IEA Committee on Energy Research and Technology
EXPERTS' GROUP ON R&D PRIORITY-SETTING AND EVALUATION

Island Energy – Status and Perspectives

The Advanced Technology and Future Prospect of OTEC for Island

- towards to Stable Energy and Sustainable Development -

October 6, 2015

Institute of Applied Energy (IAE)
Tokyo, Japan,
5-6 October 2015

Yasuyuki Ikegami
ikegami ◎ cc.saga-u.ac.jp
Institute of Ocean Energy, Saga University(IOES), JAPAN

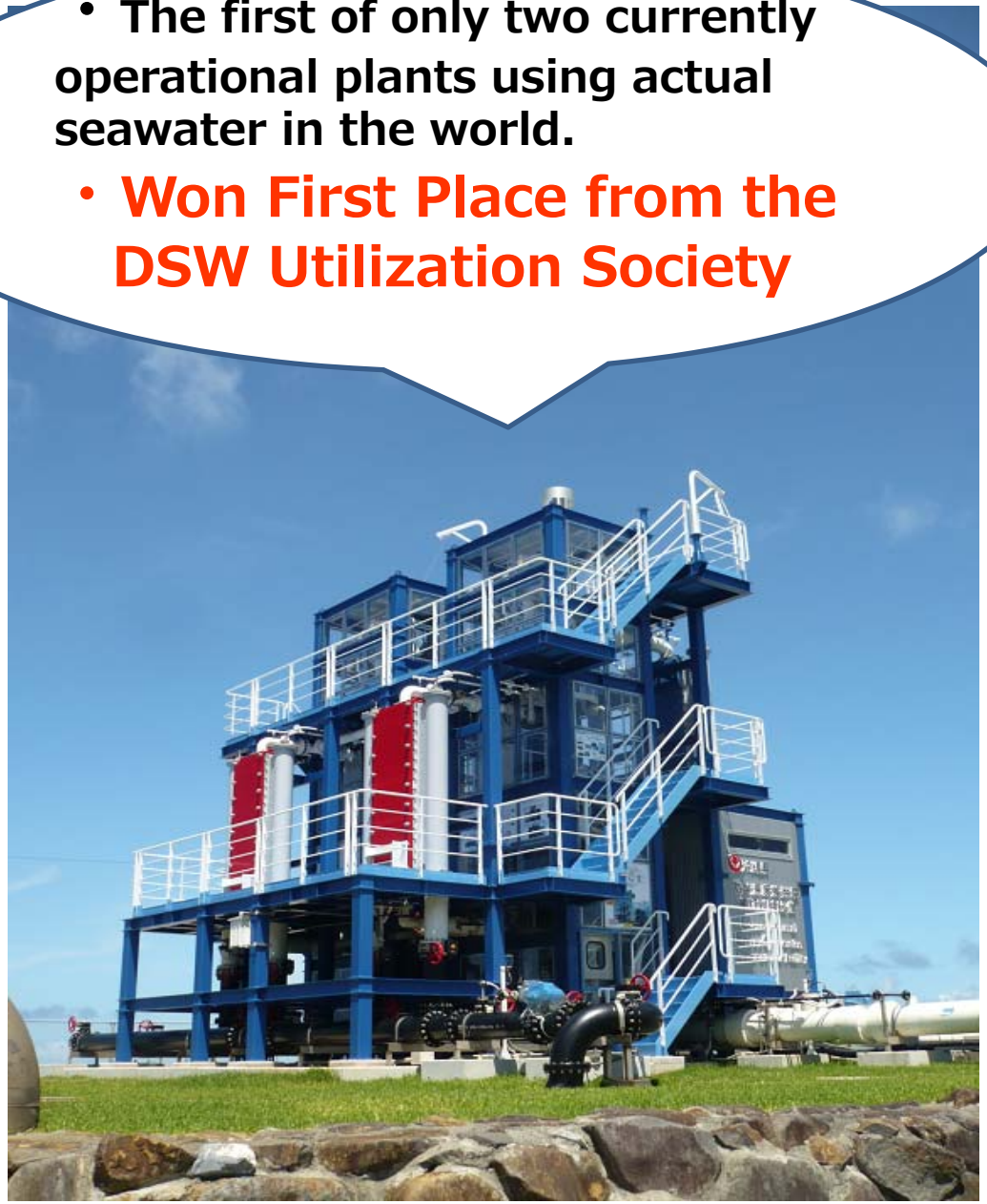

Go to NEW STAGE (Re START) of
Real OTEC Technology to
connect the electric grid
for the first time in 15 years
in the world.

Overview of Okinawa's OTEC Demonstration Facility

1 Appearance

Okinawa DSW Research Institute
(Maja District, Kumejima)

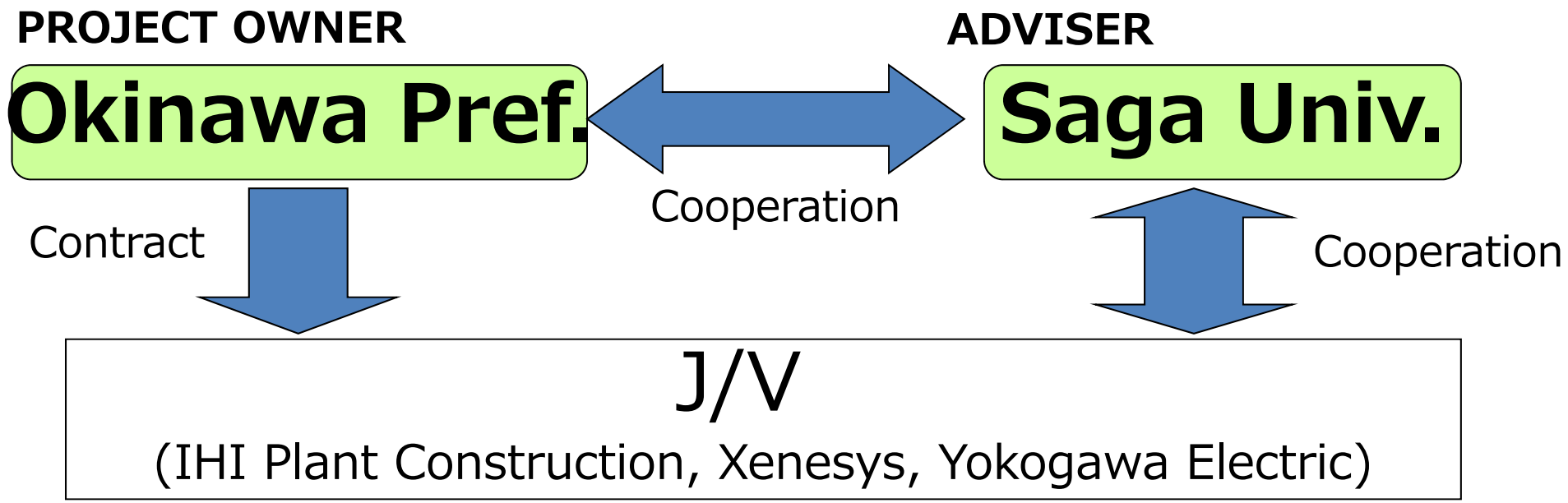
- **The first of only two currently operational plants using actual seawater in the world.**
- **Won First Place from the DSW Utilization Society**



Okinawa Prefecture OTEC Demonstration Facility
(Inside the Okinawa DSWRI)
Photo Credit : Okinawa Prefecture

OTEC Demonstration Facility in Kumejima (Okinawa)

Project Scheme

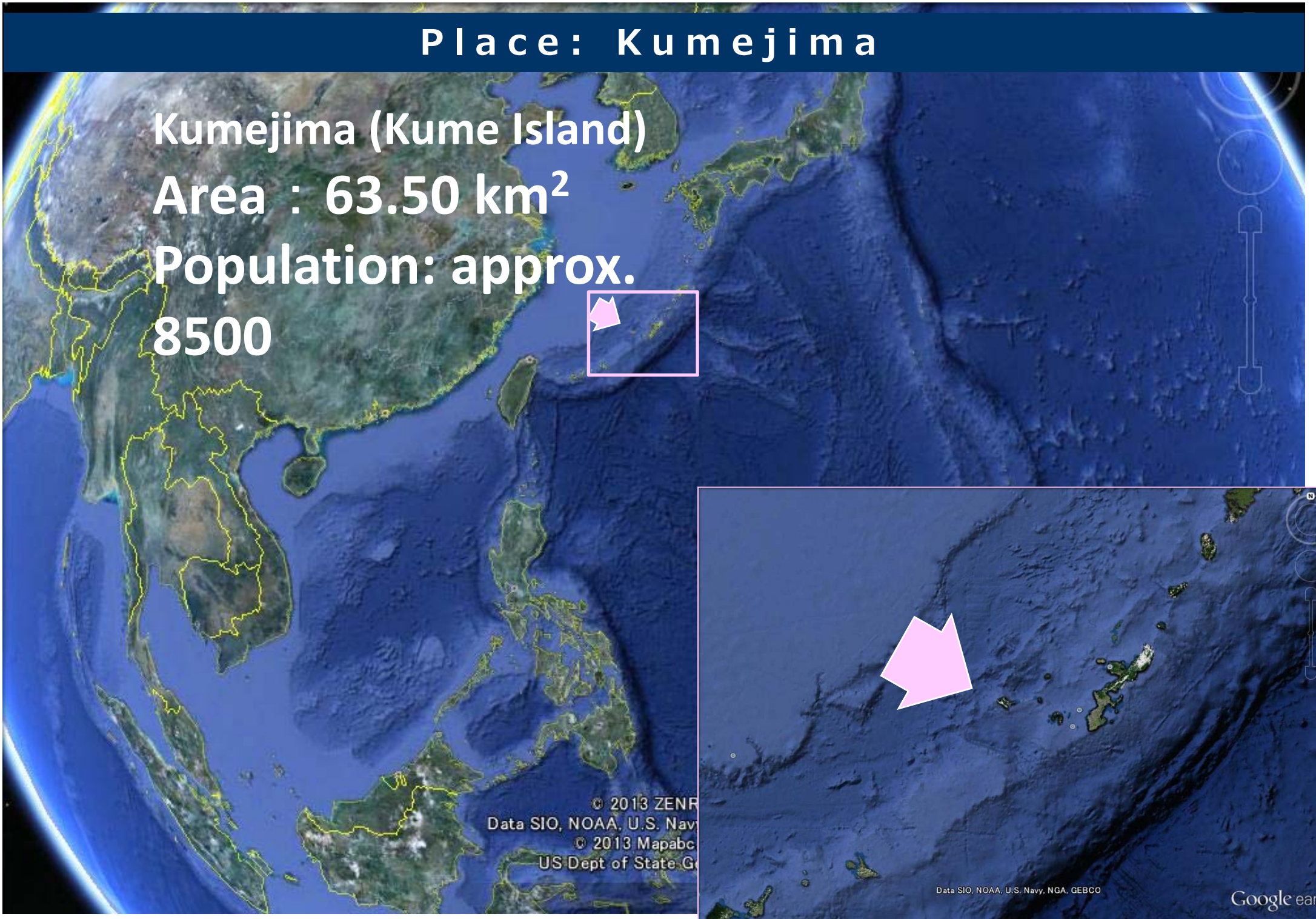


Schedule

FY2012 (-March 2012): Construction of Demonstration Facility

FY2013-16 (April 2013 -March 2017): Continuous Operation and Experiment

Place: Kumejima



Okinawa Prefectural Deep Sea Water Research Center and Business Park

DSW Pump-up Capacity: 13,000 ton/day, the Largest Capacity in Japan.

Overview of Deep Seawater Utilization on Kumejima

Renewable Local Resources: Industrial Development Taking Advantage of Deep Seawater.

Okinawa Deep Seawater Research Institute (2000～)

