

# IGM Seminar on Non-Petroleum Geologically-related Sources of Energy in Malaysia

## “Ocean Thermal Energy Conversion (OTEC) to Power or Hydrogen-Fuel in Perspective”

by

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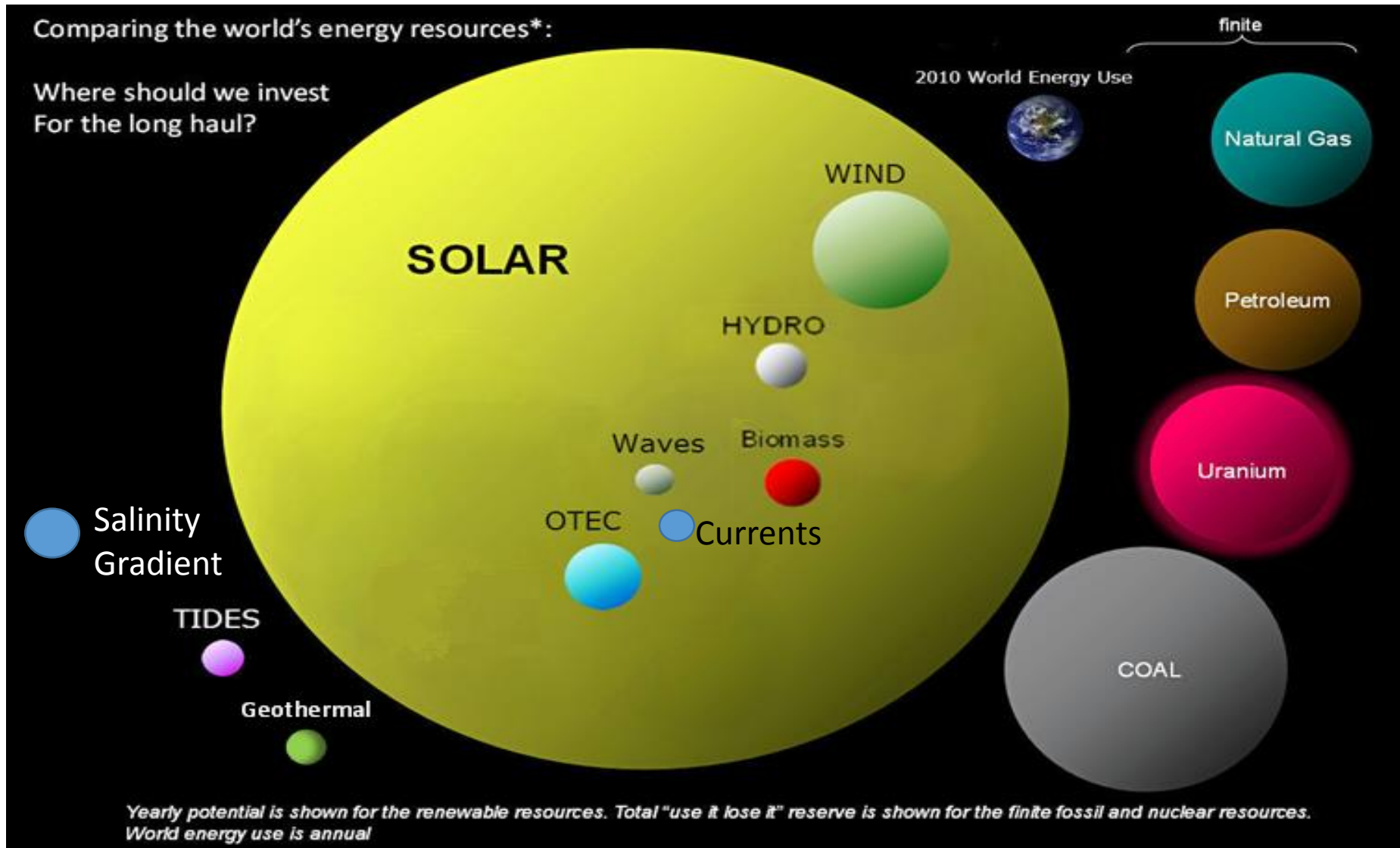
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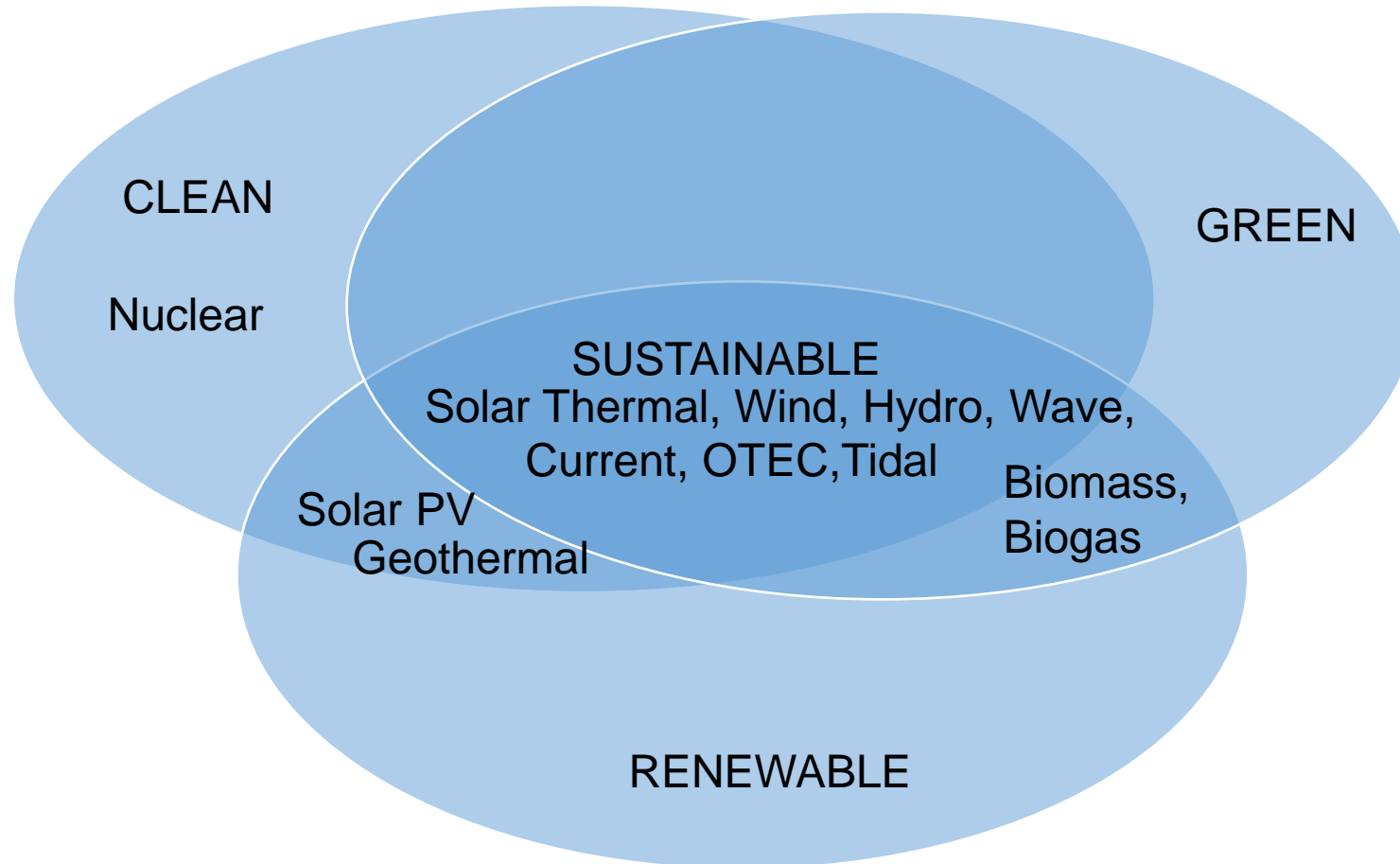
# OUTLINE OF PRESENTATION

