level in New Technology	80
	5.3.4 Social Perception Analysis	80
	5.3.5 Experts View on Social Acceptance	81
	5.3.6 Conclusion on Social Acceptance of OTEC in Sabah	81
5.4	Conclusion on OTEC Challenges and Innovative Solution	82
5.5	Recommendation	83
	<b>REFERENCES</b>	86
	<b>APPENDIX</b>	89

## LIST OF TABLES

<b>NO.</b>	<b>TITLE</b>	<b>PAGE NUMBER</b>
2.1	Technical Criteria for Fossil Fuels and OTEC	15
4.1	Descriptive Statistic for Quantitative Question No. 15	54
4.2	Descriptive Statistic of Quantitative Question No. 14	58

## LIST OF FIGURES

<b>NO.</b>	<b>TITLE</b>	<b>PAGE NUMBER</b>
2.1	Global source of energy 2006 in Cubic Mile of Oil (CMO)	12
2.2	Social Acceptance of New Technology Adoption	17
2.3	Theoretical Framework for OTEC	19
4.1	Sabah Through	40
4.2	Sabah Energy Generation Capacity by Plant Type	42
4.3	Quantitative Question No. 5	46
4.4	Quantitative Question No. 6	47

<b>No.</b>	<b>TITLE</b>	<b>PAGE NUMBER</b>
4.5	Quantitative Question No. 8	48
4.6	Quantitative Question No. 1	50
4.7	Quantitative Question No. 10	51
4.8	Quantitative Questions No. 7	53
4.9	Quantitative Question No. 15	54
4.10	Quantitative Question No. 3	56
4.11	Quantitative Question No. 4	57
4.12	Quantitative Question No. 14	58
5.1	Blueprint for Operation of OTEC	84
5.2	Blueprint for Physical Structure of floating OTEC Plant	85

## LIST OF SYMBOLS

%	=	Percent
$\Delta T$	=	Delta Temperature
$^{\circ}C$	=	Degree Celsius
$^{\circ}F$	=	Fahrenheit
btu	=	British Thermal Unit
ft	=	Feet
$km^2$	=	Kilometers square
kW	=	Kilowatt
kWh	=	Kilowatt per hour
m	=	Meter
$m^3$	=	Meter cube
MW	=	Megawatt
P	=	Pressure
T	=	Temperature
V	=	Volume
USD	=	United State Dollar



## LIST OF APENDIX

<b>NO.</b>	<b>TITLE</b>	<b>PAGE NUMBER</b>
A	Qualitative Questionnaire	89
B	Quantitative Questionnaire	92

## **CHAPTER 1**

### **INTRODUCTION**

#### **1.1 Background of the study**

Energy sources are another challenge after human revolution. Limitation in energy sources had been the bottle neck for human in development of different fields. Over depending on fossil fuels as energy sources also bring direct negative impacts to our environment. Keep on burning fossil fuels will send greenhouse gases into the atmosphere, trapping the sun's heat and contributing to global warming. According to Public Citizen (2012), renewable technologies could address global climate change more quickly than nuclear power, and without the production of radioactive waste or other significant types of pollution. Ocean Thermal Energy Conversion (OTEC), renewable energy that generate electricity by using gradient of temperature in sea water. According to Vega (2003), for an OTEC efficiency of 3%, in converting OTEC to electricity, we would need less than 1 % of this renewable energy to satisfy all of our desires for energy. According to New Straits Times (2012), The Sabah government is embarking on

aggressive policies to promote large-scale use of renewable or green energy. OTEC could be another option of renewable energy to be applied.

## 1.2. Research Question

Consumption of energy increasing rapidly day by day, human should not only depend on fossil fuels as energy sources anymore. Thus, renewable energy becomes another option that able to generate clean energy for human. As we know, ocean is covering around 70% of surface on our earth, which mean ocean is a biggest panel that collecting solar energy from sunlight. The energy that absorb by ocean is equal to 4000 times the amount presently consumed by humans (Vega, 2003), we can see the potential of OTEC to contribute as our energy sources. According to Yunus (2012), Malaysia PM Najib said he approved the application of Ocean Thermal Energy Corporation to conduct a study to generate electricity from the deep sea in Sabah.

Sabah is cover by coastal zone of 27549 km<sup>2</sup> in Malaysia, so there is a high potential to utilize ocean-based energy sources. However, this study is not considering implement Ocean Wave Energy in Sabah because there are lands surrounding the coastal zone of Sabah such as Philippines. Thus, OTEC have higher feasibility to implement in Sabah compare with Ocean Wave Energy. Research question constructed as below:

1. How the technical criteria of OTEC affect in the transition of technology?
2. What the trend of social acceptance of Sabah residents on the OTEC implementation?
3. How to overcome current challenges of OTEC by innovative solution?

### **1.3 Objectives**

The objective of this study is to examine the technical criteria and social response of OTEC implementation at Sabah compare with fossil fuels as energy sources. The study also investigate how the implementation of OTEC at Sabah. Lastly the report will come out with innovative solution to overcome the weaknesses of OTEC to enable its application.