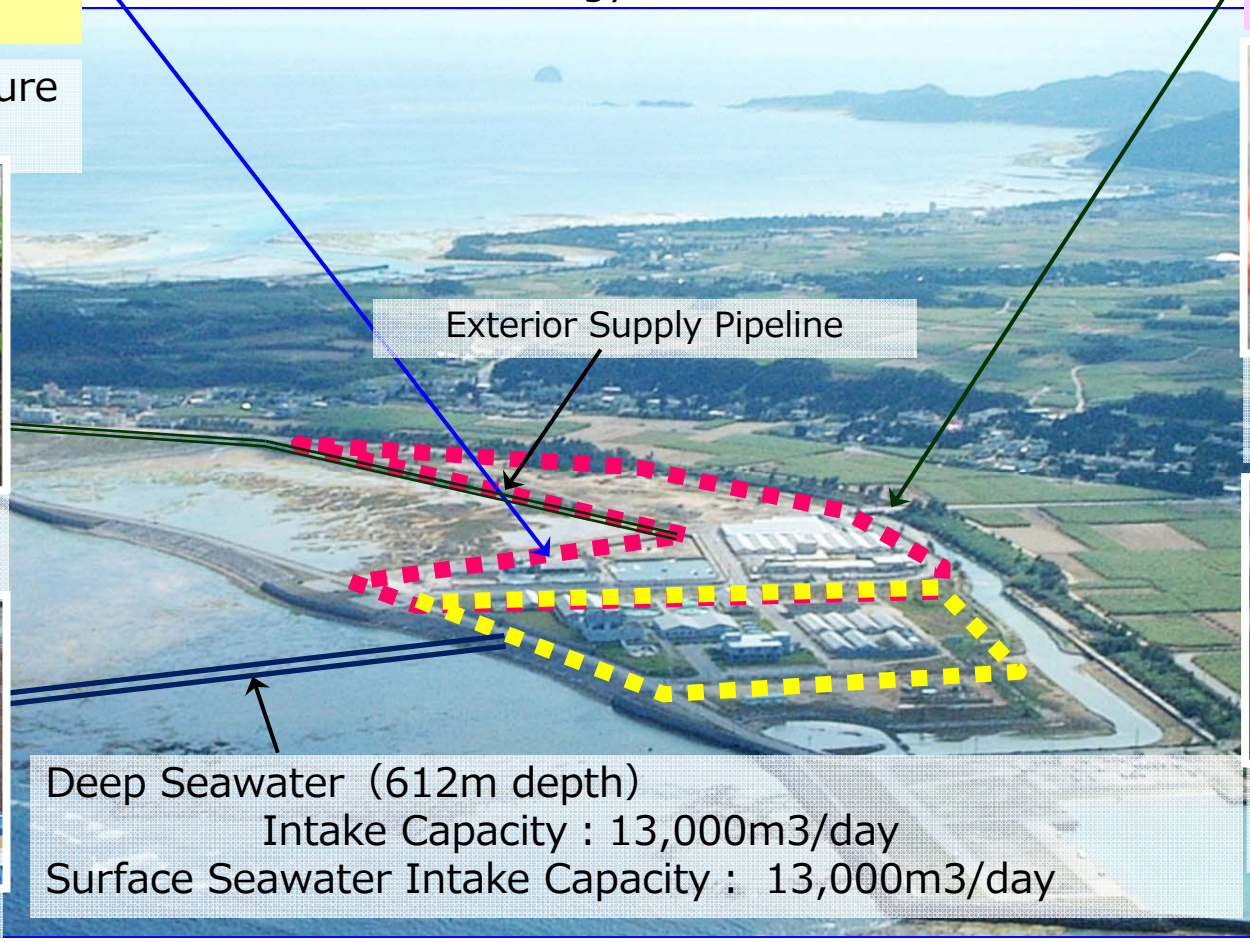
Technology Transfer

Deep Seawater Use Companies

Aquaculture and Agriculture Research Facilities

Cooled Soil Agriculture Research

Aquaculture Research



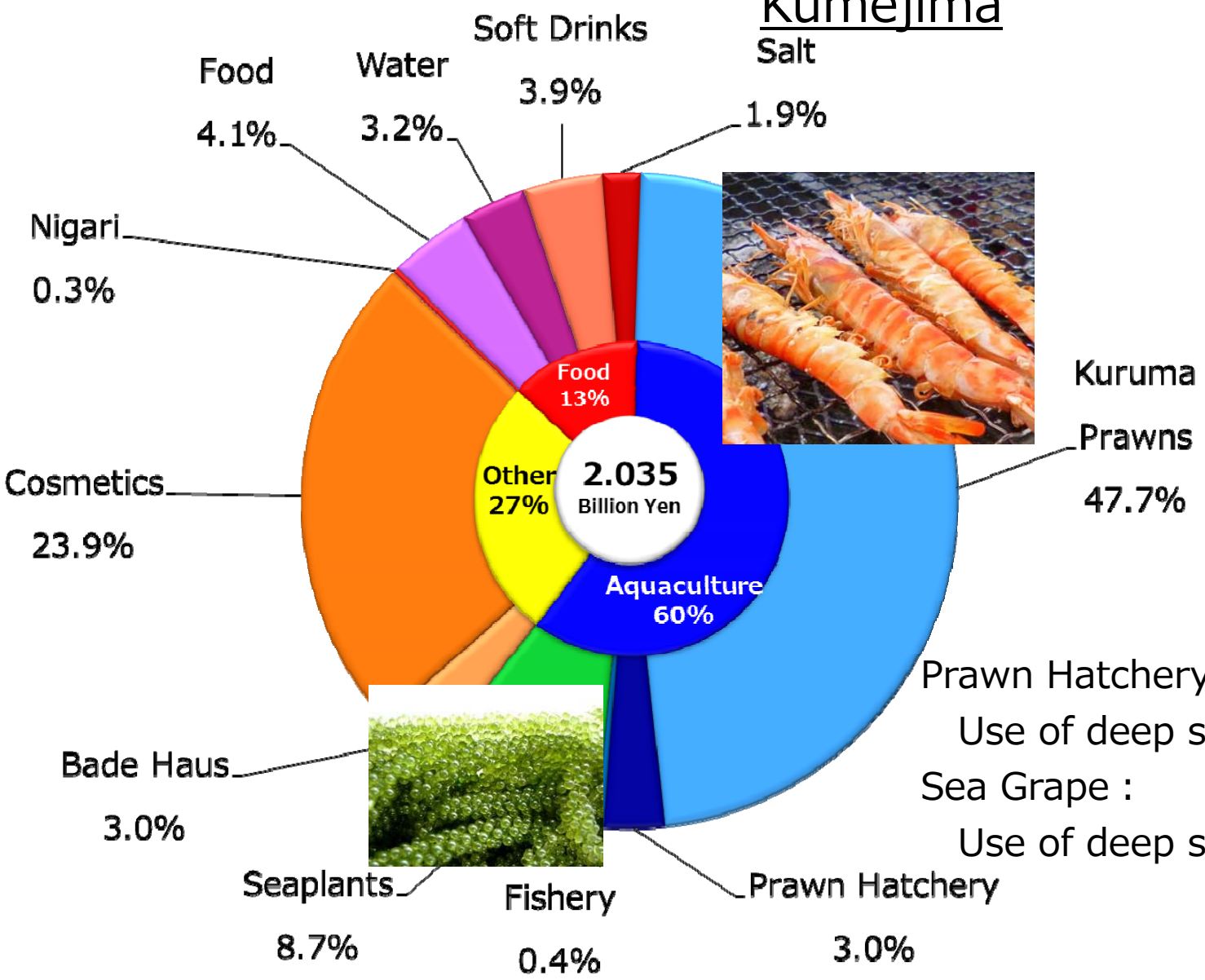
Sea Grapes (#1 Share in Japan)

Kuruma Prawn (#1 Share in Japan)

- 18 deep seawater related companies with annual production of 2 billion yen. With nearly 300 employees, it has become a major industry for Kumejima.
- Industries that use the largest water volume (Sea Grapes and the Kuruma Prawn Hatchery) both use the cold deep seawater in place of energy.

Deep Seawater Use as a Regional Resource…
Excellent Industrial Promotion Effect

Current State of Industrial Development Due to Deep Seawater Use on Kumejima



Kumejima's Main Industry

2 billion yen in sales of deep seawater-related companies each year. Employment of about 300 people in Kumejima Town (140 new jobs from intake start). Seawater utilization industries have become the major industry on the island. (Kumejima Town has the largest market share in Japan for sea grapes and kuruma prawn).

Prawn Hatchery Production :

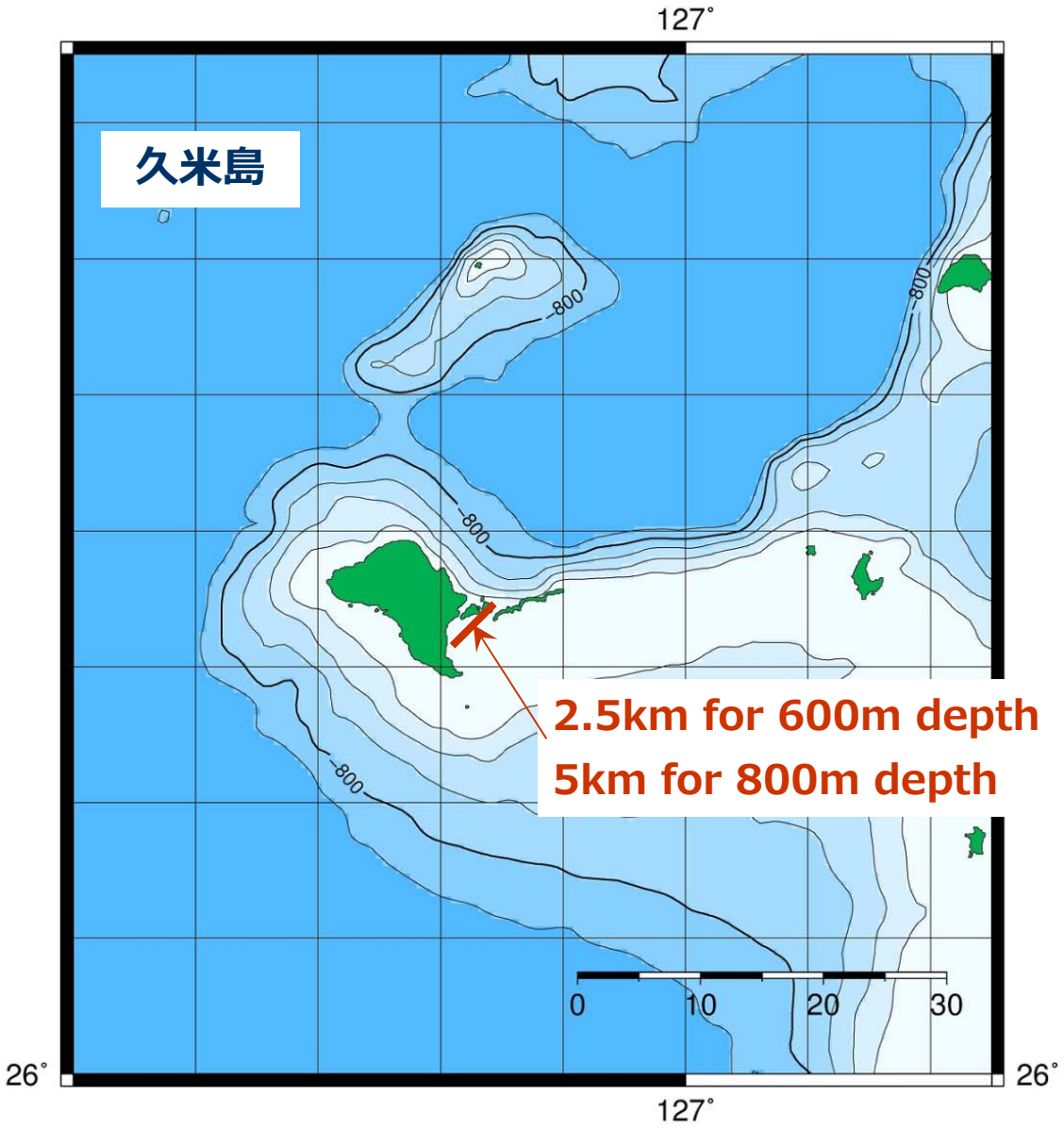
Use of deep seawater cold and cleanliness.

Sea Grape :

Use of deep seawater cold and eutrophication

Source: "Advanced Deep Seawater Use Feasibility Study" Report March 2011 Kumejima Town

Kumejima as OTEC Site



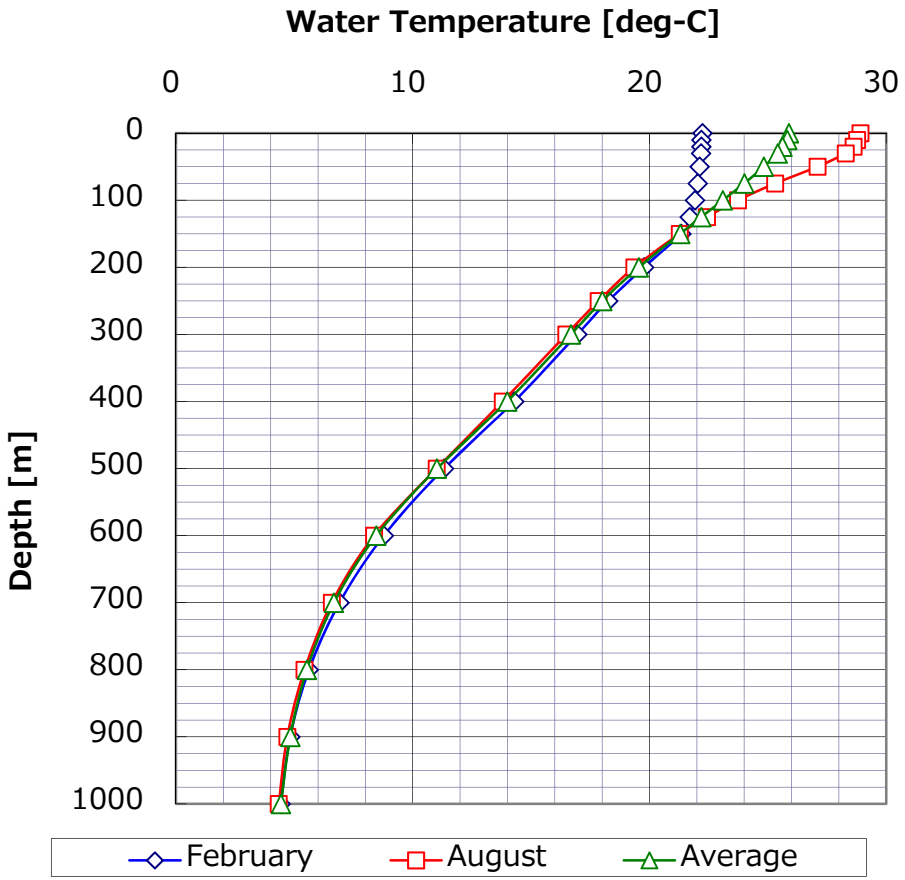
Kumejima Electricity

Population: **approx. 8.500**

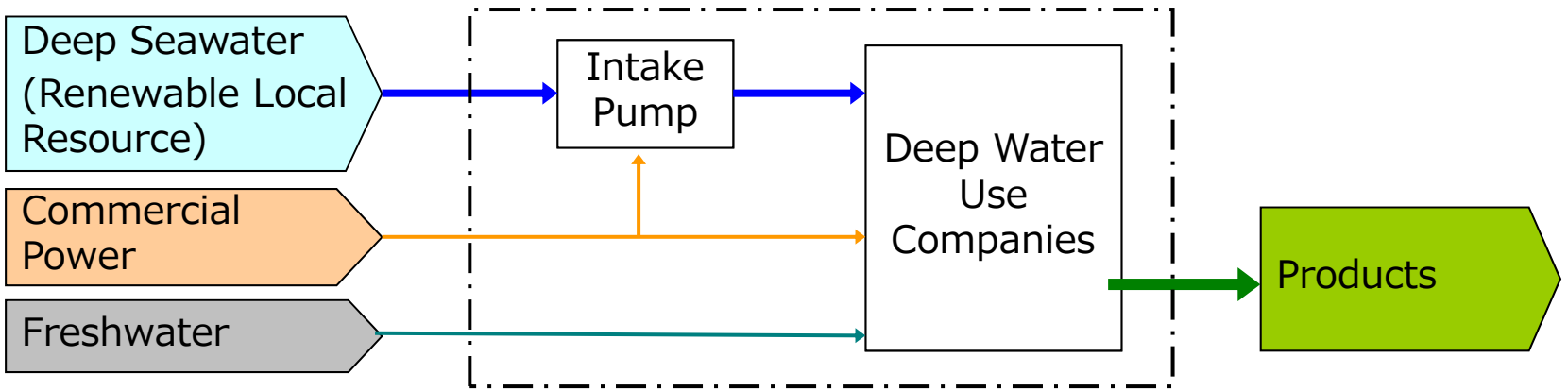
Power Plant: Kumejima Power Plant

Capacity **18,500kW**

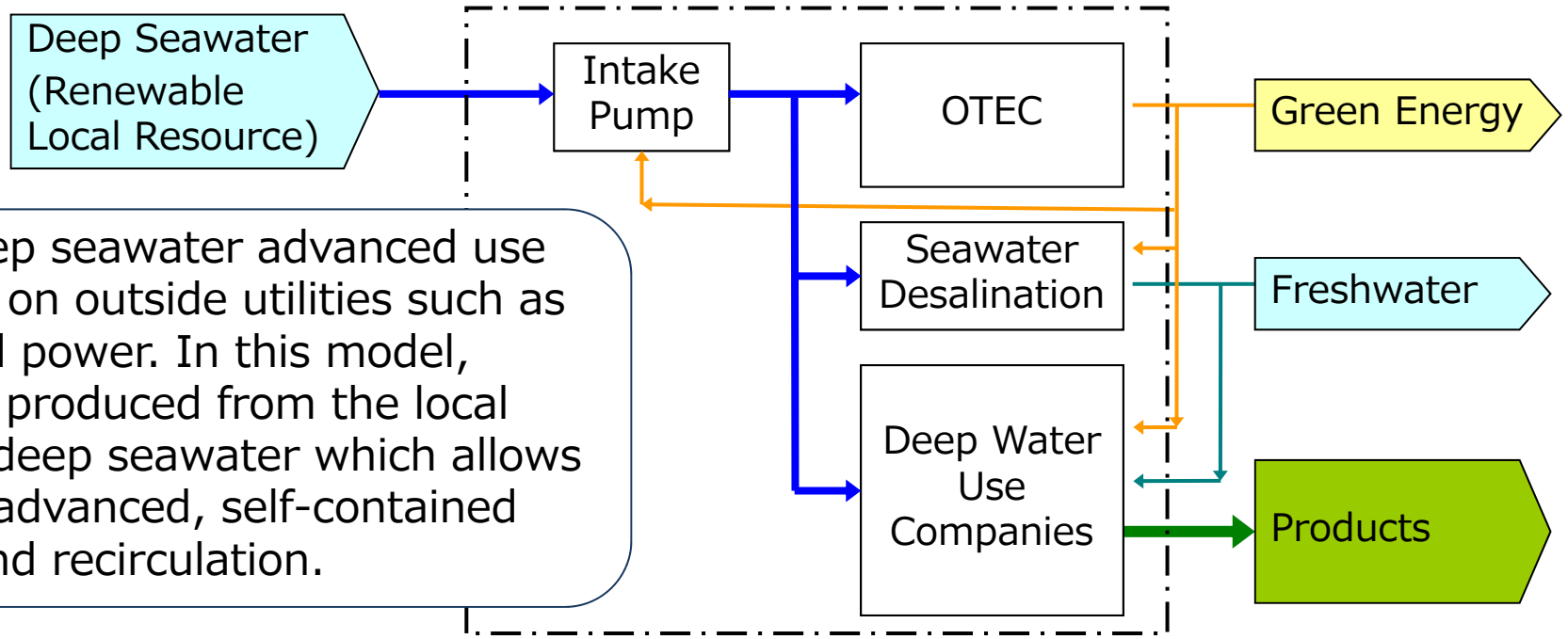
Diesel Engine Generator (HFO)



Aim of the “Kumejima Model”