1. Introduction: Energy Resources in Perspective and OTEC Potential
2. OTEC Definition, Principle & Potential OTEC Project Sites
3. OTEC Production Cost and Spin-Offs
4. Way Forward for Sustainability

# 1. GLOBAL SOURCES OF ENERGY, PETROLEUM & NON-PETROLEUM, IN PERSPECTIVE



# FORMS OF CARBON FREE-ENERGY & CLASSIFICATION



## 2. OTEC Legal Definition:

“OCEAN THERMAL ENERGY CONVERSION”

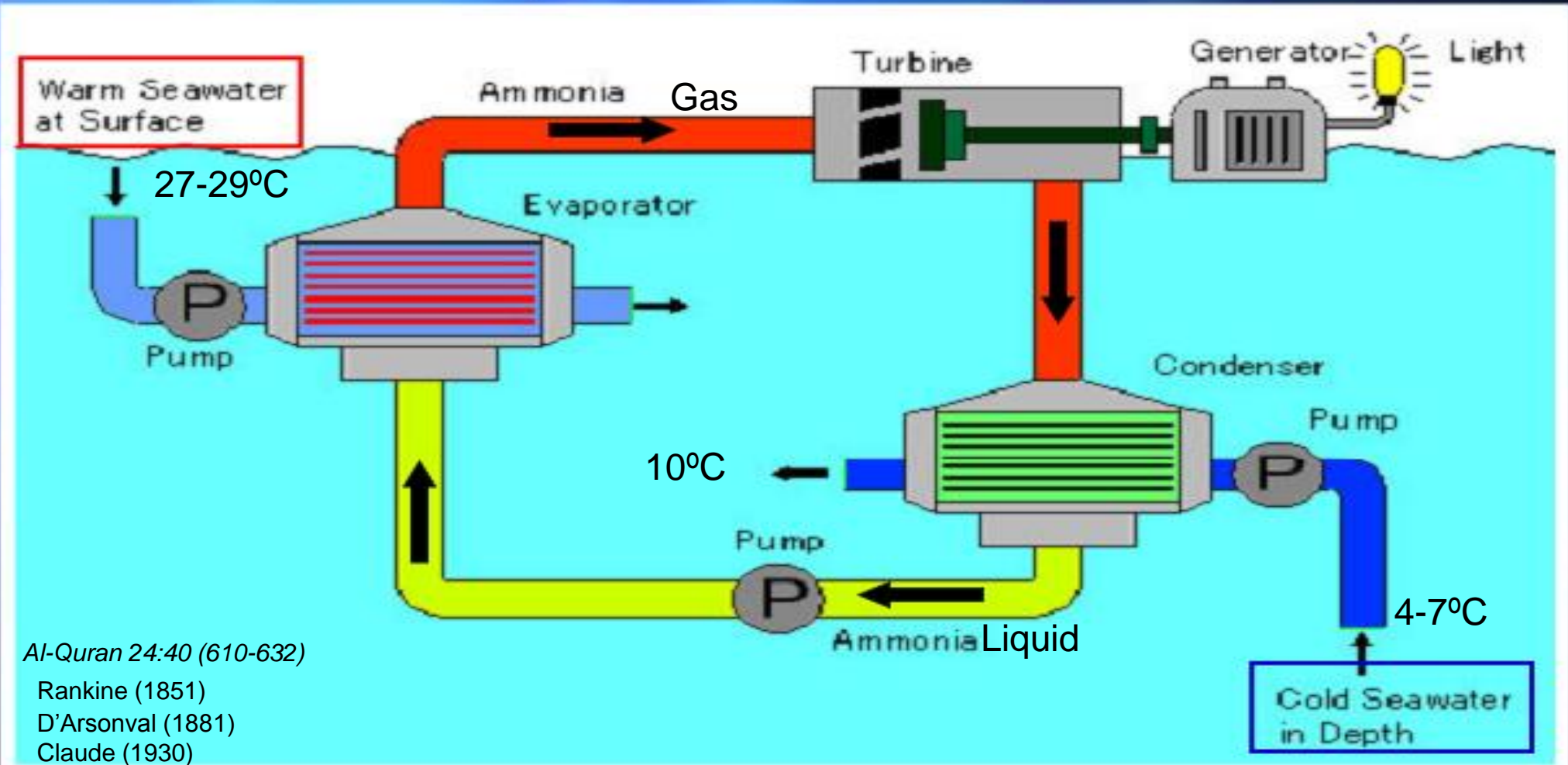
“... a method of converting part of the heat from the Sun which is stored in the surface layers of a body of water into electrical energy or energy product equivalent”;

[Pub. L. 96-310, Sec. 9, July 17, 1980, 94 Stat. 946.]

Ref:

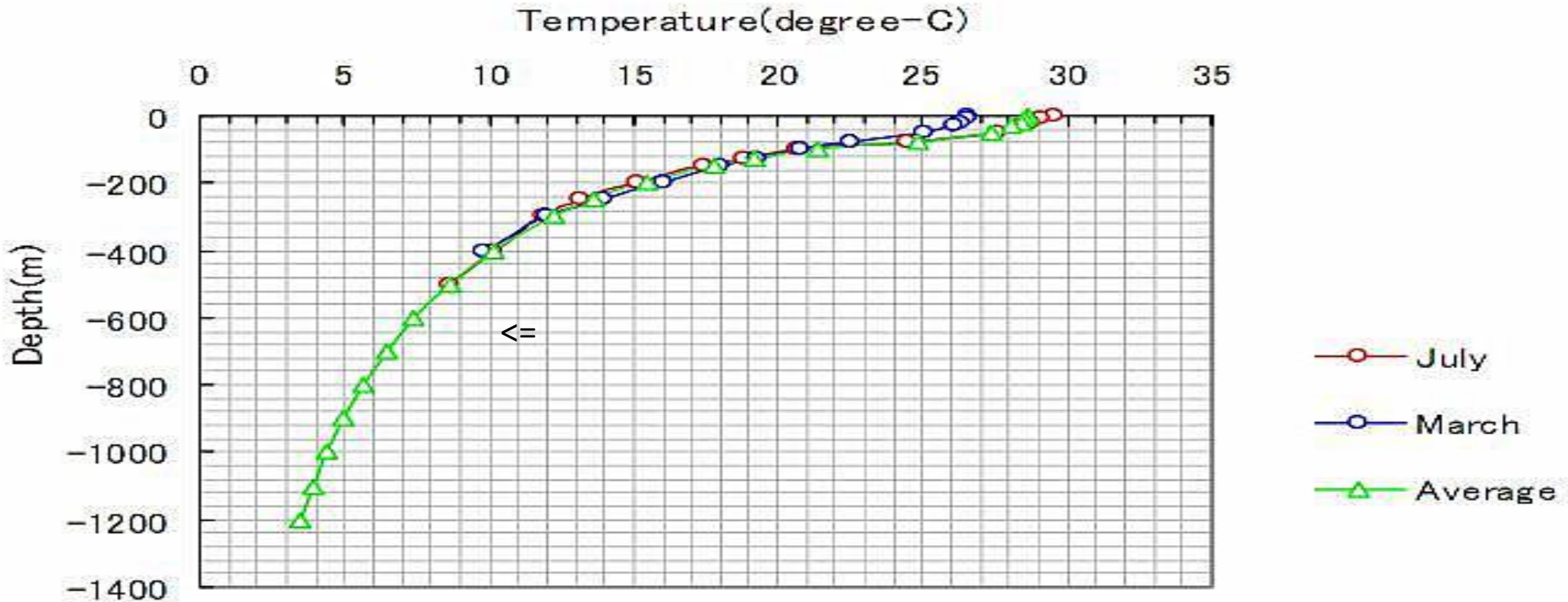
<http://uscode.house.gov/download/pls/42C98.txt>