The objective of study are stated as below,

- 1.3.1. To investigate the technical criteria for the implementation of OTEC in Sabah, compare with fossil fuels power station.
- 1.3.2. To investigate the social acceptance of the application of OTEC in Sabah, compare with fossil fuels power station.
- 1.3.3. To suggest an innovative solution to overcome the challenges of OTEC and enable its application.

### **1.4 Scope**

The scope of this research is to investigate the acceptance level of Sabah people for the implementation of OTEC around the coastal line of Sabah state, by considering the impact to environment, economic growth, and energy efficiency after the

implementation compare with fossil fuels as energy supply. Besides, the study will also identify the technical criteria that need to consider during the implementation of OTEC in Sabah, with the opinions from expert in particular field. Therefore experts from energy field including researchers, engineers and also experts from overseas are referred to investigate the applicability of OTEC in Sabah.

Respondents are mainly divided into two groups. First group are from local residents, which are people from Sabah or who stayed at Sabah coastal zone for a certain period, that they can feel the implementation of any facility will affect their living life. This group of respondents is providing the acceptance level, and satisfaction level on different type of energy sources. Second group will be from the expert in the particular field of study, engineers and researchers from academic field, and also OTEC field experts. This group will provide a more detail, professional and technical information for the level of applicable for implementation of OTEC in Sabah, and also all the technical criteria that related on OTEC and fossil energy.

## **1.5 Limitation**

There are limitations identified in the research study. First, the case study is to investigate the application of OTEC as energy sources at Sabah only, thus other locations within or out of Malaysia also not going to discuss. Second, the researcher assuming the respondents answers with logical and honestly. Thus, mixed method will be applied as research strategy in this case.

## **1.6. Importance of the Project**

The project is a practical study that benefits on people in Sabah by investigate the application of OTEC as energy source. It was important to identify the applicable level of OTEC and also investigation on certain criteria that might affect the peoples at Sabah such as economy impact, environment impact, energy efficiency and more. Besides, the project also provides a deeper study on OTEC as renewable energy. This was important for energy field since fossil fuels are facing crisis, the project will contribute in replacement of fossil fuels with the new option of renewable energy that more sustainable and less environment impact. Successful in the study will raise the awareness of renewable energy especially OTEC while ocean covering 70% on the surface of Earth and we can see the potential of technology.

## **1.7. Summary**

Ocean Thermal Energy Conversion is very effective as energy sources. The coastal zone with 27549 km<sup>2</sup> at Sabah been one of the selling points show topic is worth to study. According to Vega (2002), in an annual basis, the amount solar energy absorbed by the oceans is equivalent to at least 4000 times the amount presently consumed by humans. Further study on this topic will leading human to get a dramatic leap on technology of renewable energy.



## **CHAPTER 2**

### **LITERATURE REVIEW**

#### **2.1 Introduction**

This chapter was discussed about the overview of fossil fuels and also Ocean Thermal Energy Conversion (OTEC) as current energy sources. The technical criteria for both energy sources will be mentioned, including effectiveness, power quality and environment impact. The comparison of technical criteria among fossil fuels and OTEC also will be discussed. Social acceptance for new technology adoption will be mentioned too. The theory and technical criteria for OTEC will be discussed in section 2.2.1 and for fossil fuels will be discussed in section 2.2.2. To make a clear scenario, the comparison among OTEC and fossil fuels has been discussed in section 2.2.3. Start from 2.3, the researcher discussed about the acceptance level of society in implementation of OTEC. Follow by section 2.4, the researcher described about the innovation of OTEC with latest technology. Lastly, the framework of the theory of OTEC has been draft in section 2.5.

## 2.2 Overview of Ocean Thermal Energy Conversion and Fossil Fuels

Fossil fuels is non-renewable energy sources which currently still mass consuming by human as energy supply, whereas OTEC is one of the alternative as renewable energy, not a new born technology, but still space for development as a main resources of energy supply. The comparison of technical criteria among OTEC and fossil fuels have been carried out, thus we can investigate the feasibility among these two energy sources for long term program.

### 2.2.1 Ocean Thermal Energy Conversion

According to SOPAC (2001), OTEC is an energy technology, which uses the ocean's natural temperature gradient to drive a turbine, which is connected to a generator. It is desirable that the temperature difference between the warm surface water and the cold deep water be at least 20°C. Ocean as the biggest solar panel in the Earth will absorb major heat from the sun, which can be utilized as energy sources by implementation of OTEC. Masutani and Takahashi (2001) stated that the warm surface layer, which extends to depths of about 100-200m, is separated from the deep cold water by a thermo cline and the cold water ranging 8 °C - 4 °C might 800-1000m depths.

OTEC systems rely on the basic relationship between pressure (P), temperature (T) and volume (V) of a fluid, which can be expressed by the following equation:

$$\frac{PV}{T} = Constant$$