Deep Seawater Use until Now

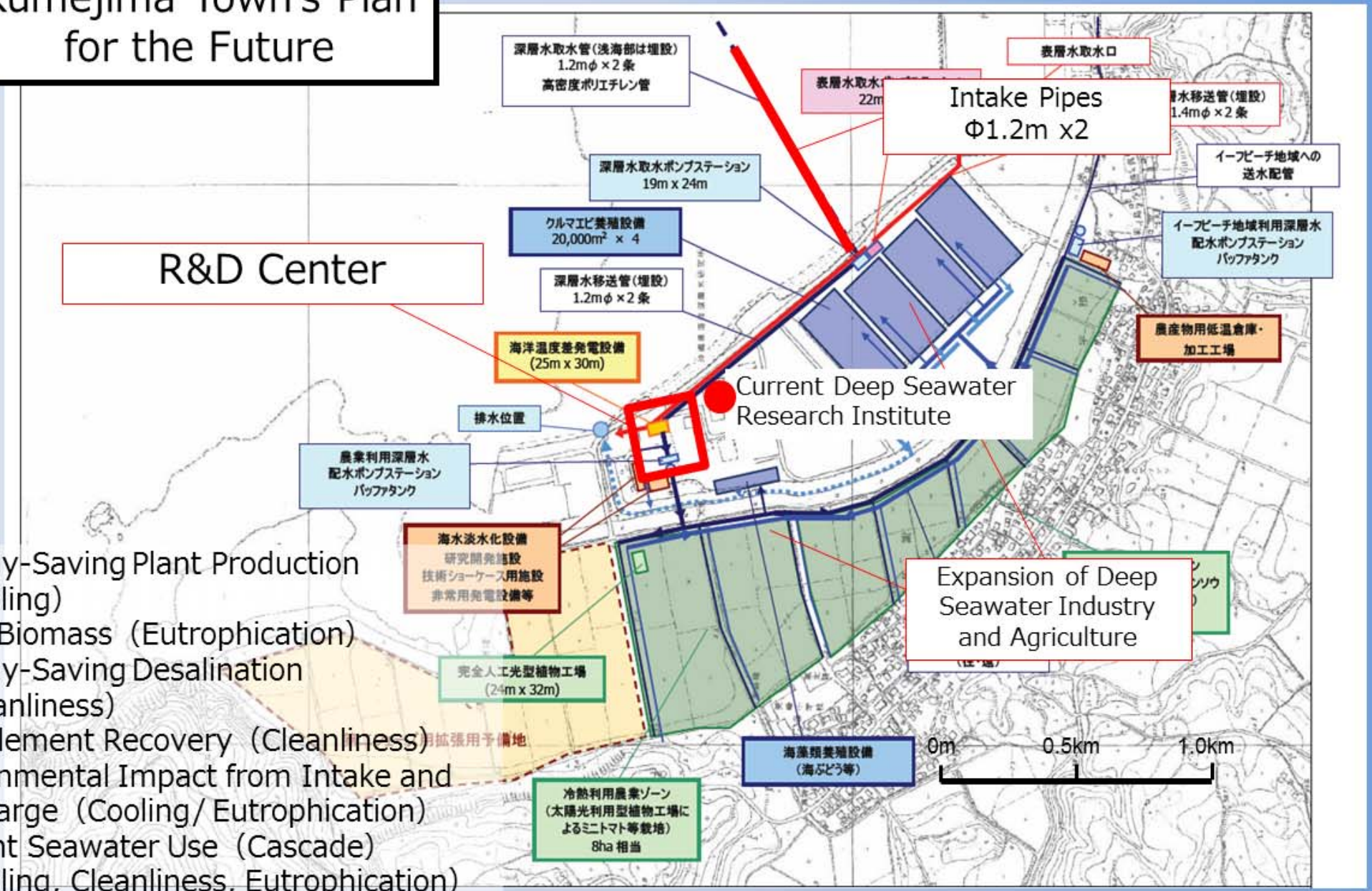


So far deep seawater advanced use must rely on outside utilities such as water and power. In this model, these are produced from the local resource deep seawater which allows for more advanced, self-contained system and recirculation.

Recycling/Self-sufficient Advanced Deep Water Use (example)

""The Kumejima Model""

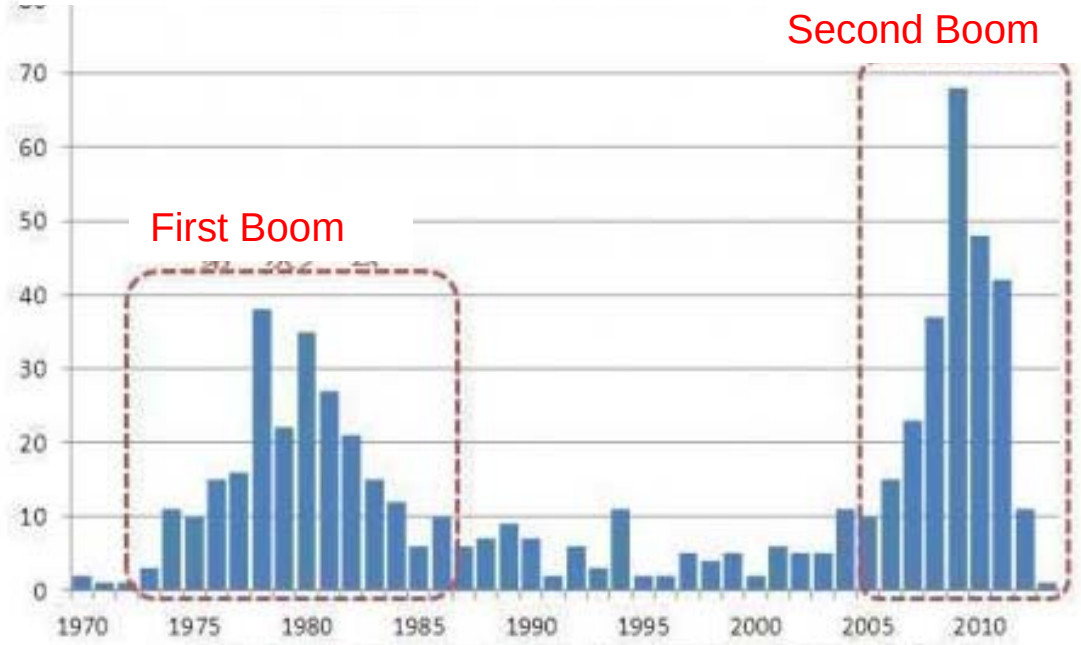
Kumejima Town's Plan for the Future



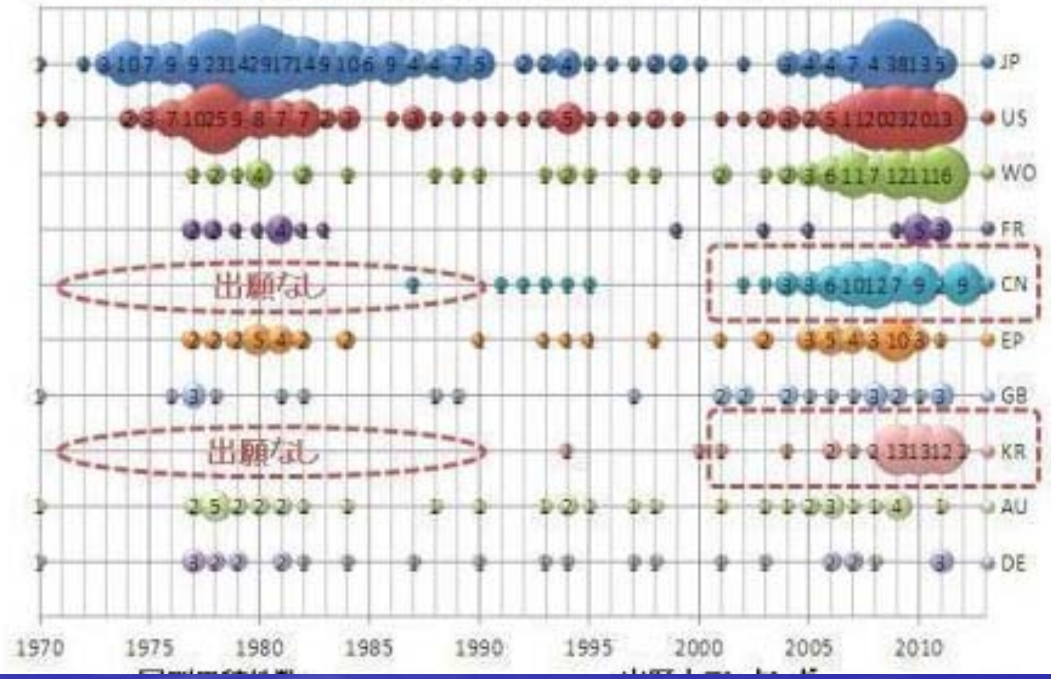
- Energy-Saving Plant Production (Cooling)
- Algal Biomass (Eutrophication)
- Energy-Saving Desalination (Cleanliness)
- Rare Element Recovery (Cleanliness)
- Environmental Impact from Intake and Discharge (Cooling/ Eutrophication)
- Efficient Seawater Use (Cascade) (Cooling, Cleanliness, Eutrophication)
- etc.

The full report can be downloaded in Japanese from the Kumejima Town W

Patent on OTEC in the World



海洋温度差発電の国別件数推移（バブルサイズ：ファミリ数、横軸：最先優先年）



BIG Second Boom of OTEC seen from the point of view of Patent!

国別累積件数

出願国/地域		件数
JP	日本	432
US	米国	326
WO	PCT	162
FR	フランス	109
CN	中国	97
EP	欧州	87
GB	イギリス	75
KR	韓国	58
AU	オーストラリア	58
DE	ドイツ	42

出典：
日本技術貿易
株式会社

USA

Prototype Plant to be First Project in the Multi-Billion Dollar Clean Energy Agreement

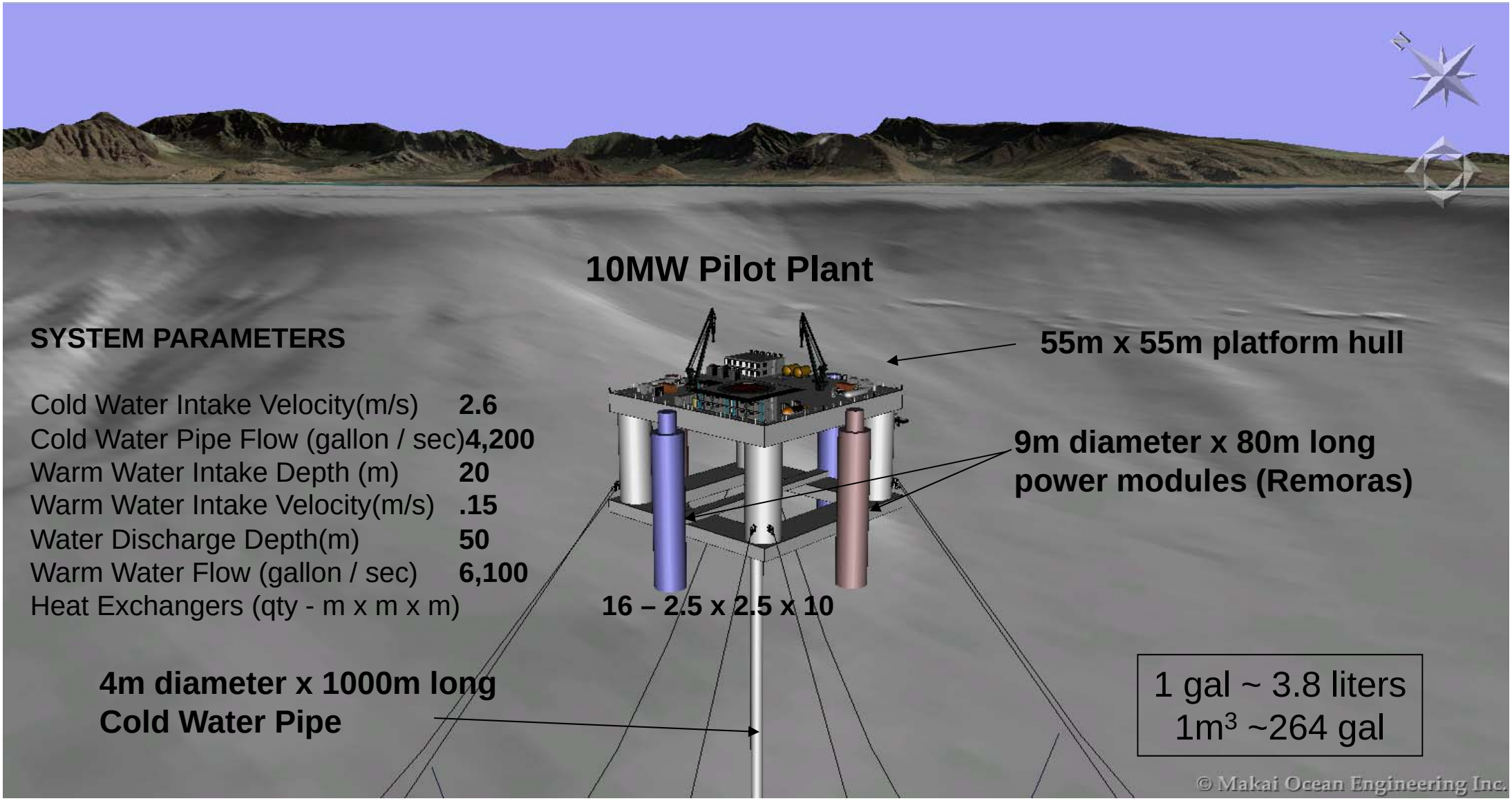
BALTIMORE, April 16, 2013 – Lockheed Martin [NYSE: LMT] has announced that it is working with Reignwood Group to develop an Ocean Thermal Energy Conversion (OTEC)pilot power plant off the coast of southern China. A memorandum of agreement between the two companies was signed in Beijing on Saturday.

Following the ceremony, both companies met with United States Secretary of State John Kerry during his first official state visit to the People's Republic of China.

The 10-megawatt offshore plant, to be designed by Lockheed Martin, will be the largest OTEC project developed to date, supplying 100 percent of the power needed for a green resort to be built by Reignwood Group.

Quoted From: http://www.lockheedmartin.com/us/news/press-releases/2013/april/lockheed-martin-and-reignwood-group-to-develop-ocean-thermal-ene.html

Getting a Feel for an OTEC Plant



From

USA

Reference: Presentation at International OTEC Symposium 2013

↑Large evaporator/condenser experimental facility was building 2011 at NELHA in Hawaii. (source: company website)

4m intake pipe model

Picture： Company Development Report

USAで始まる本格的なOTECプラントの運転　8月21日

World's Largest Ocean Thermal Power Plant to Connect to the U.S. Grid

Makai is celebrating the completion of the world's largest Ocean Thermal Energy Conversion (OTEC) power plant with a dedication ceremony on August 21st, 2015.

This breakthrough marks the first true closed-cycle OTEC plant to be connected to a U.S. electrical grid, and represents a major achievement for Hawaii, the U.S., and marine renewable energy.

Makai's OTEC power plant will supply 100 kilowatts of power to Hawaii Island, and provide critical testing infrastructure needed to develop and transition OTEC technologies to market.

The ceremony will culminate in "flipping the switch" to deliver its OTEC power to the U.S. grid for the first time.

http://www.makai.com/ocean-thermal-energy-conversion/

2.Freance 10MW Floating and 5MW Onland OTEC

8 JULY 2014: AKUO ENERGY AND DCNS WIN EU FUNDING UNDER THE NER 300 PROGRAM

After a 12-month audit by the European Investment Bank, the NEMO ("New Energy for Martinique and Overseas") project to create a floating Ocean Thermal Energy Conversion (OTEC) facility has been awarded funding as part of the European Commission's NER 300 program.