# Principle of OTEC

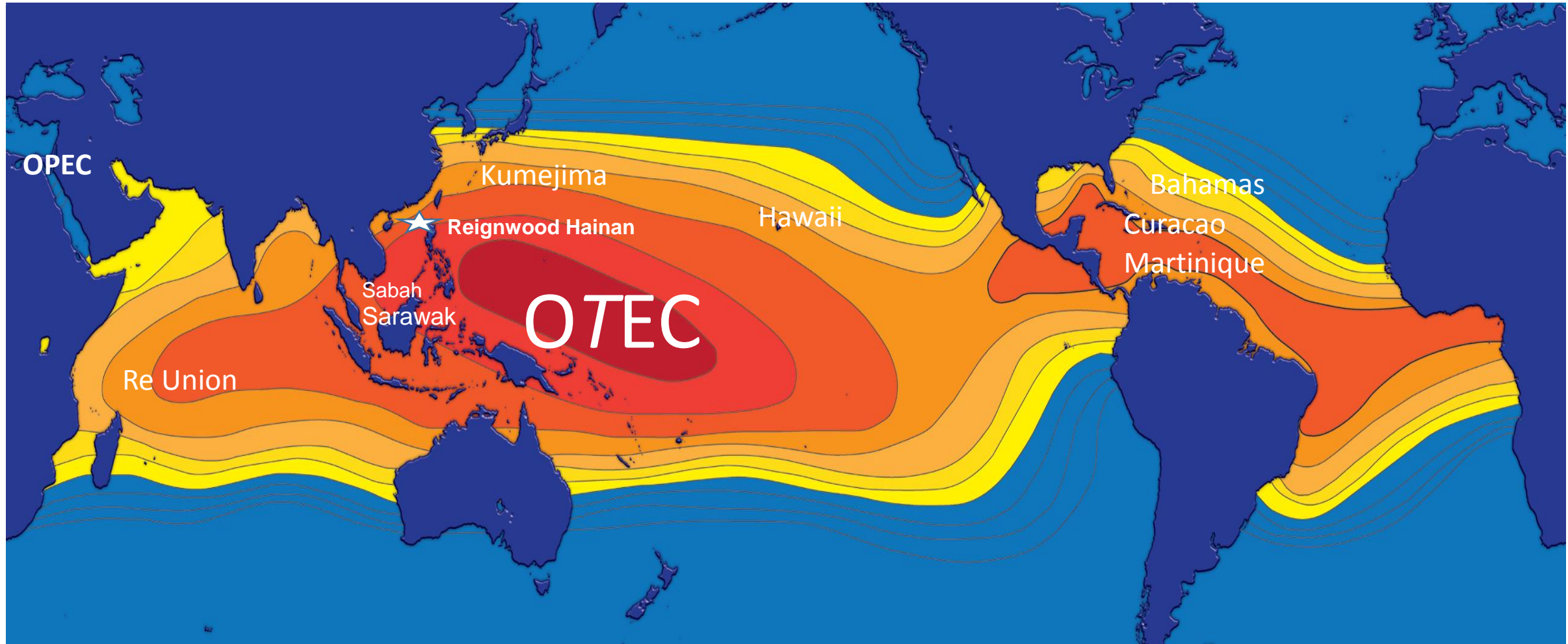


Off Sabah:

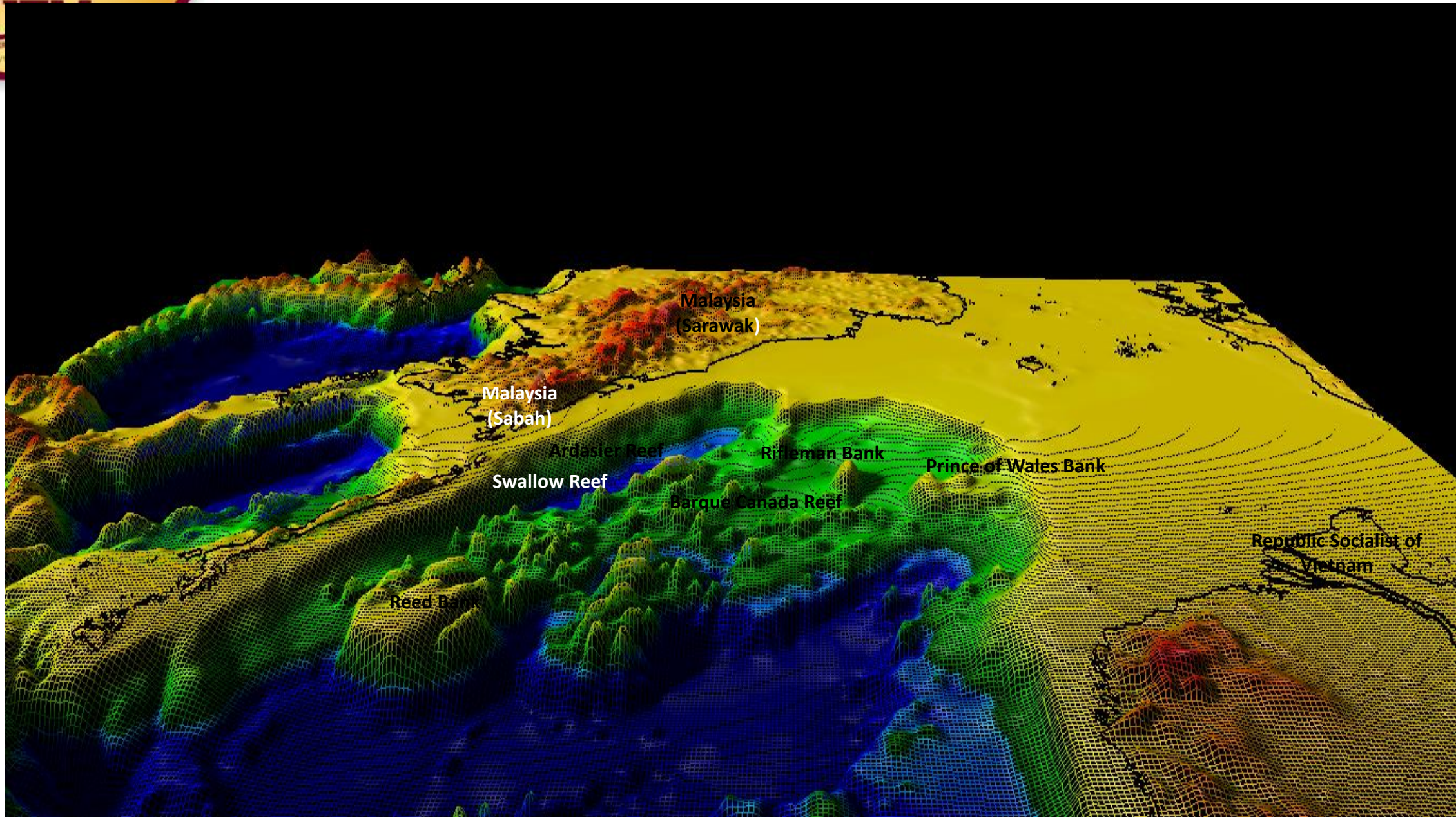
# Temperature-Depth Profile

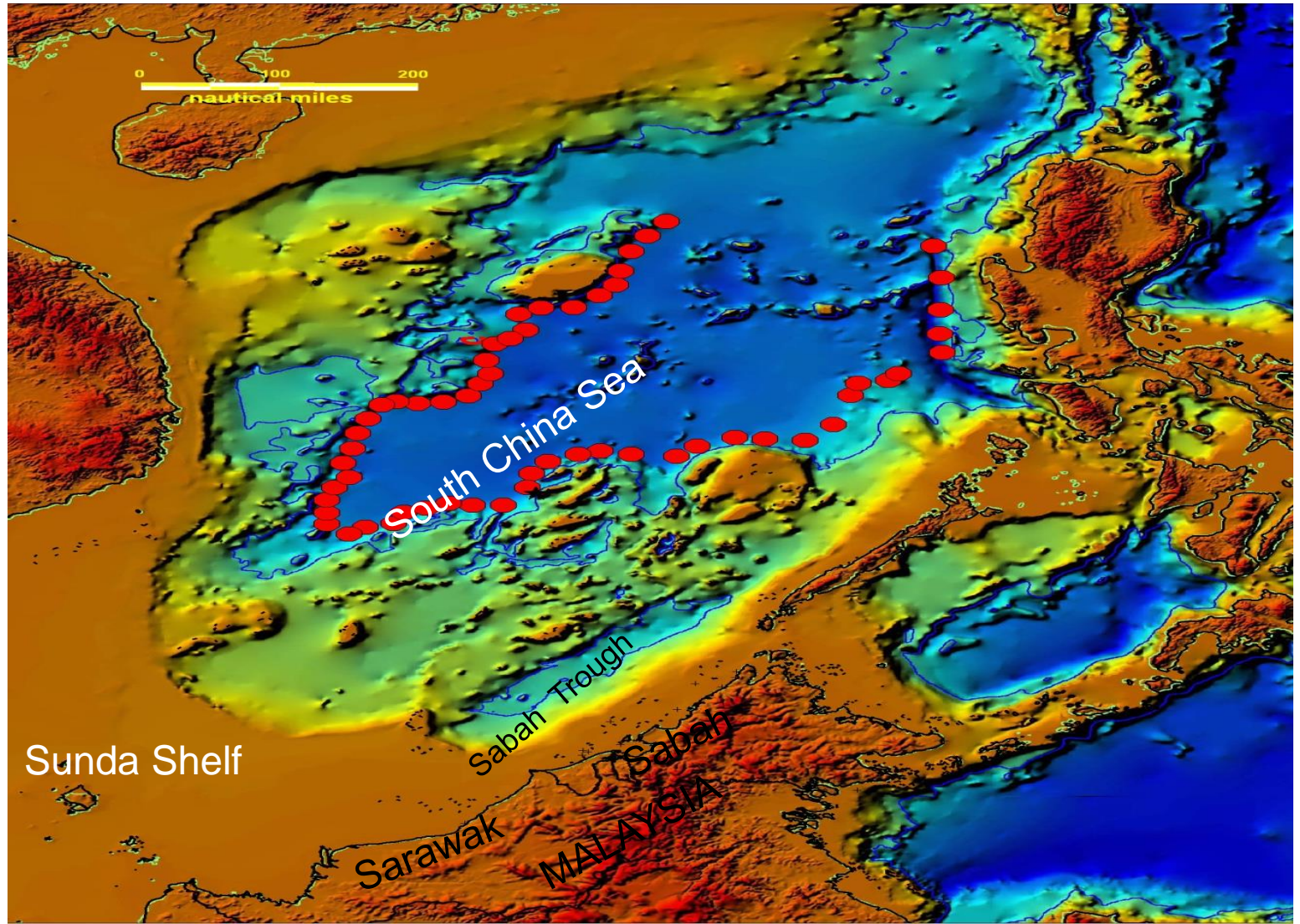


# Global OTEC Potential & Development: From OPEC to OTEC

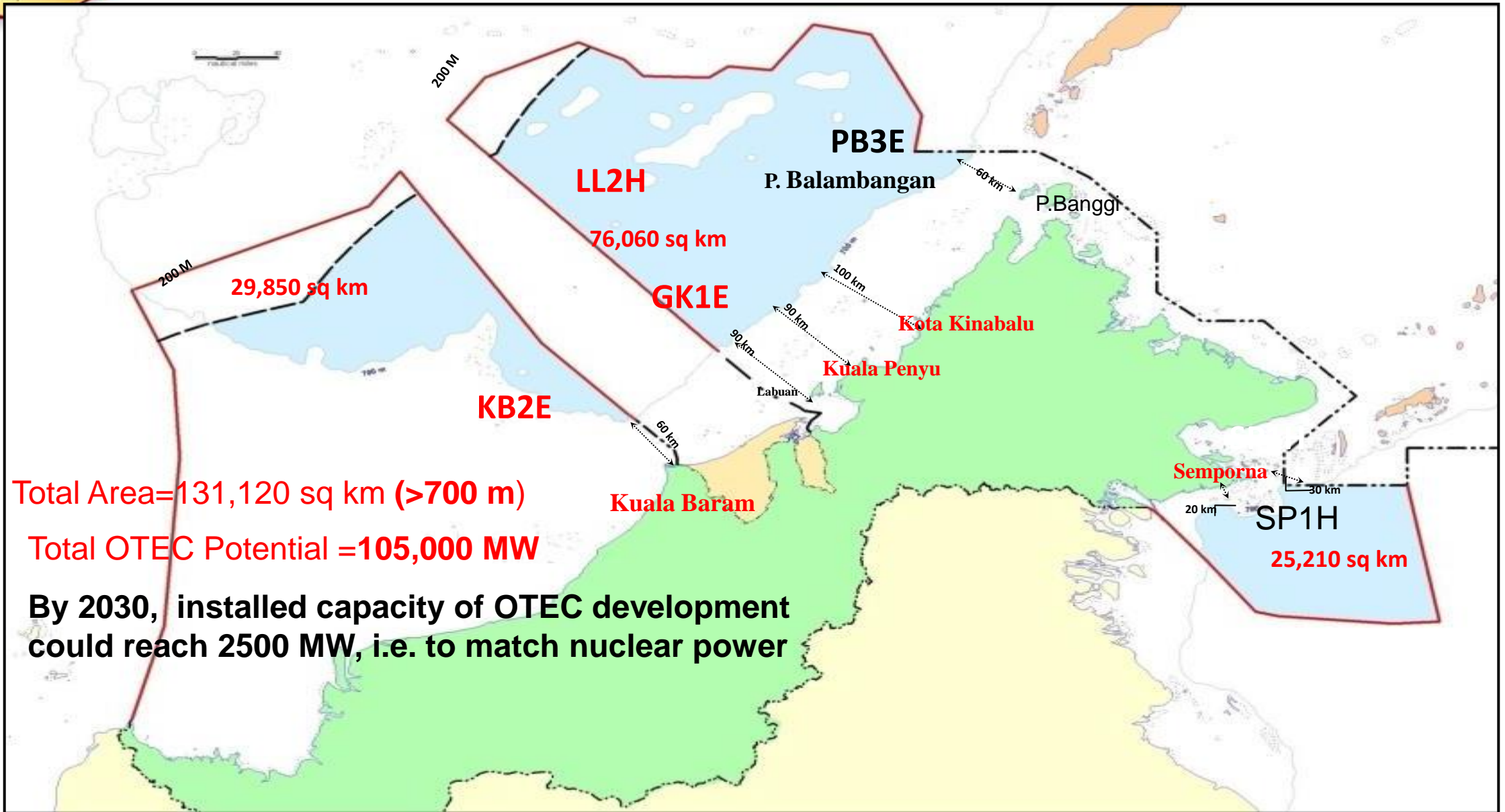


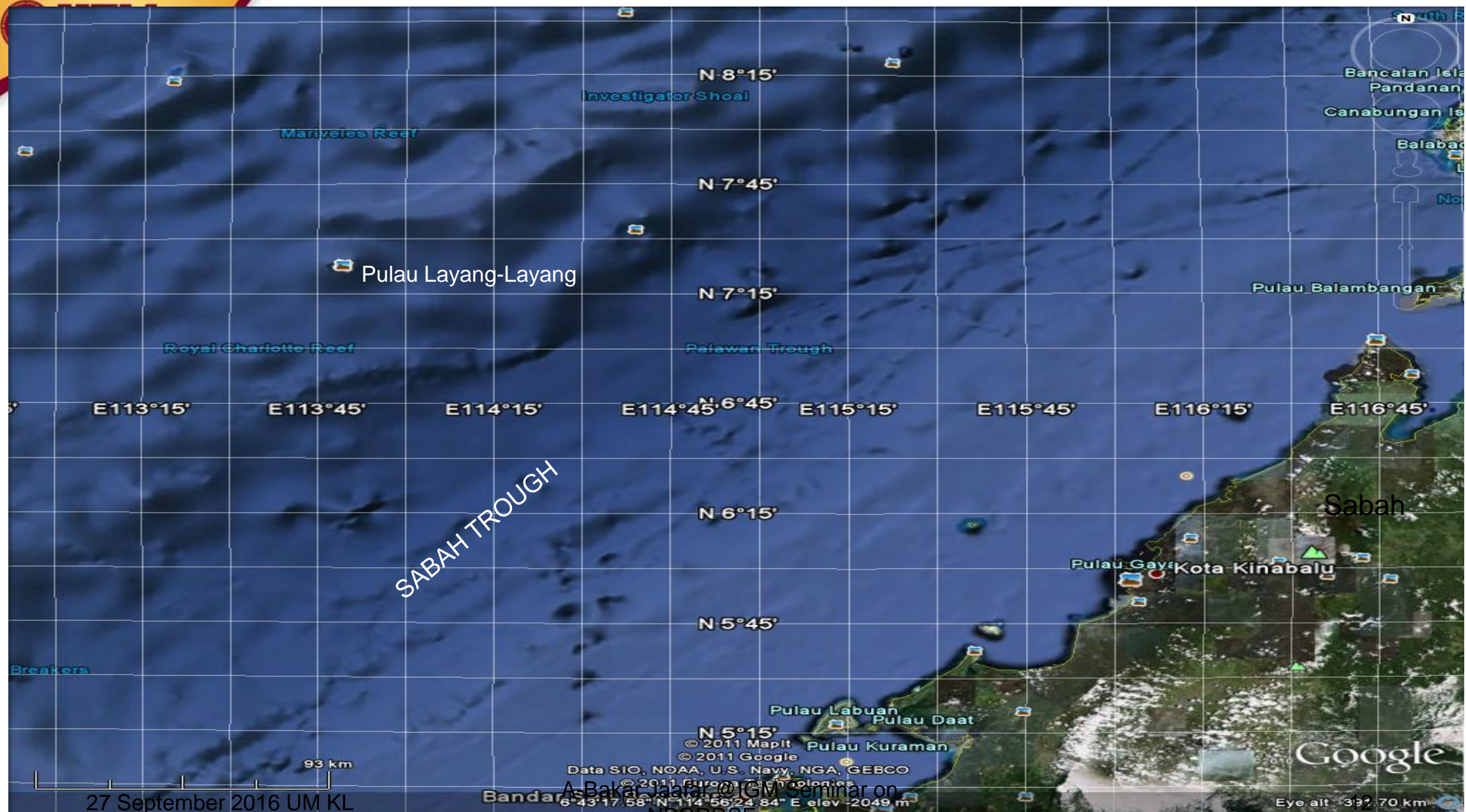






## OTEC POTENTIAL IN MALAYSIA & THE FIRST FIVE OTEC POTENTIAL SITES





27 September 2016 UM KL

Bandar

A. Bakar Jaafar @ IGM Seminar on  
 NPGRRSEnergy

6°43'17.58" N 114°56'24.84" E elev: 2049 m

A PRE-FS being conducted @Pulau Layang Layang funded by DCNS 10.4 million Euro Offset Programme for the 1<sup>st</sup> Pioneer OTEC Plant in Malaysia



**DCNS FIRST OTEC COMMERCIAL OFFSHORE PLANT:  
 NEMO Project**



- 16 MW (gross output) offshore OTEC plant