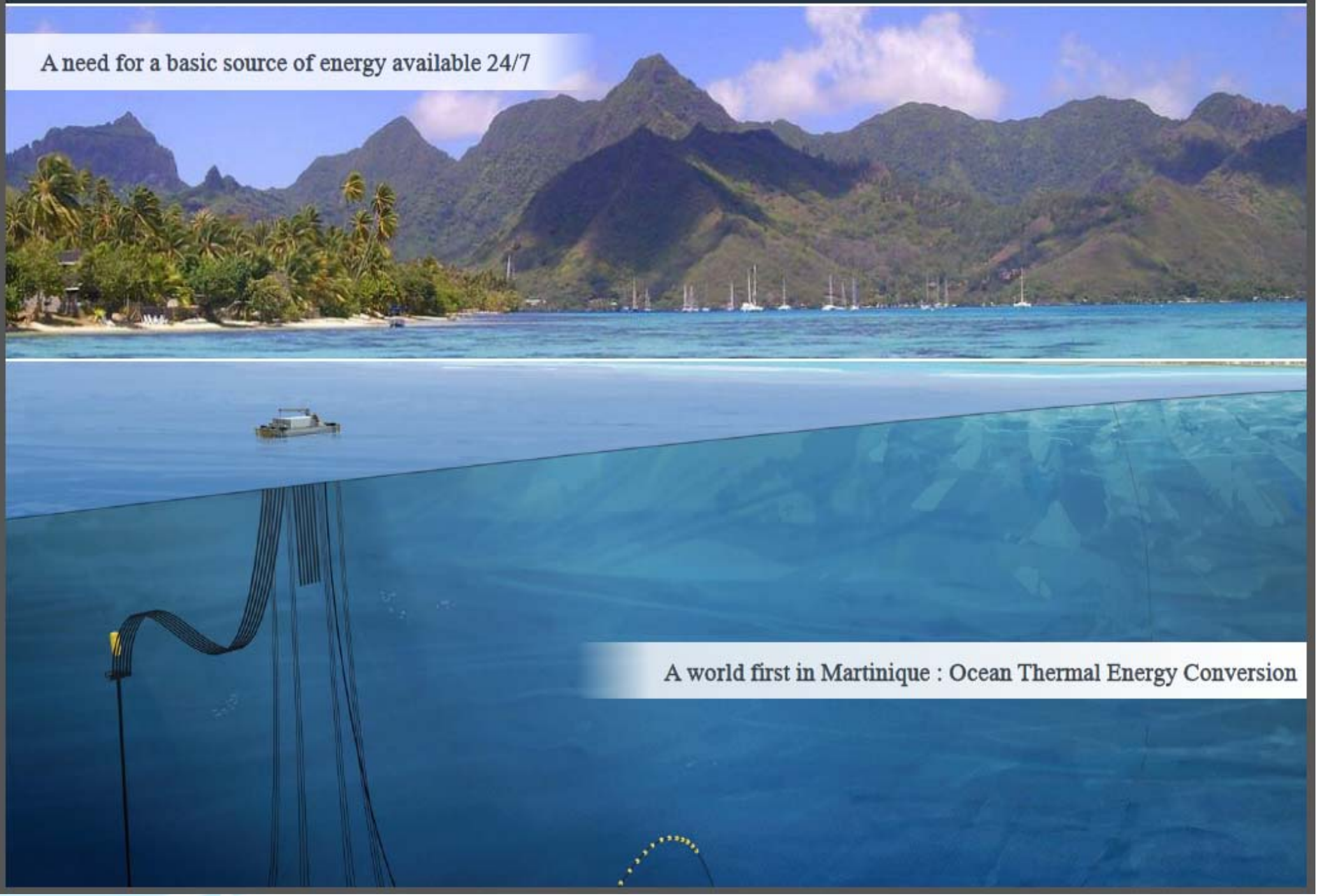
NEMO
New Energy for Martinique and Overseas

AKUO ENERGY - 140, avenue des Champs Elysées – 75008 Paris - France

Contact :
Axelle Vuillermet
vuillermet@akuoenergy.com
01 47 66 62 69

From WEB

Supply islands with the most relevant renewable energy



Localisation of the NEMO project in Martinique

Local context : a high cost of energy

- Strong dependency to fossil fuels (94% of the Martinique's energetic mix comes from thermic power)
- Non-interconnected areas
- Significant land pressure and reliefs
- Seismic and cyclonic area

Bellefontaine : a site fit for the installation of an OTEC power plant

- Significant temperature difference between cooler deep and warmer shallow tropical water
- Volcanic bathymetry : 1000 m deep close to the shore (as from 5km approximately)
- Nearby preparation site, adapted to the construction phase (mounting in a sheltered bay)
- Linkage to the communal and port land coverage with praticable injection to network at the Bellefontaine EDF power plant

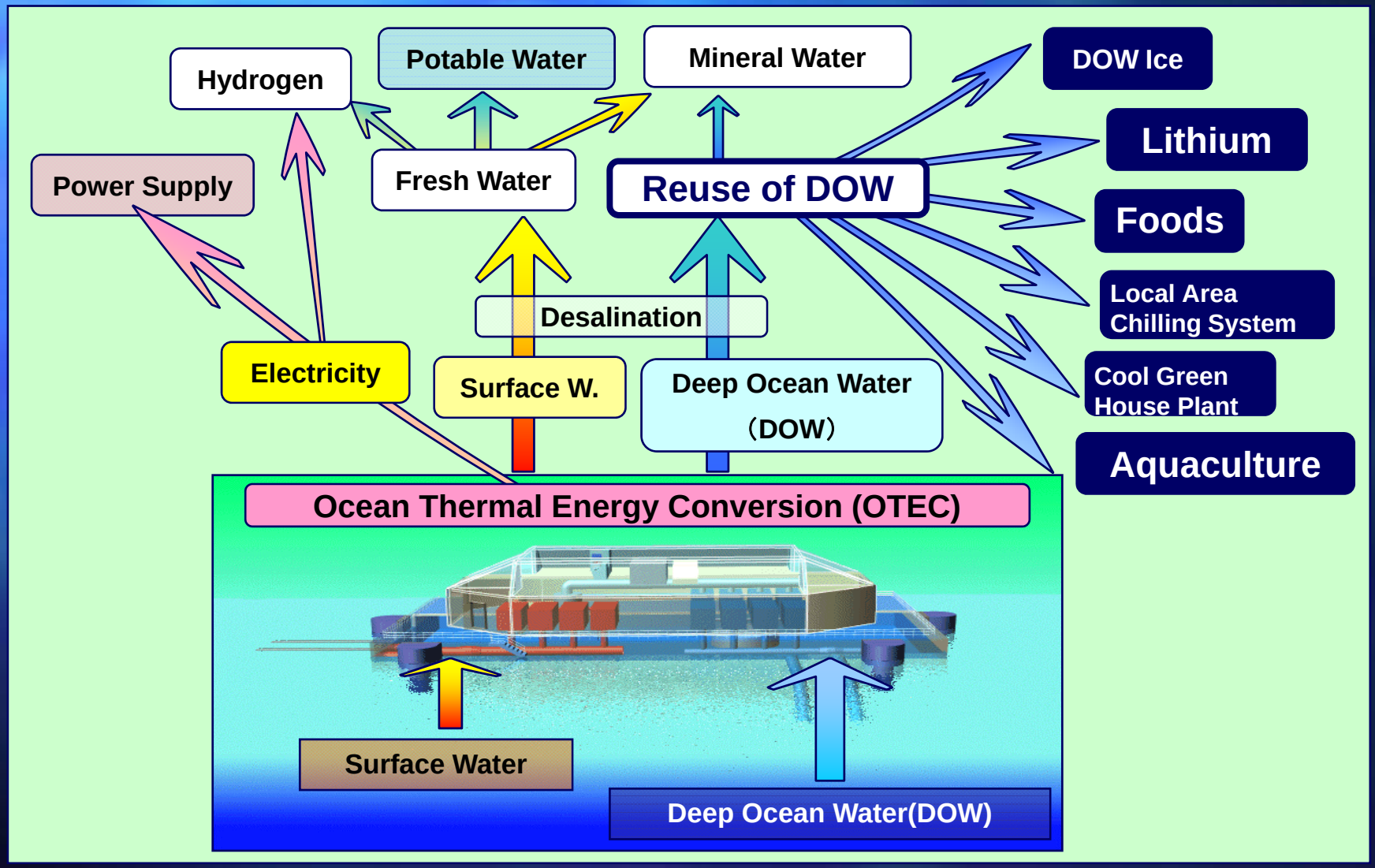
Why now is OTEC for Island in the world?

Yauyuki Ikegami,IOES,JAPAN

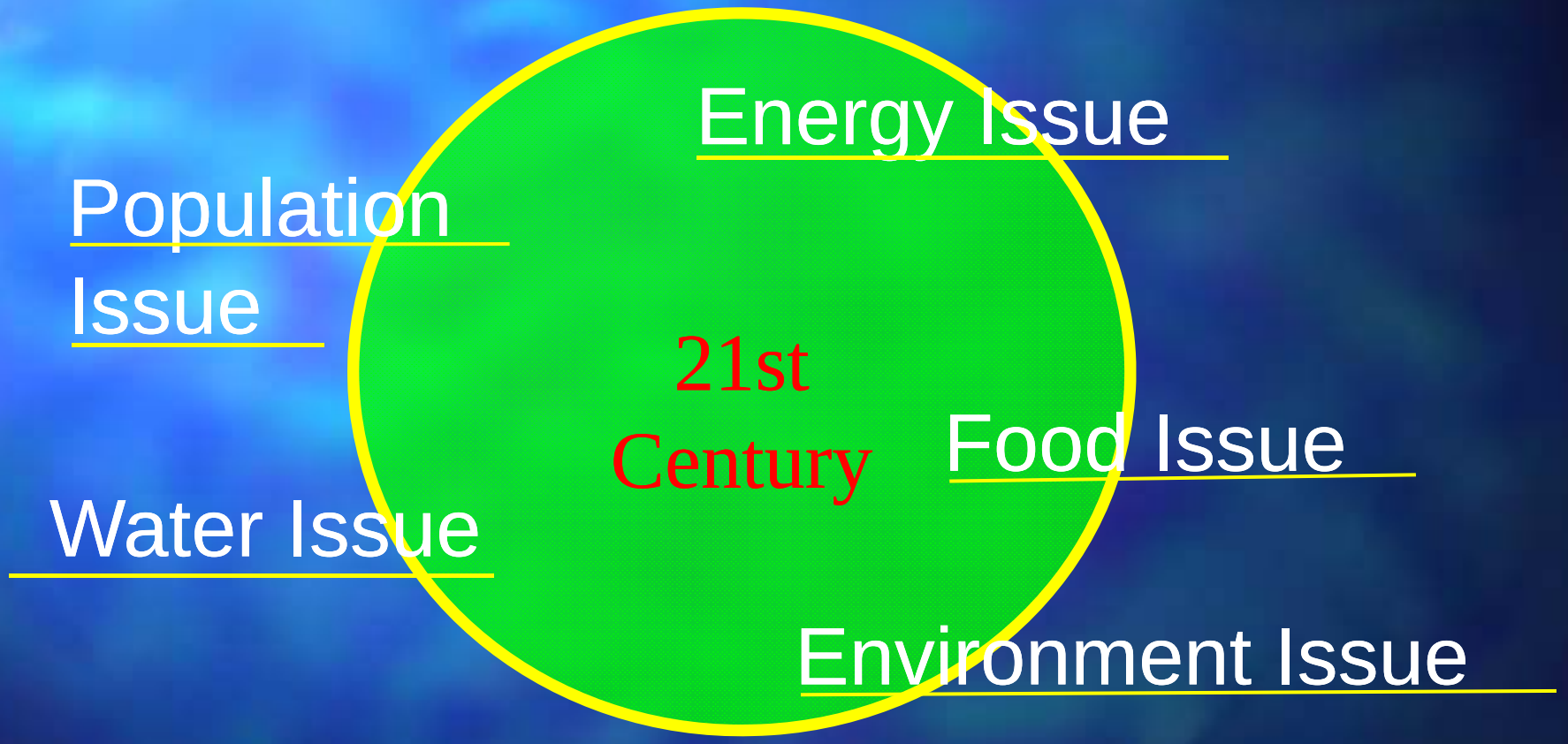
Characteristics of OTEC

- **Clean & Renewable Energy**
  OTEC uses only seawater as energy resource.
- **Inexhaustible Energy**
  10^{14} kWh/year is available only in Japanese territory. It's applicable in 98 countries in the world.
- **Stable Energy**
  It's possible to generate stably day and night though the year.
- **Zero Emission**
  No CO_2 & other Green house gas, SOx, NOx and any wastes.

By Products of Hybrid OTEC Plant for Island



Five Issues in 21st Century for Island



By Products of OTEC for Island

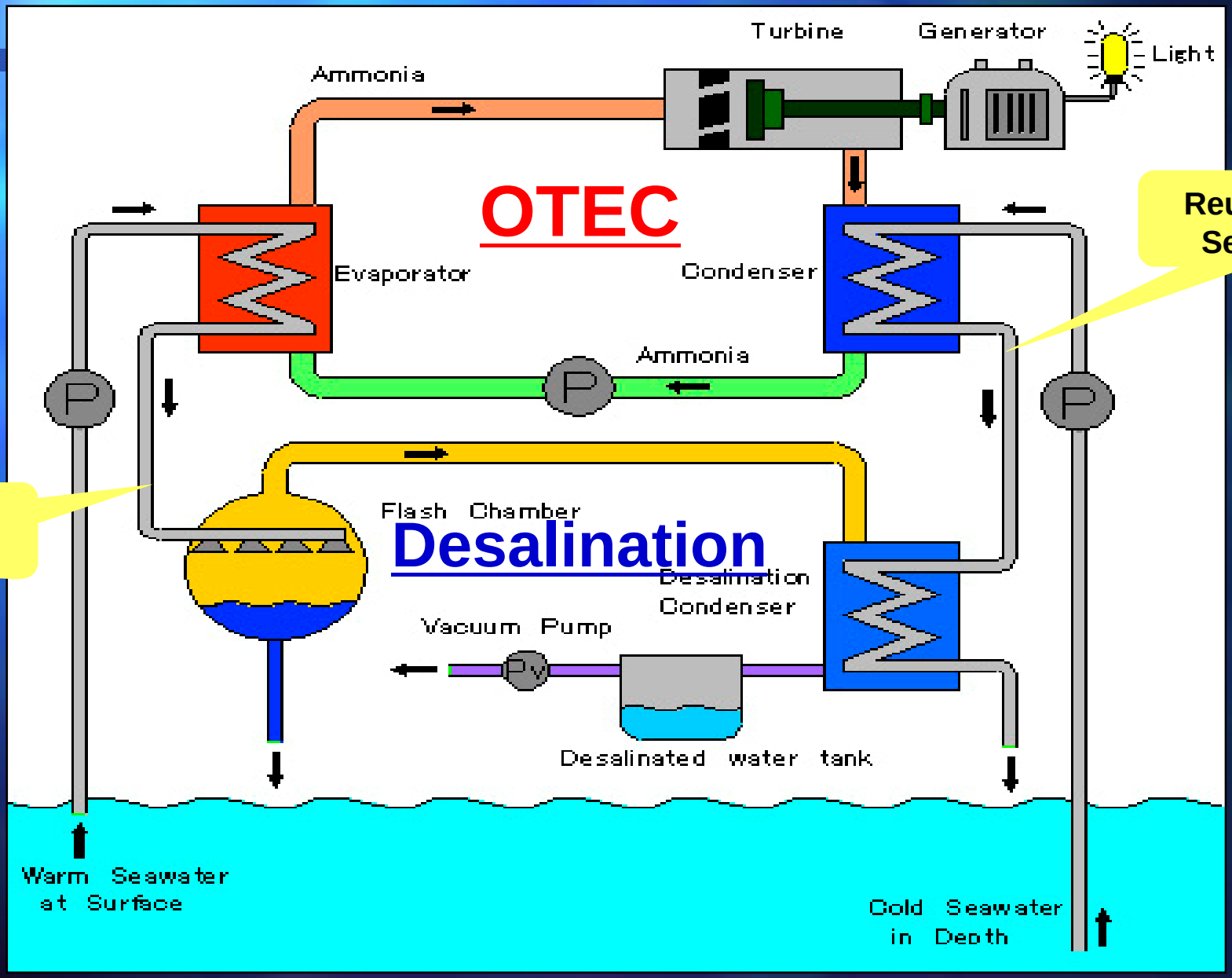
By Products of OTEC

- 1 –

Drinking Water

Hybrid OTEC Plant

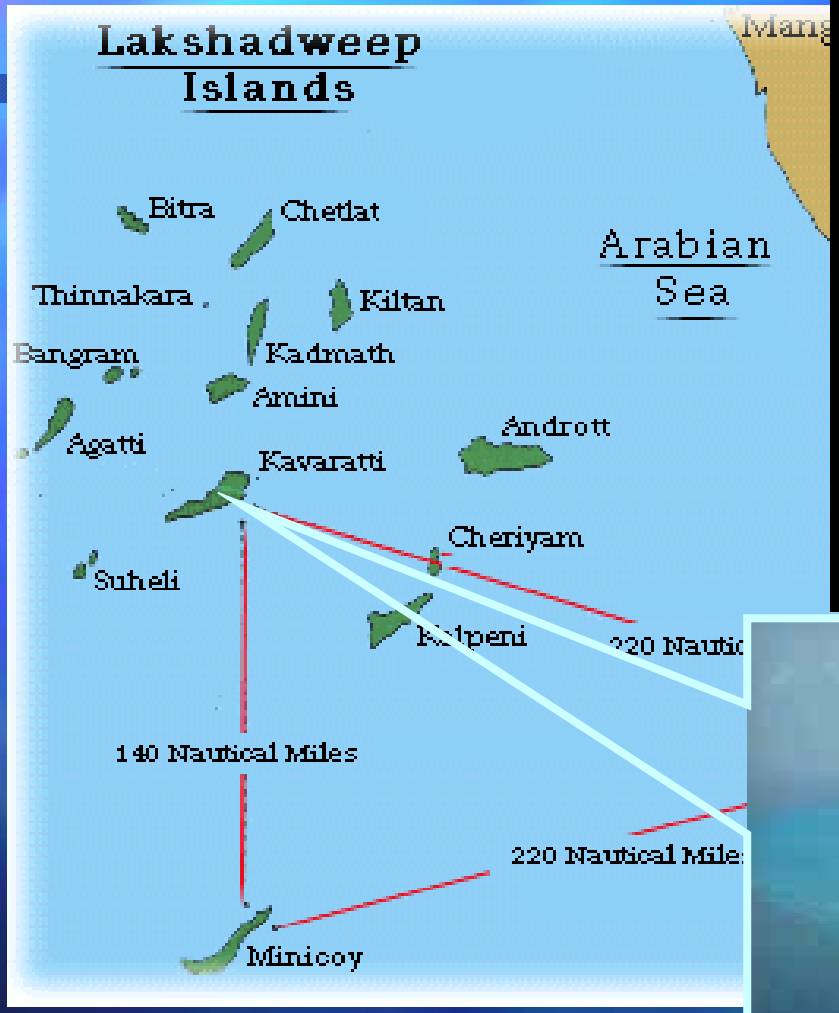
- Example of Combined Cycle with Desalination Plant.