- To be operating in Martinique island before 2020
- 72 M€ awarded under the NER300 programme by the European Commission

OTEC-Power Generation

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15 | July 2015 | OTEC by DCNS



**OCEAN THERMAL ENERGY CONVERSION TO ELECTRICITY OR HYDROGEN FUEL**



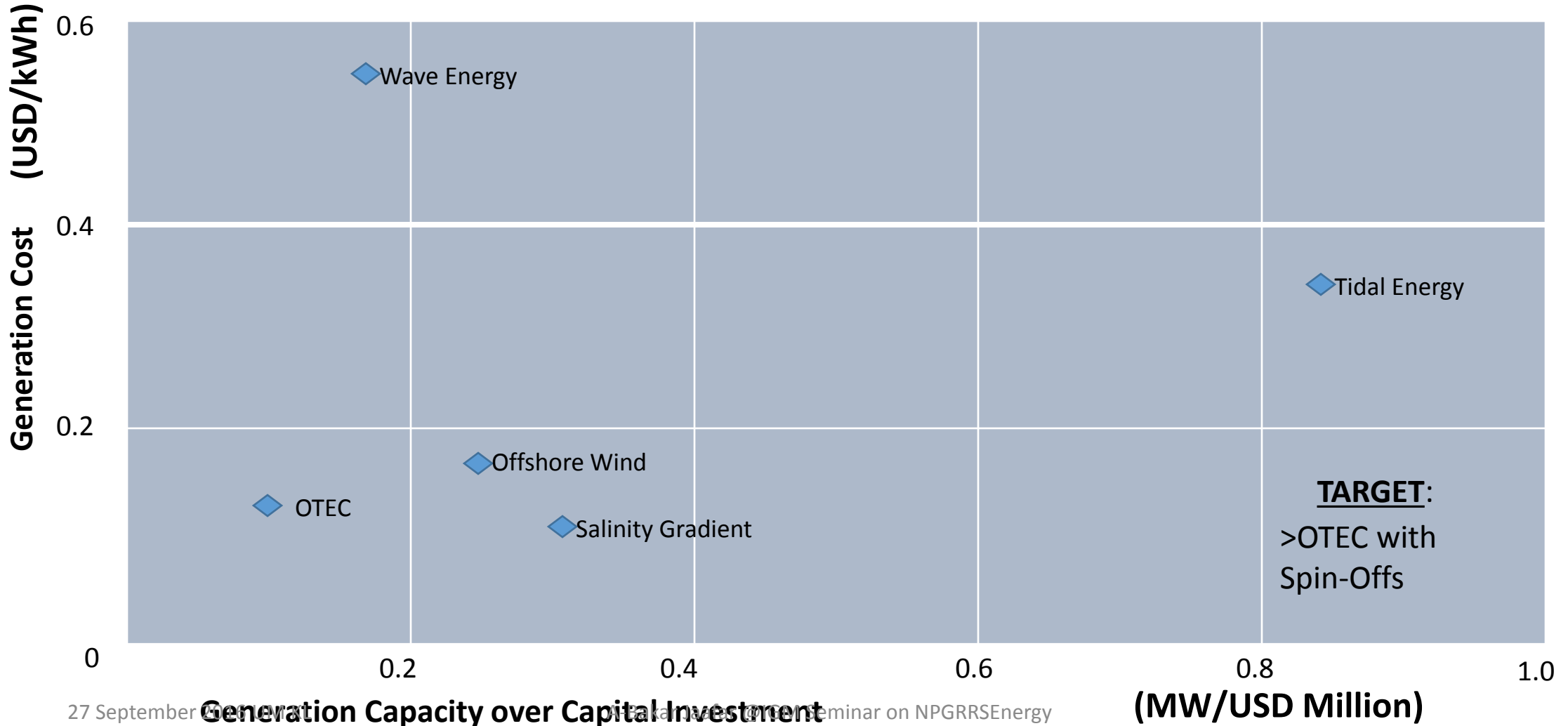
Shimizu- FLOATING CITY

Ocean Energy	Input			Output Cost of Ocean Energy (USD/KWh)
	Generation Capacity (MW)	Capital Investment (Million USD)	MW/Million USD	
Wave Energy	10	62.75	<b>0.16</b>	<b>0.561</b>
Tidal Energy	254	298	<b>0.85</b>	<b>0.28</b>
Offshore wind	10	40	<b>0.25</b>	<b>0.165</b>
OTEC	53	451	<b>0.12</b>	<b>0.13</b>
Salinity gradient	200	600	<b>0.33</b>	<b>0.09</b>

kWh = kilowatt-hour, MW = megawatt

Source: Asian Development Bank Report & IRENA Technology Brief

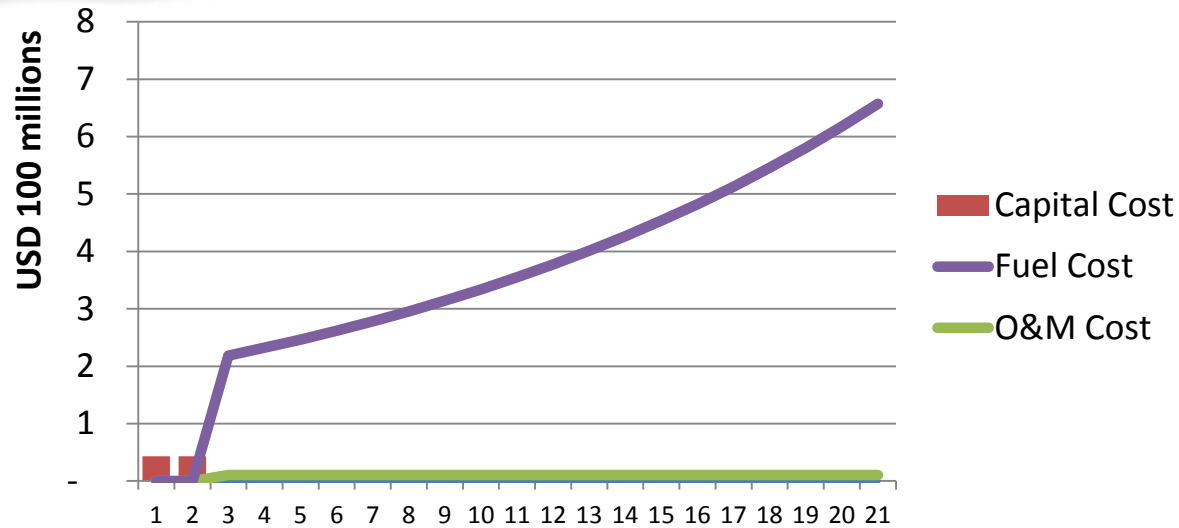
### 3. Ocean Energy Production Cost & Generation Capacity over Capital Investment



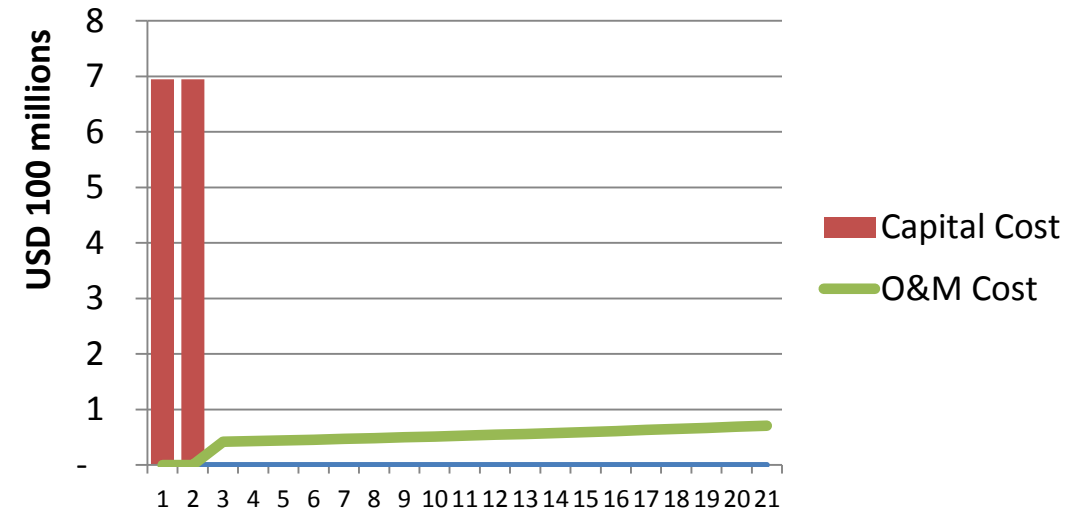


# COMPARATIVE CAPITAL & OPERATING COSTS OVER PROJECT LIFE CYCLE

## 100MW OIL-FIRED POWER PLANT



## 100MW OTEC POWER PLANT



## Total costs (USD) over 21 years of operation

OIL-FIRED POWER	OTEC-POWER
USD 7.5 billion	USD 1.5 billion

# 5

## 4. WAY FORWARD FOR SUSTAINABILITY

- Ocean Energy & 11<sup>th</sup> Malaysia Plan, Already in Place;
- OTEC addressing all the 10 Impactful Focus Areas outlined by National Council for Science & Research
- OTEC-H2 & Fuel-Cell would contribute about one-third of the total power generation capacity by 2050 [Ref: ASM TF-CFE]

## 11<sup>th</sup> MALAYSIA PLAN & OCEAN ENERGY

- The subject of “ocean energy” has been incorporated in 11<sup>th</sup> Malaysia Plan (2016-2020):

### Exploring New Renewable Energy Sources

17.78 Studies will be conducted to identify new RE sources to diversify the generation mix. In the Eleventh Plan, new RE sources such as wind, geothermal and **ocean energy** will be explored. Currently, the national wind mapping exercise is underway and it is expected to be completed by 2016. The exercise will further enable a study on the feasibility of wind energy to be developed. Geothermal potential will also be further explored with the discovery of a 12 square kilometres geothermal field in Apas Kiri, Sabah. Viability of ocean energy will be explored to take advantage of **Malaysia’s geographical position** of being surrounded by sea.