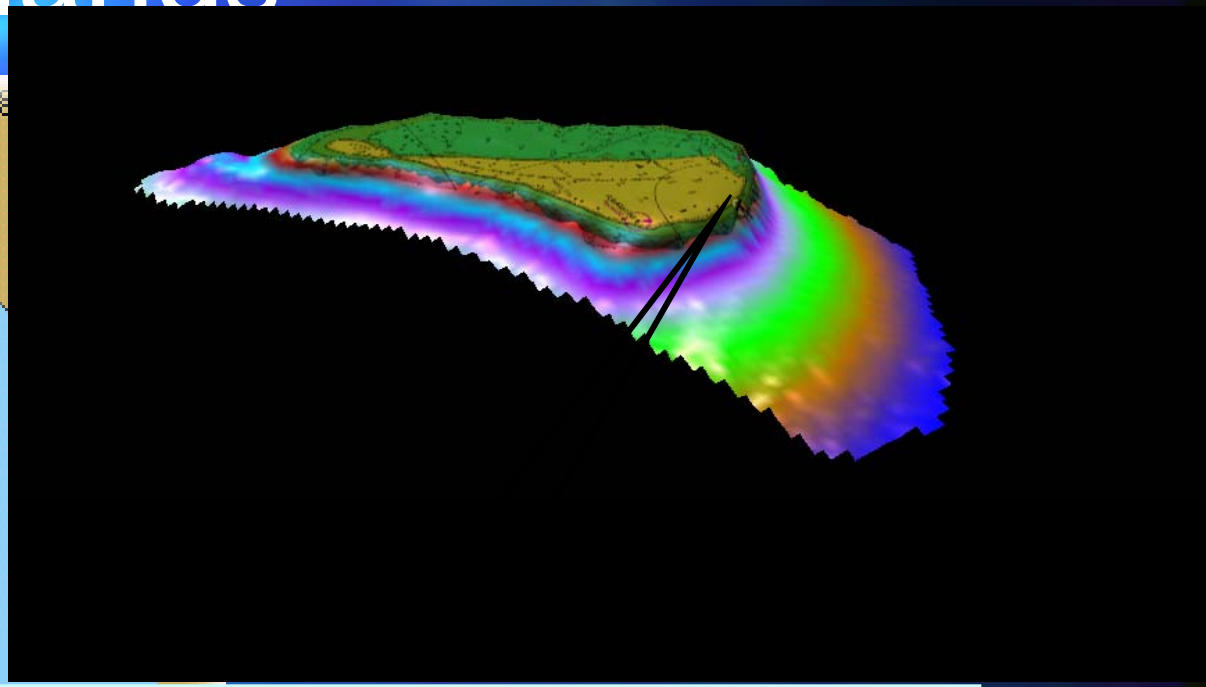


Flush Evaporation

NIOT Project in India

Lakshadweep Islands





Low Temperature Thermal Desalination Plant

Schematic Diagram of LTTD working principle

NIOT Project in India

100t/d Desalination Plant by NIOT,India

1,000t/d Desalination Plant using Ocean Thermal Energy（NIOT）

NIOT Project in India

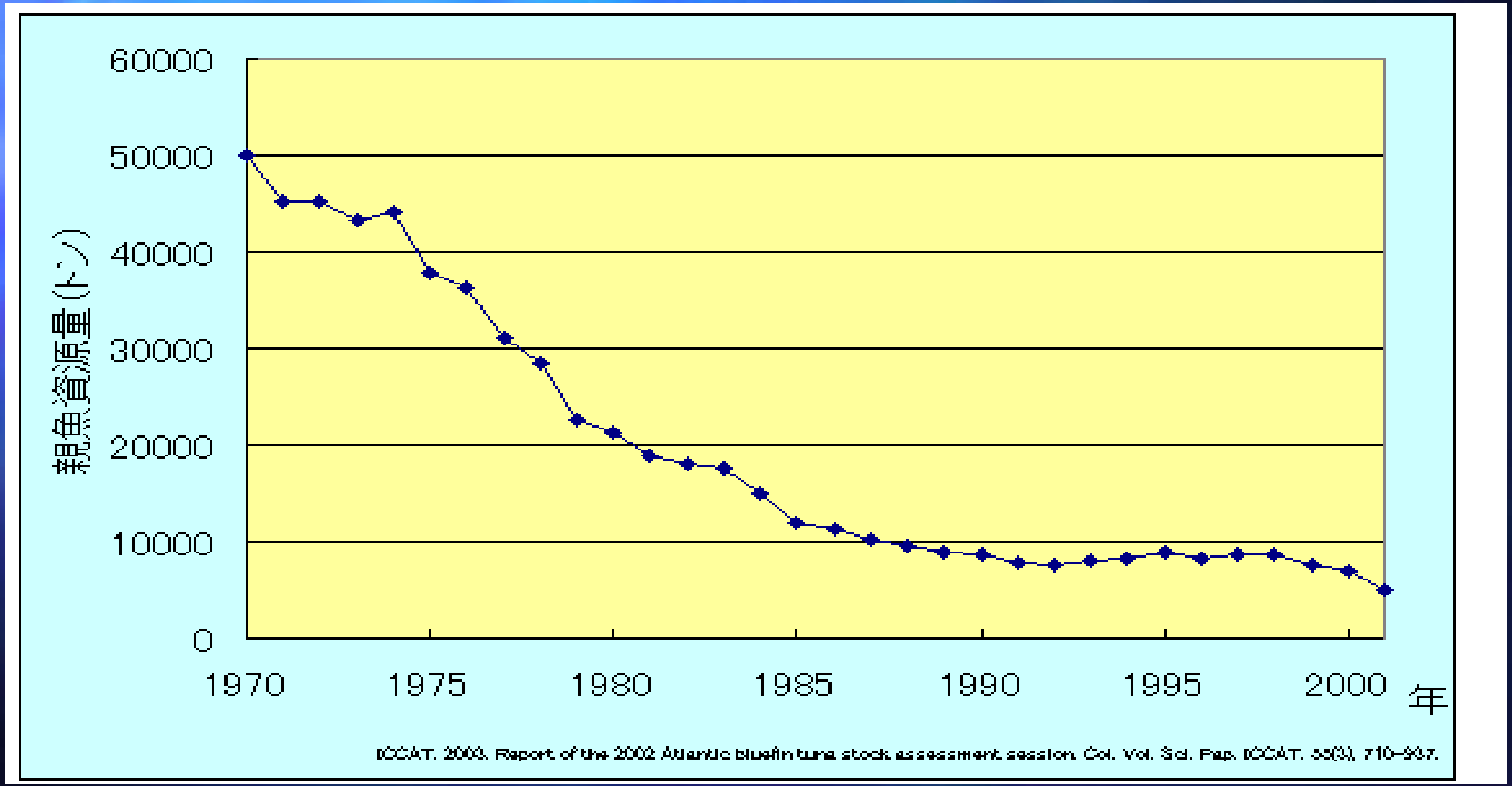
NIOT Project in India

1,000t/d Desalination Plant

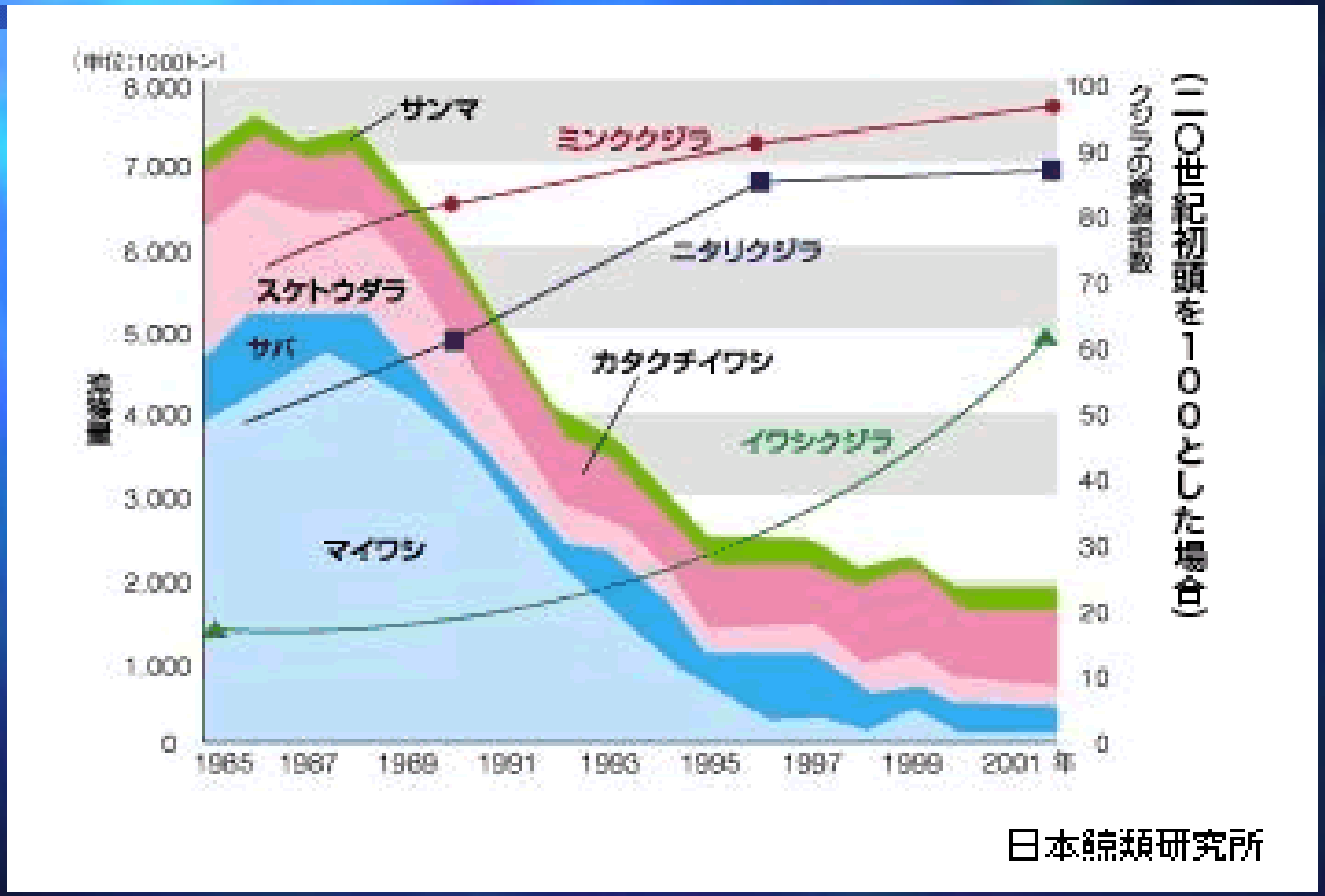
By Products of OTEC
- 2 –
Recover & Amplify Fishery Resources

CRISIS & DEPLETION of FISHERY RESOURCES

Tuna Fish in East Atlantic Ocean



Fish Resources in EEZ of Japan

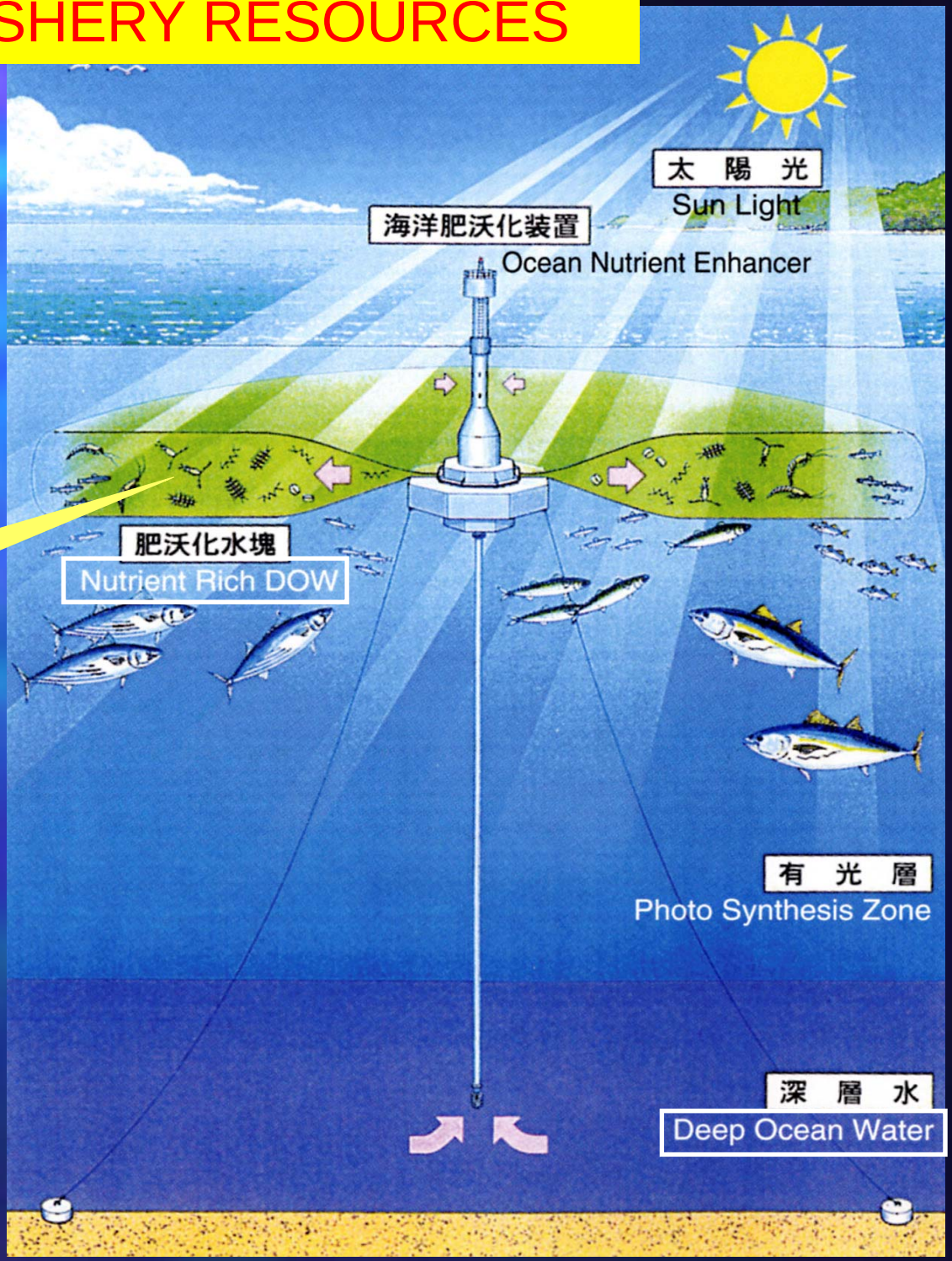


RECOVERY of FISHERY RESOURCES

Aquaculture Using DOW

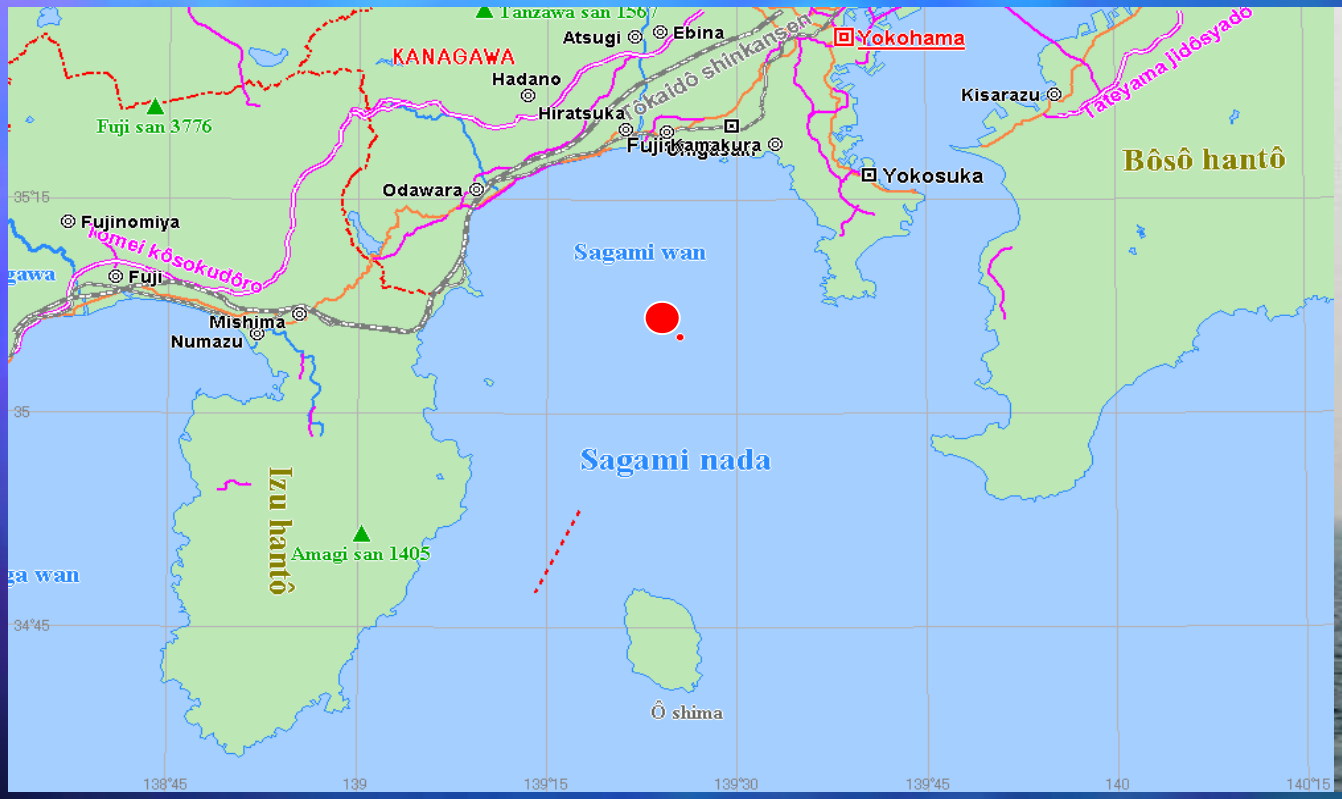
‘TAKUMI’ Project
拓海

Recycling Mineral Rich Deep Ocean Water



(by Prof. Ouchi)