“Ocean Energy”=>

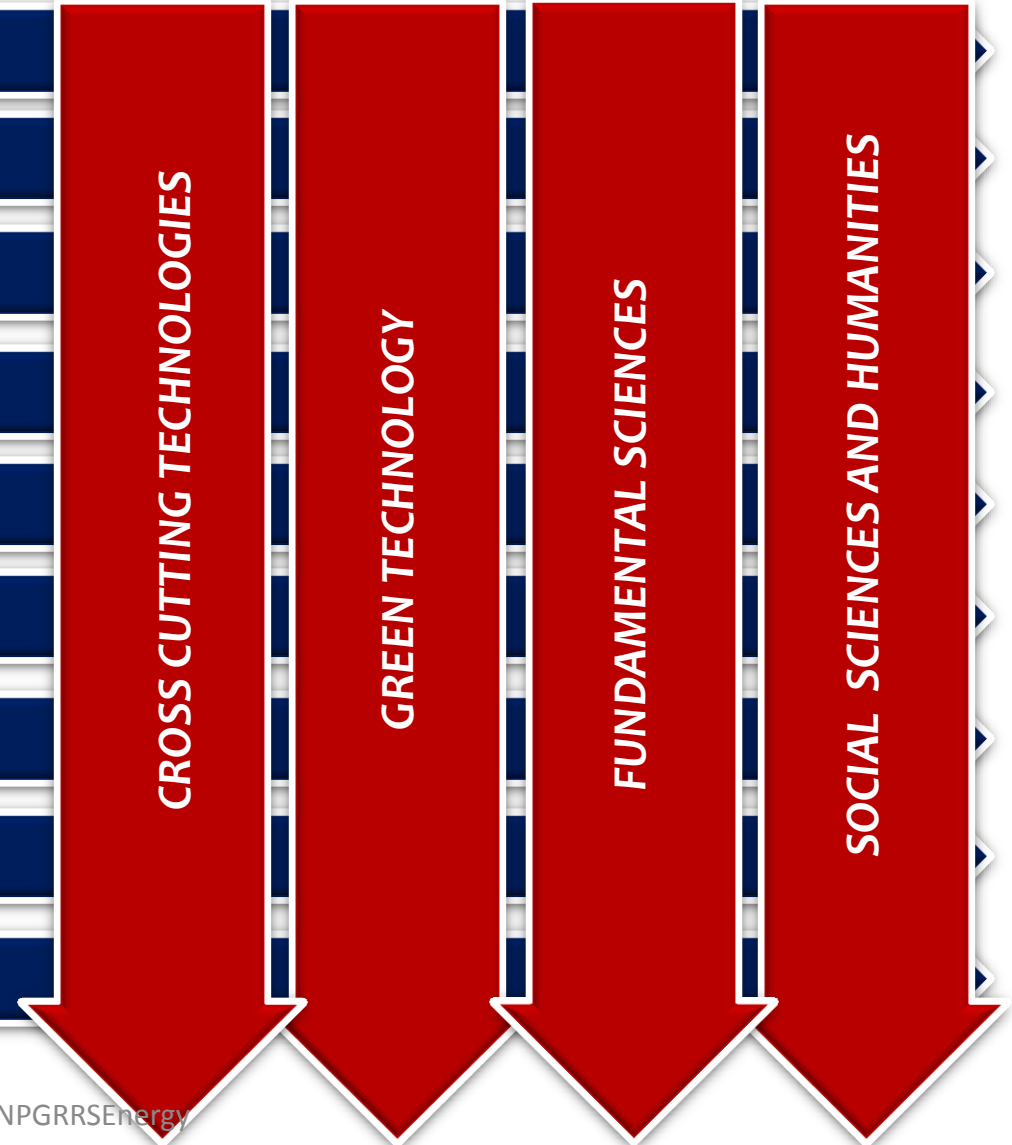
- Ocean thermal energy;
- Offshore wind energy;
- Tidal movements;
- Oceanic current;
- Wave energy; and
- Salinity gradient

# IMPACTFUL FOCUS AREAS

## Issues

9. **BIODIVERSITY**
7. **CYBER SECURITY**
1. **ENERGY SECURITY**
8. **ENVIRONMENT & CLIMATE CHANGE**
3. **FOOD SECURITY**
5. **MEDICAL & HEALTHCARE**
4. **PLANTATION CROPS & COMMODITIES**
6. **TRANSPORT & URBANISATION**
2. **WATER SECURITY**

## Enablers



# OTEC SPIN-OFF INDUSTRIES FOR WATER, FOOD, & RENEWABLE ENERGY FOR SUSTAINABILITY

Temperate Produce



“Import Substitutions”

High Value Produce



Capture-Fisheries

Health & Cosmetics



Ms Earth Japan, 2012

Lithium Production

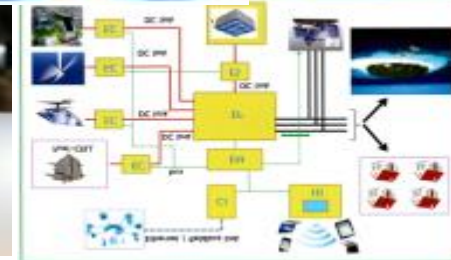


Picture 5: Lithium extraction facility

Mineral H<sub>2</sub>O

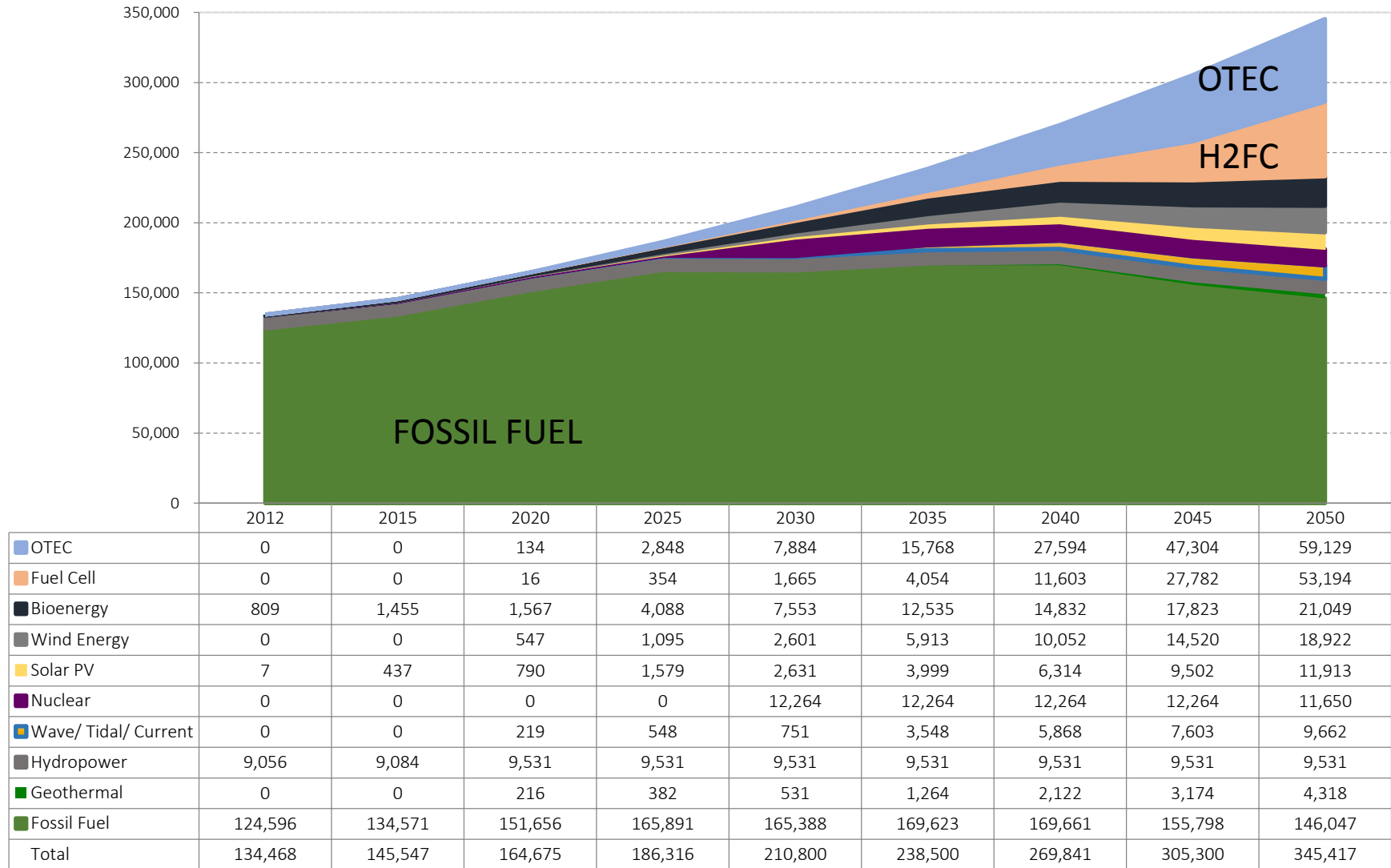


OTEC-H2



Smart-Grid  
With all  
Renewables

## Malaysia: Projected Electricity Generation by Energy Source (GWh) 2012-2050



Source: ASM Task Force on Carbon Free Energy (2015)