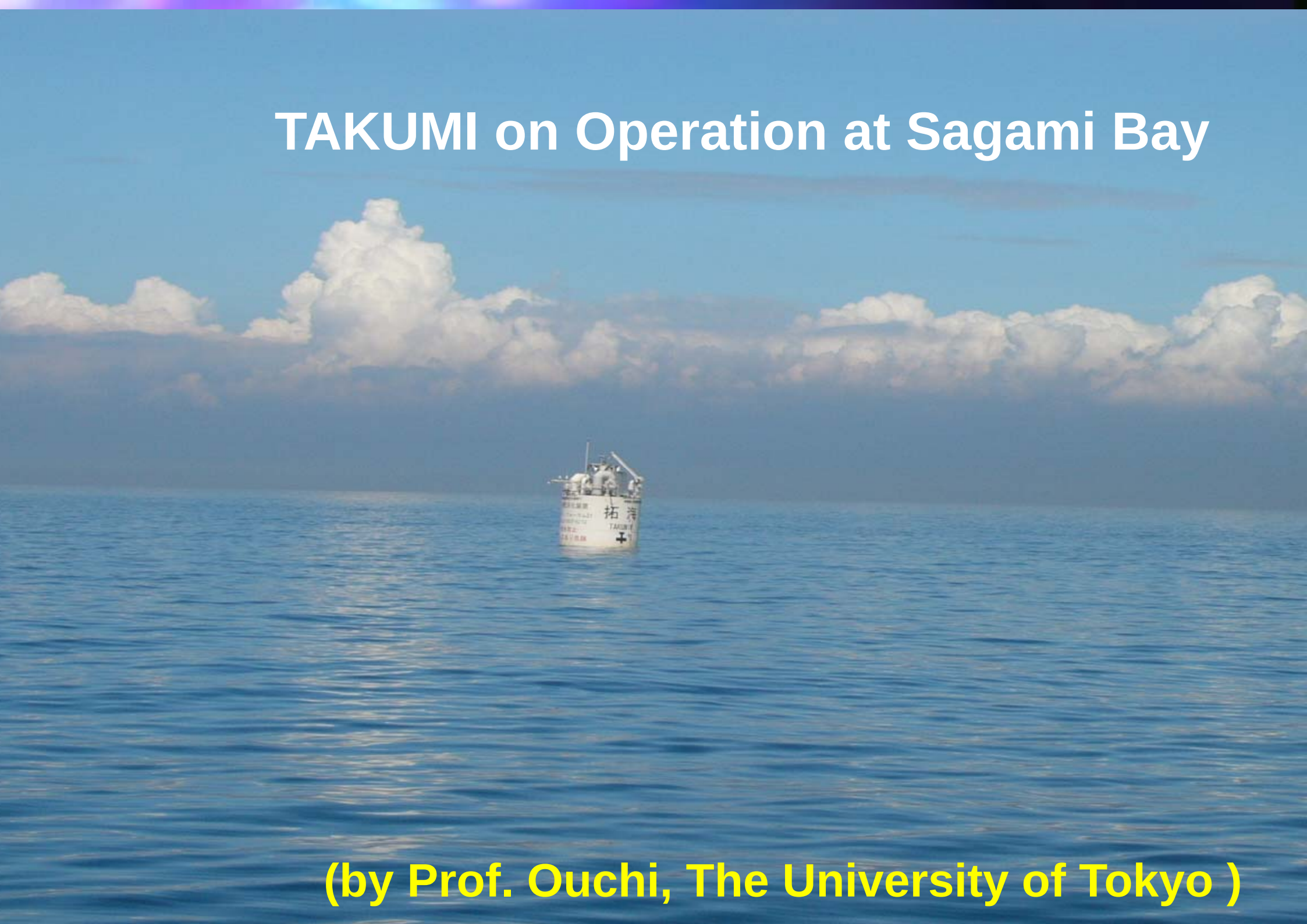
Marine Forum 21 Project



(by Prof. Ouchi)

TAKUMI in Final Docking Before Delivery in IHI Yokohama Shipyard, May 2003

TAKUMI on Operation at Sagami Bay

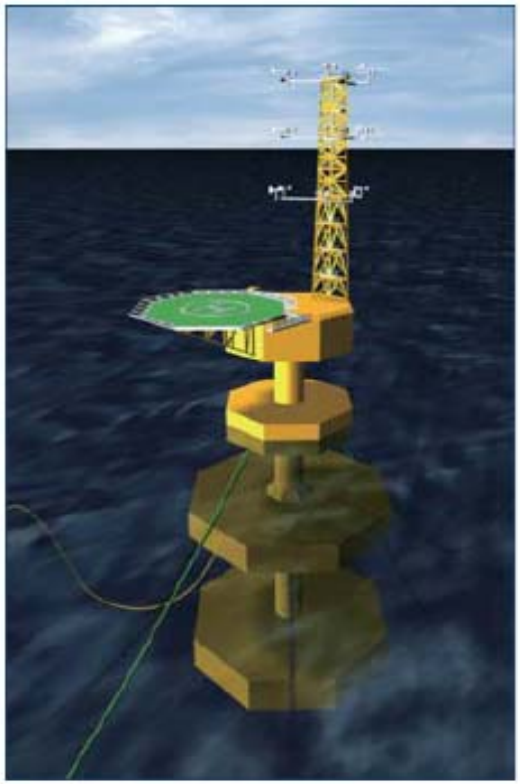


(by Prof. Ouchi, The University of Tokyo)

Scope of FORWARD

Phase Ⅰ (2011～2013) → Phase Ⅱ (2014～2015)

Floating Substation



Compact Semi-Sub
（2MW）

Advanced Spar
（7MW）

V-shape Semi-Sub
（7MW）

Three key factors for success

Technical Challenge ／ Social Acceptance ／ Recovery of Fukushima

Design ／Test ／ Optimization

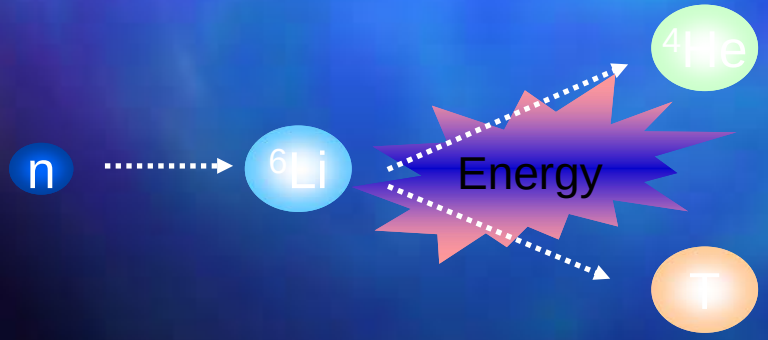
Cost efficiency ／ Standardization ／ Industrialization

By Products of OTEC
- 3 –
Recover the Rare Material from Ocean

Application Fields of Lithium

Light alloy mixed with
Al for aircraft

Electric vehicle
without emission

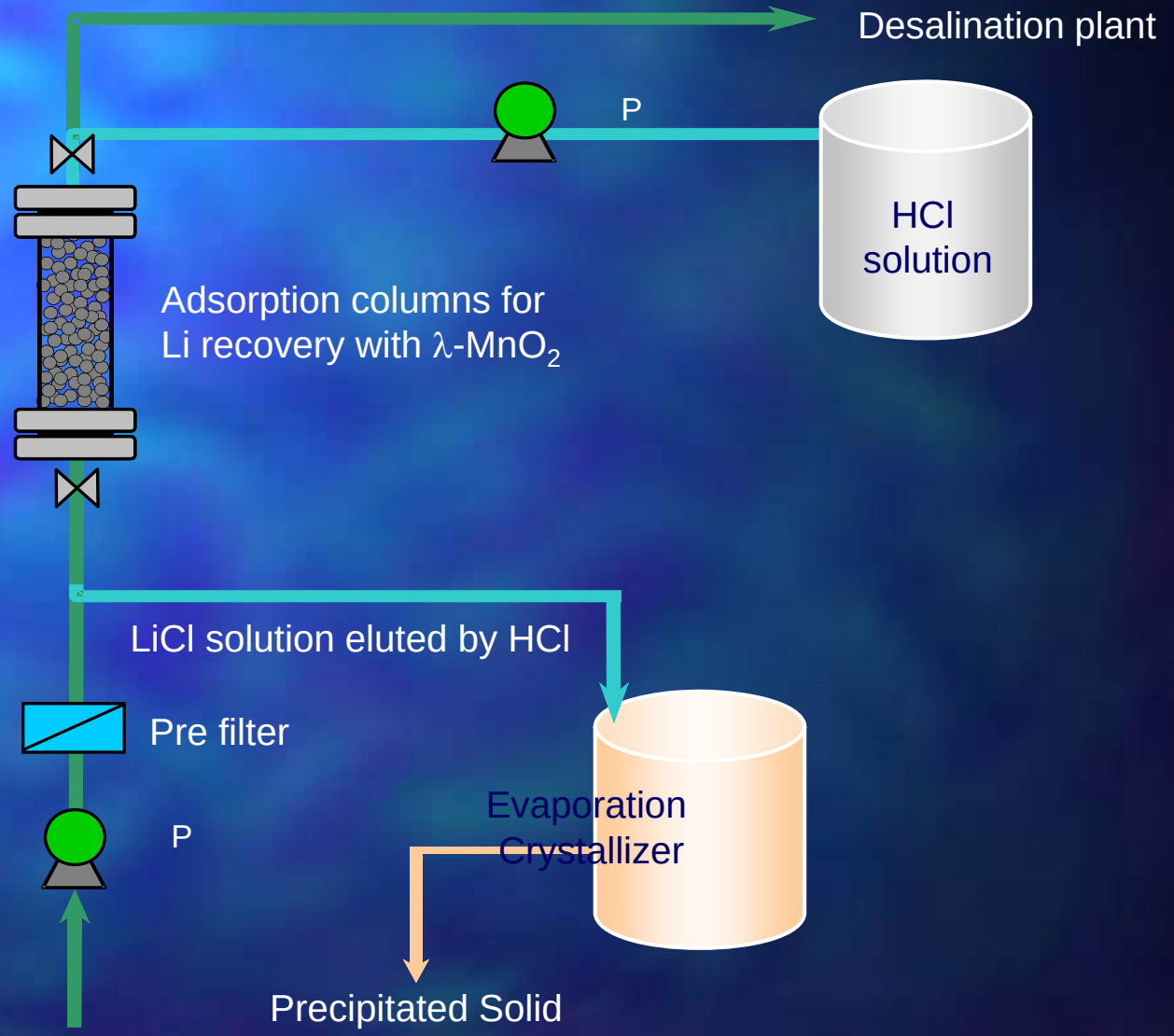


Next energy fuel for
nuclear fusion

Rechargeable battery of
mobile IT devices

By Prof. Kazuharu

Benchmark Plant of Lithium Recovery from Seawater in IOES



Performance of Equipment

Adsorbent weight: 60 kg

Adsorbent volume: 0.6 m^3

Eluting aq. soln.: 0.8 M HCl

Flow rate of seawater supply: 200 L/h

By Prof. Kazuharu Yoshizuka

Benchmark Plant of Lithium Recovery from Seawater in IOES,Saga University

Performance of Equipment

Adsorbent weight: 60kg x 2 columns

Adsorbent volume: 0.6m^3 x 2 columns

Eluting aq. soln.: 1-0.2M HCl

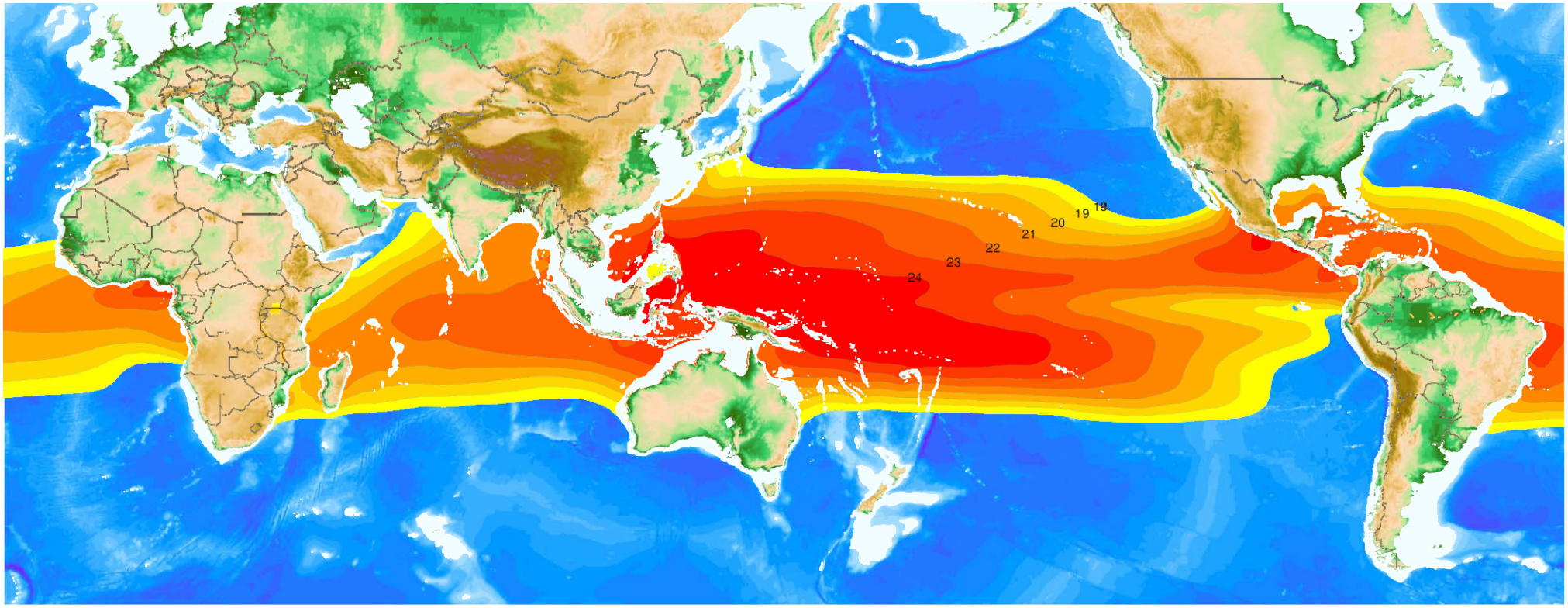
Flow rate of seawater supply: 200L/h

Evaporated Salt Obtained from 150 Days Operation

Dried precipitate 791g

By Prof. Kazuharu Yoshizuka

Asia and Pacific Ocean is best potential for OTEC



Drawn using Data from World Ocean Atlas 2009 (WOA2009)

Temperature Difference between Surface and Deep Water (1000m)

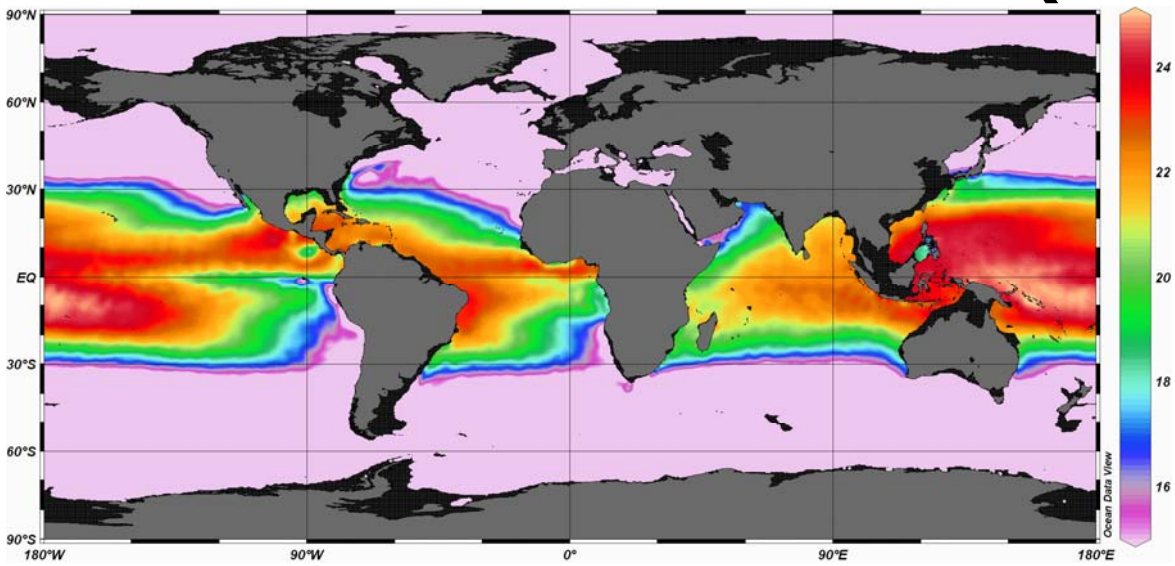
Hawaii and Okinawa are located in the north-most of favorable area for OTEC (temperature difference > 20°C). OTEC power plants in Hawaii and Okinawa can be “Model Case” for tropical and subtropical islands.