Our Vision:  
From Three Columns of Knowledge to  
Three Towers of Prosperity  
for Sustainable Future

**OCEAN OF DISCOVERY**  
**KNOWLEDGE & THE SOURCE OF KNOWLEDGE**

*(Al-Quran 24:40; 18:109; 31:27)*

**TERIMA KASIH**

**GRACIAS**

**MERCI**

**SPASBO**

**SYUKRAN**

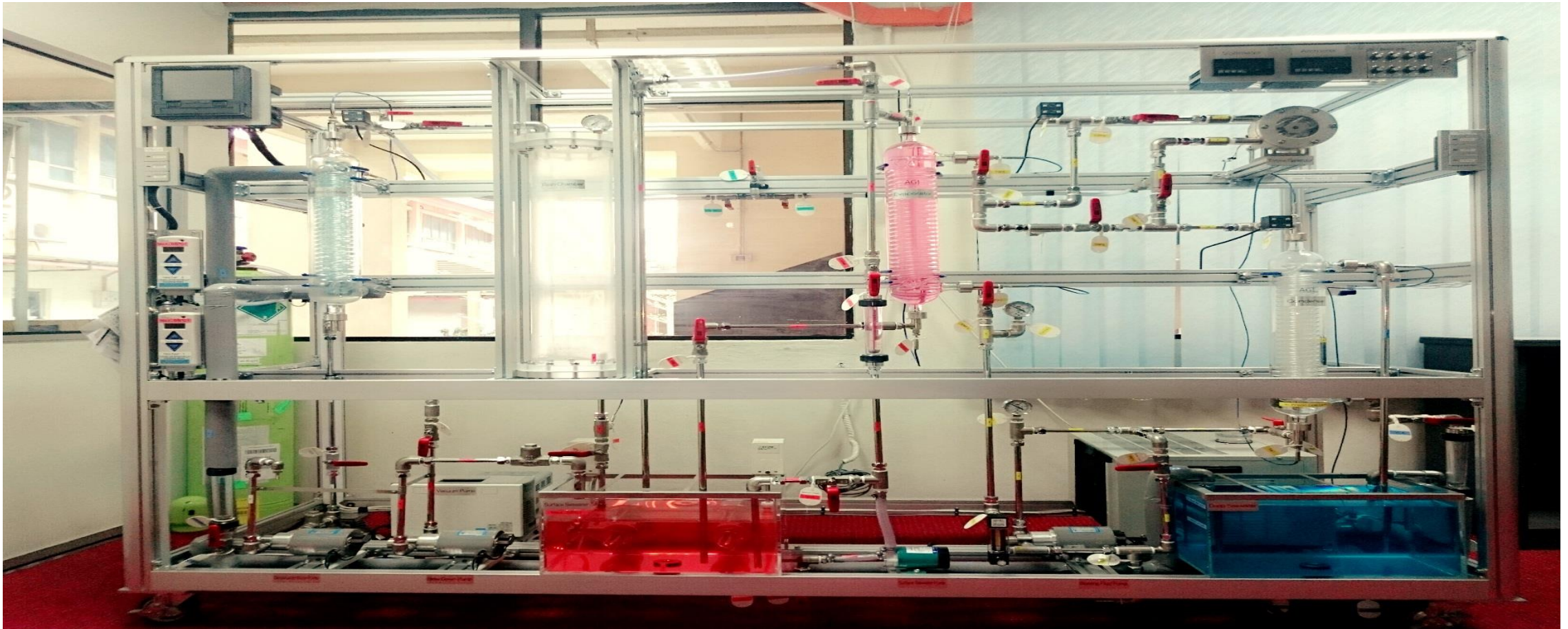
**THANK YOU**

**XIE-XIE**

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# 3W Micro-OTEC @UTM OTEC Block Q Commissioned on 22 May 2015





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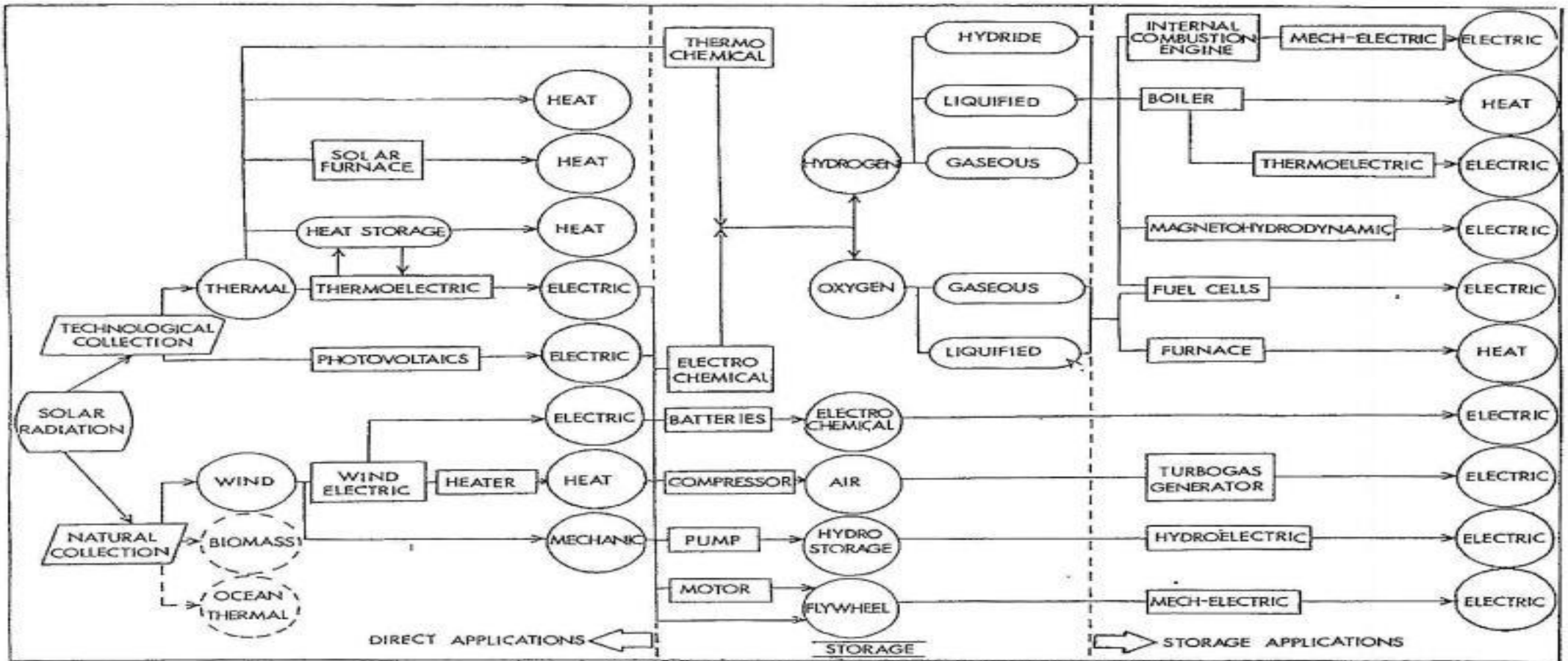


Figure 8 Solar and Wind Energy Technological Options

[Ref: Abu Bakar Jaafar (1976). "Applicability of Solar Energy Technology for Industrial Pollution Control and Production: The Case of the Primary Copper Smelting Industry". An Internship Report. Submitted to the Faculty of Miami University in partial fulfillment of the requirements for the degree of Master of Environmental Science Institute of Environmental Sciences. Oxford, Ohio. P.82]

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