Present: OTEC Resources

- **Technical** resource, expressed as electrical energy generated with OTEC plant, can be estimated from the **Theoretical** thermal resource: *ΔT between surface waters and water from 1000 m depth*;
- 98 Nations with adequate OTEC resource within their EEZ (200 nautical miles);
- Annual production (GWh) with 100 MW OTEC plants located in the OTEC-Region estimated (*Nihous, University of Hawai'i*) →

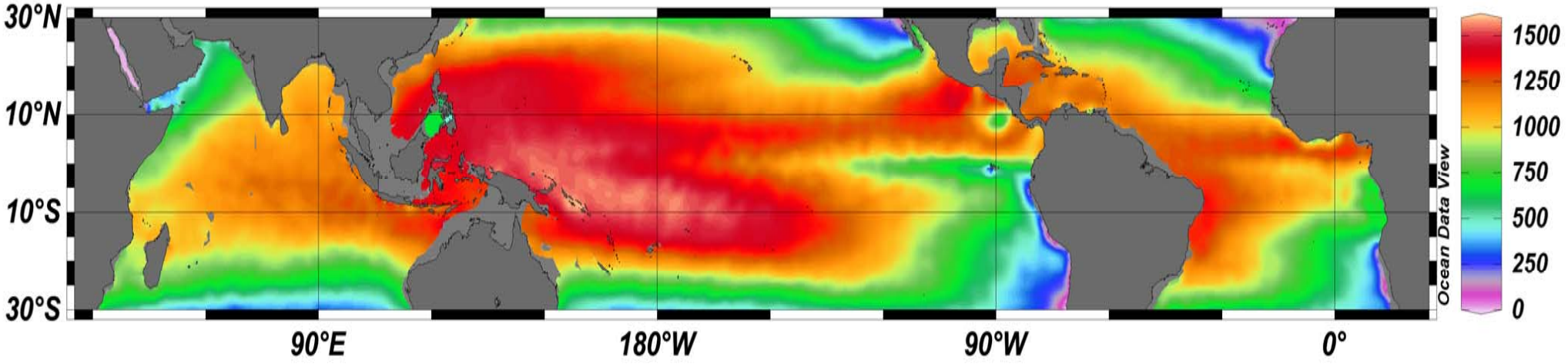
from Dr. Luis Vega

Ocean Thermal (OTEC) Resource



Color palette
15° C to 25° C

Theoretical Resource: World Ocean Atlas Annual Average ΔT ($T_{20m} - T_{1000m}$)



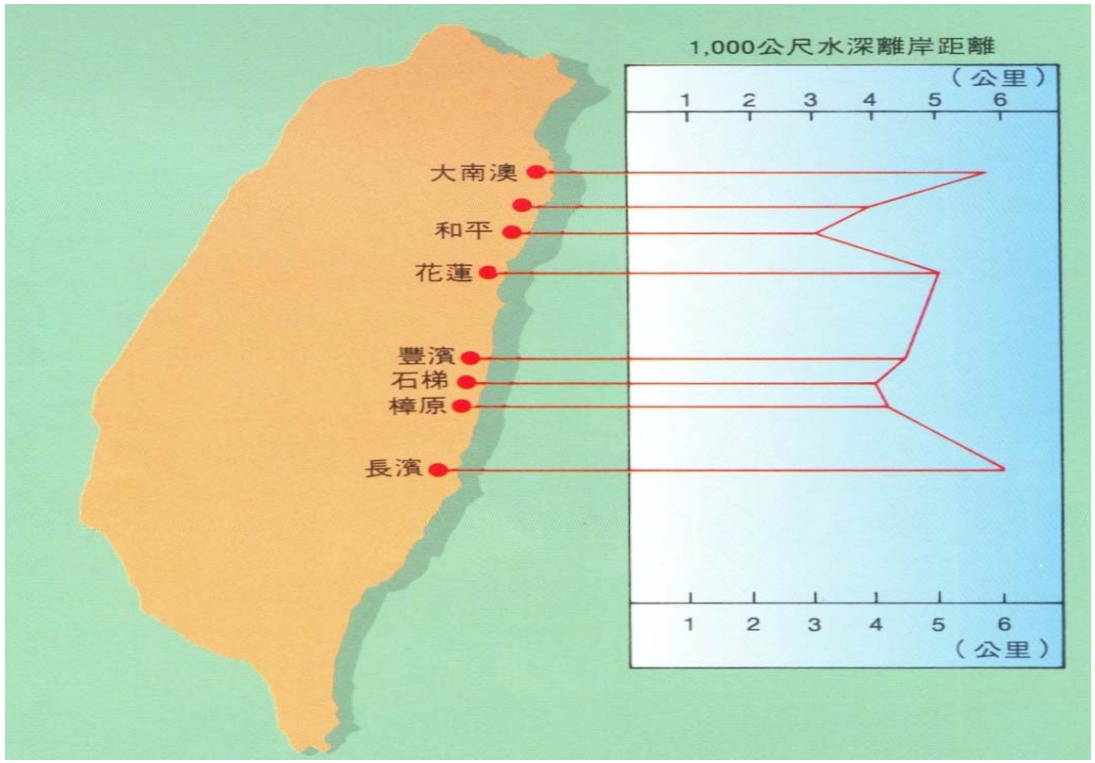
Technical Resource: 100 MW OTEC Plant Annual Electricity Generation (GWh)

Baseline: 877 GWh/year @ ΔT = 20 ℃

OTEC Potential and Activity in the Asia Pacific for Island

Potential Ocean Thermal Energy in Taiwan

- **Can be used as Based Load**
- **52GWe net power within 30 km of Taiwan east coast (Taipower, 1992)**



工業技術研究院
Industrial Technology Research Institute

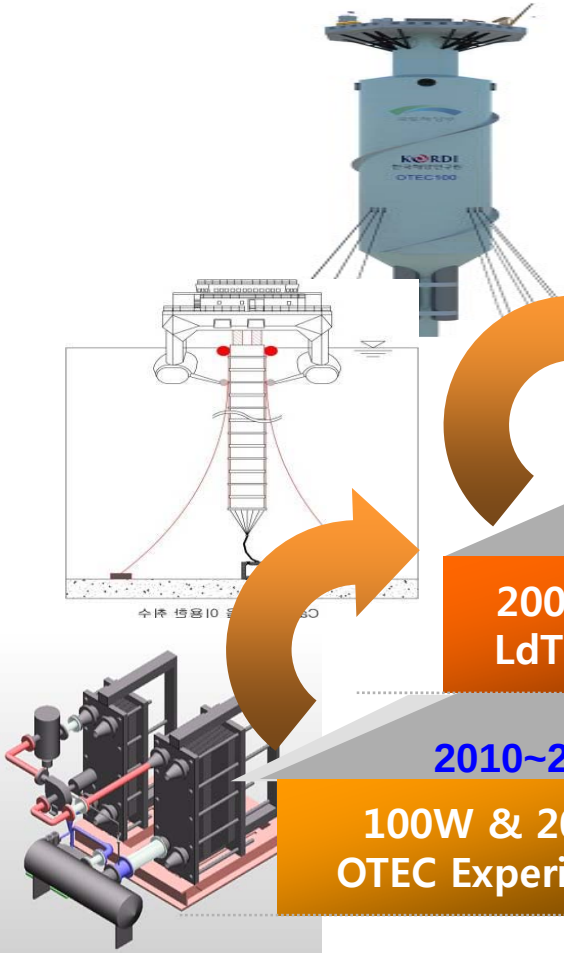
KOREA

Reference: Presentation by KIOST at International OTEC Symposium 2013

Final Goals and Approaching Steps

Final Goals

Design, manufacture, installation and operation of 100MW commercial OTEC plants in tropical waters



2020~

100MW OTEC Commercial Plant

- Prototype 100MW OTEC plant for commercialization

2018~2020

10MW OTEC Practical Plant

- Practical OTEC plant for multi-staged use
- ODA project and deep sea mining assistance

2014~2017

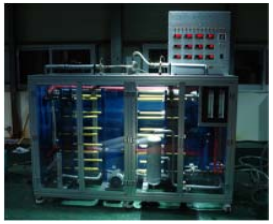
200kW HdT & 1MW LdT OTEC Pilot Plant

- Deign and fabrication of small practical OTEC plant
- Installation and operation for domestic(HdT) and tropical(LdT) implementation of Blue Infrastructure

2010~2013

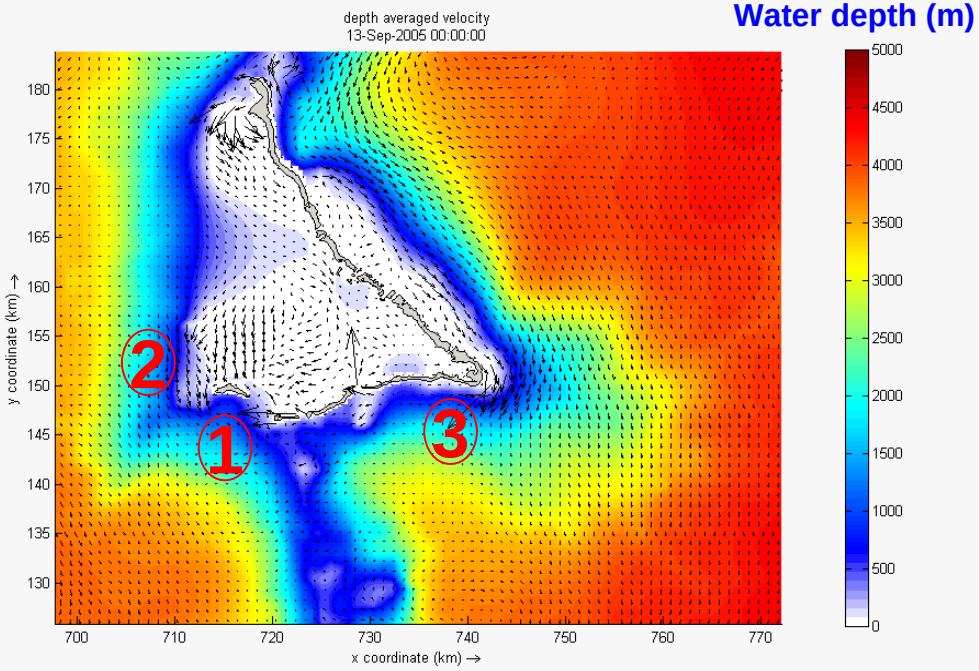
100W & 20kW OTEC Experiments

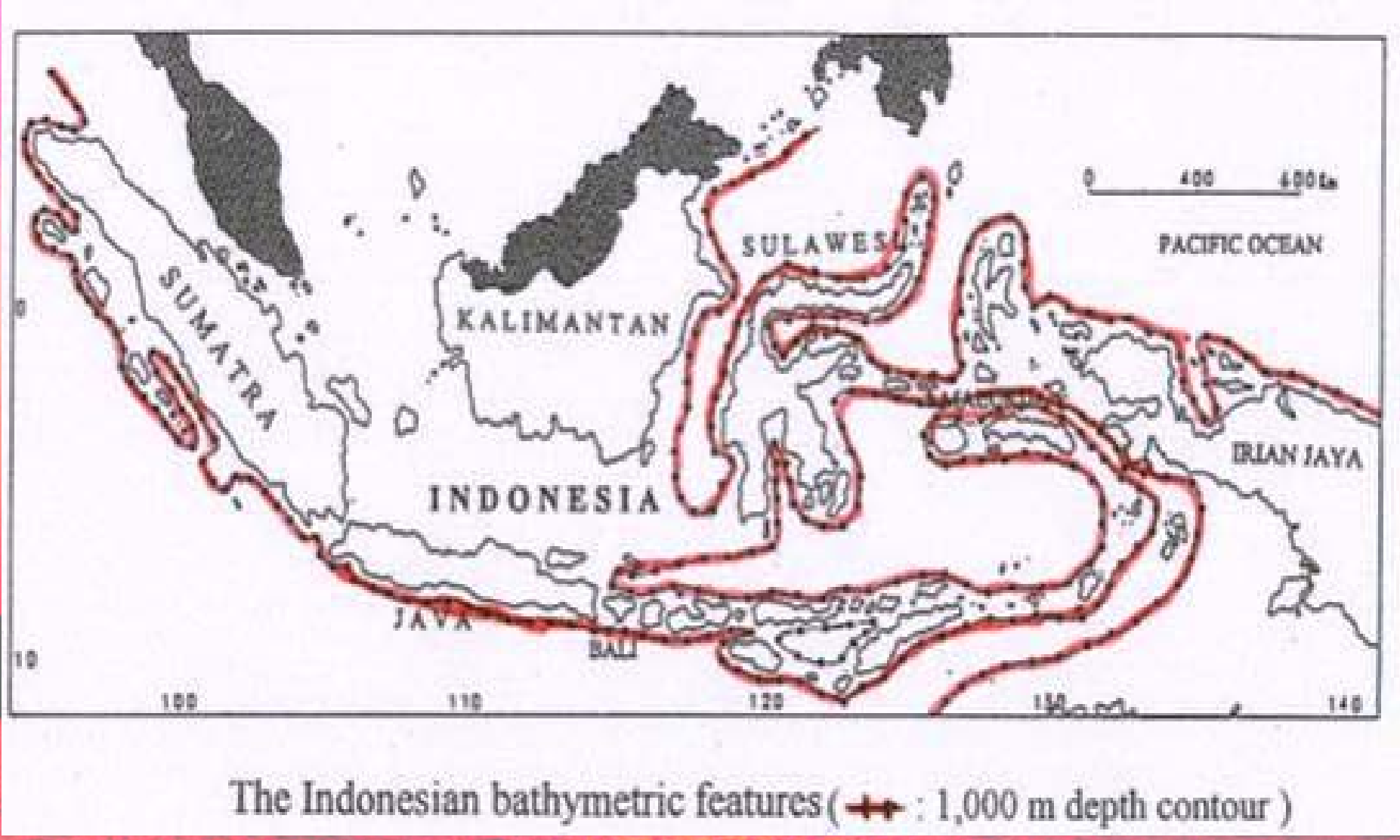
- Educational demonstration of OTEC mock-up in 2011
- Public demonstration of small OTEC pilot plant in 2013



OTEC – *1MW OTEC at Tarawa, Kiribati*

Korea project from IEA-OES





The Indonesian bathymetric features (++ : 1,000 m depth contour)

INOCEAN (2011) has ratified national-wide ocean energy potentials based on previously conducted exploration/surveys

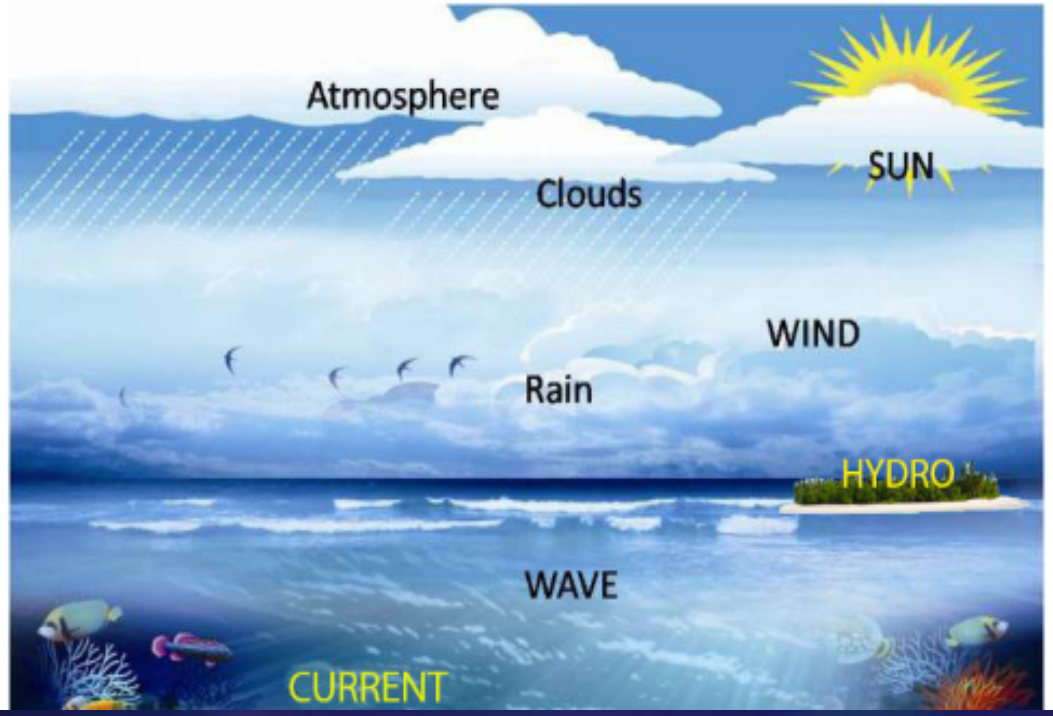
	Theoretical (GW)	*Technical (GW)*	*Practical (GW)*
Tidal current	**160.0**	**22.5**	**4.8**
Ocean wave	**510.0**	**2.0**	**1.2**
Ocean thermal	**57.0**	**52.0 ***	**43.0 ***
Total	**727.0**	**76.5**	**49.0**

depending on the technological maturity and market development, including availability of successful project in gird connection.

UTM Ocean Thermal Energy Centre (UTM-OTEC) (Established since 3rd January 2013)

Universiti Teknologi Malaysia
innovative.entrepreneurial.global

RENEWABLE ENERGY



May 2014

M	T	W	T	F	S	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

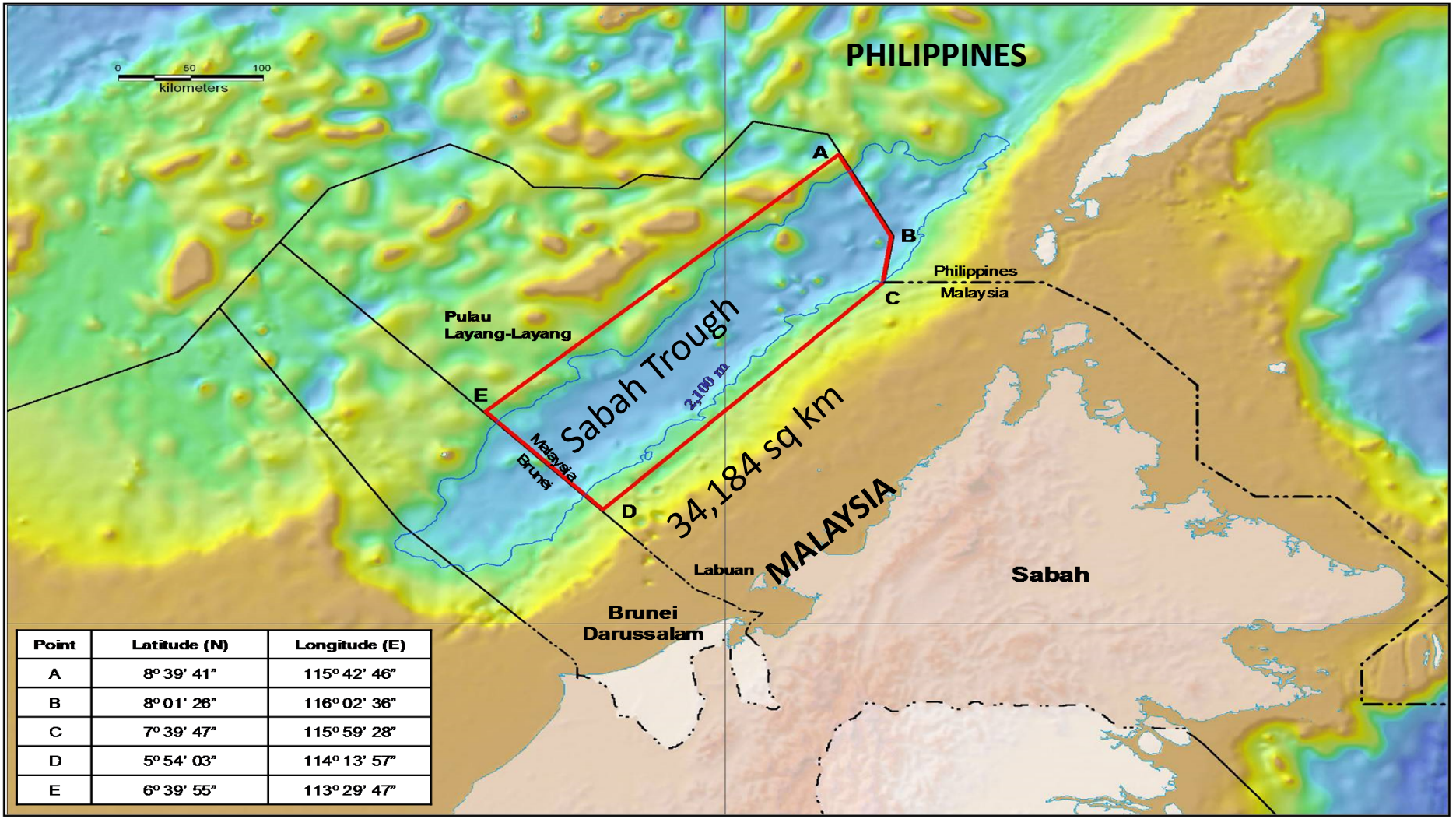
« Jan

UTM-OTEC Kuala Lumpur

Ocean Thermal Energy Centre
Universiti Teknologi Malaysia
Block Q
Kuala Lumpur
54100 Jalan Semarak
Malaysia
Tel: +(6)03-26154882
Fax: +(6)03-26154283
email: utmotec@ic.utm.my

shamsulskl

OTEC POTENTIAL:
SUBREGIONAL COOPERATION IN OCEAN THERMAL ENERGY DEVELOPMENT: BRUNEI DS-MALAYSIA-PHILIPPINES



Point	Latitude (N)	Longitude (E)
A	8° 39' 41"	115° 42' 46"
B	8° 01' 26"	116° 02' 36"
C	7° 39' 47"	115° 59' 28"
D	5° 54' 03"	114° 13' 57"
E	6° 39' 55"	113° 29' 47"

Presented by:
Dato' Ir Dr A Bakar Jaafar

MP for Palau OTEC Project

Potential	Size of OTEC plant
Melkeok	3MW x2+4MW x1=10MW
Airai	3MW x2+4MW x1=10MW
Ngarchelong	2MW x 1 = 2MW
Ngaraard	2MW x 1 = 2MW
Ngiwal	2MW x 1 = 2MW
Peleliu	2MW x 1 = 2MW
Angaur	2MW x 1 = 2MW
Total	30MW

Location and Size of Potential OTEC Site in Palau

Ngarchelong St.
2MW OTEC
with
- Potable Water Production
- Aquaculture
- DOW Ice Production

Ngaraard St.
2MW OTEC
with
- Potable Water Production
- Aquaculture
- DOW Ice Production

Ngiwal St.
2MW OTEC
with
- Potable Water Production
- Aquaculture
- DOW Ice Production

Melkeok St.
10MW OTEC
with
- Potable Water Production
- New Capital Area Chilling Service (for office, hotel)
- DOW Ice Production
- Hydrogen

The first priority to be offered to initial 3MW of Melkeok St.

Angaur St
2MW OTEC
with
- Potable Water Generation
- Aquaculture
- Local Area Chilling Service
- DOW Ice Production

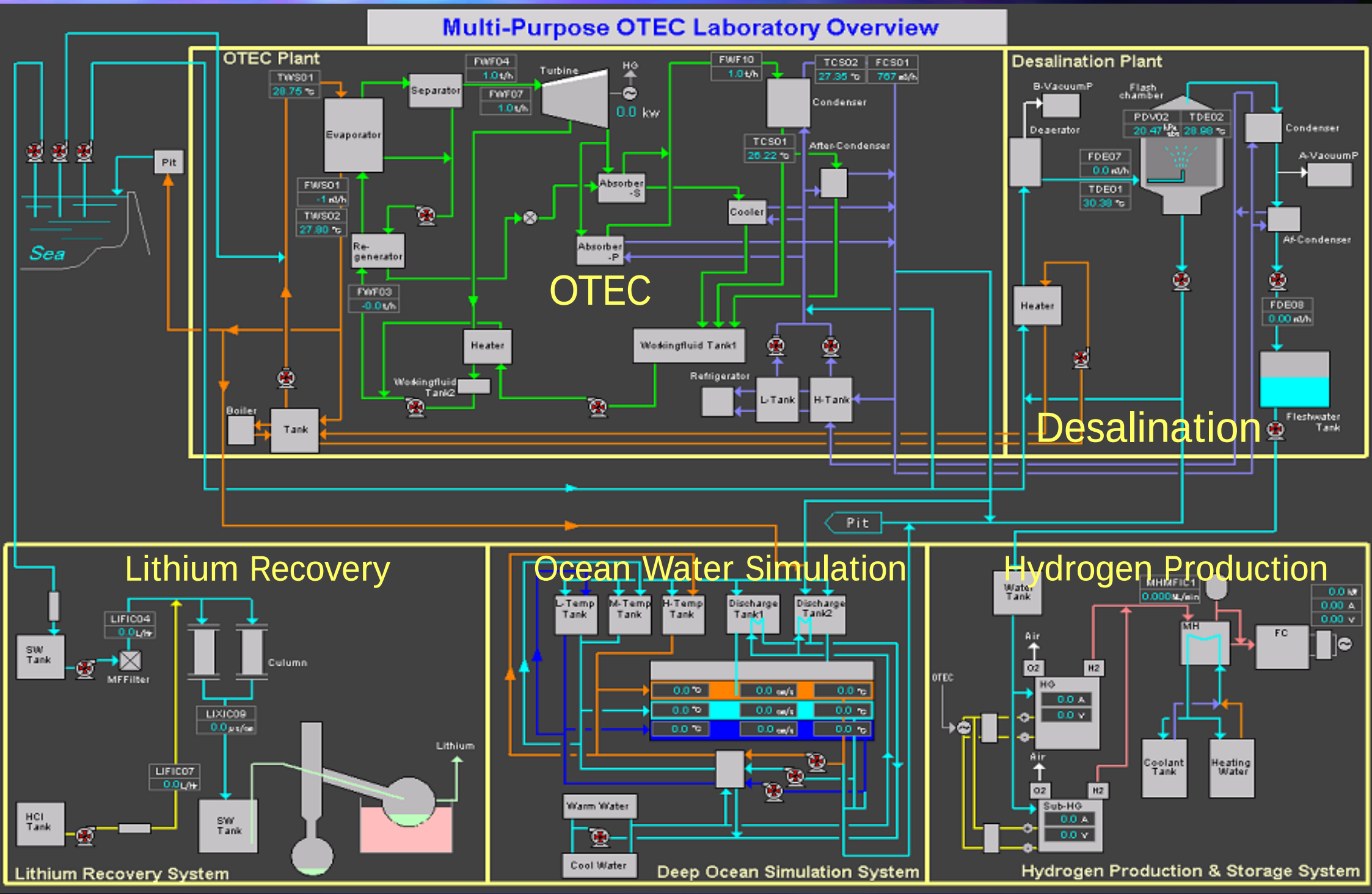
Peleliu St.
2MW OTEC
with
- Potable Water Generation
- Aquaculture
- Local Area Chilling Service
- DOW Ice Production

Airai St.
10MW OTEC
with
- Potable Water Generation
- Local Area Chilling Service
- Hydrogen Production

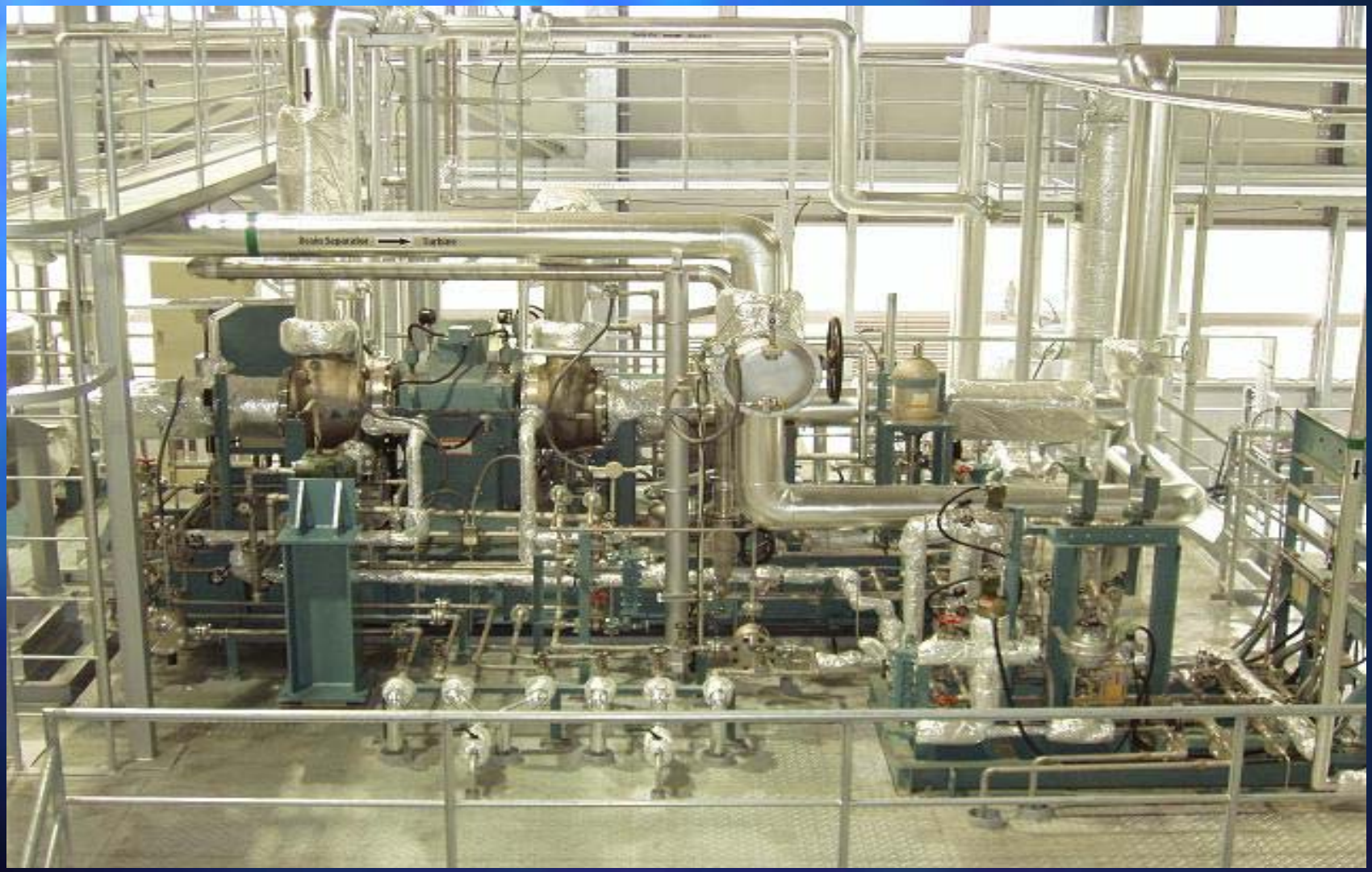
Institute of Ocean Energy, Saga University (IOES)

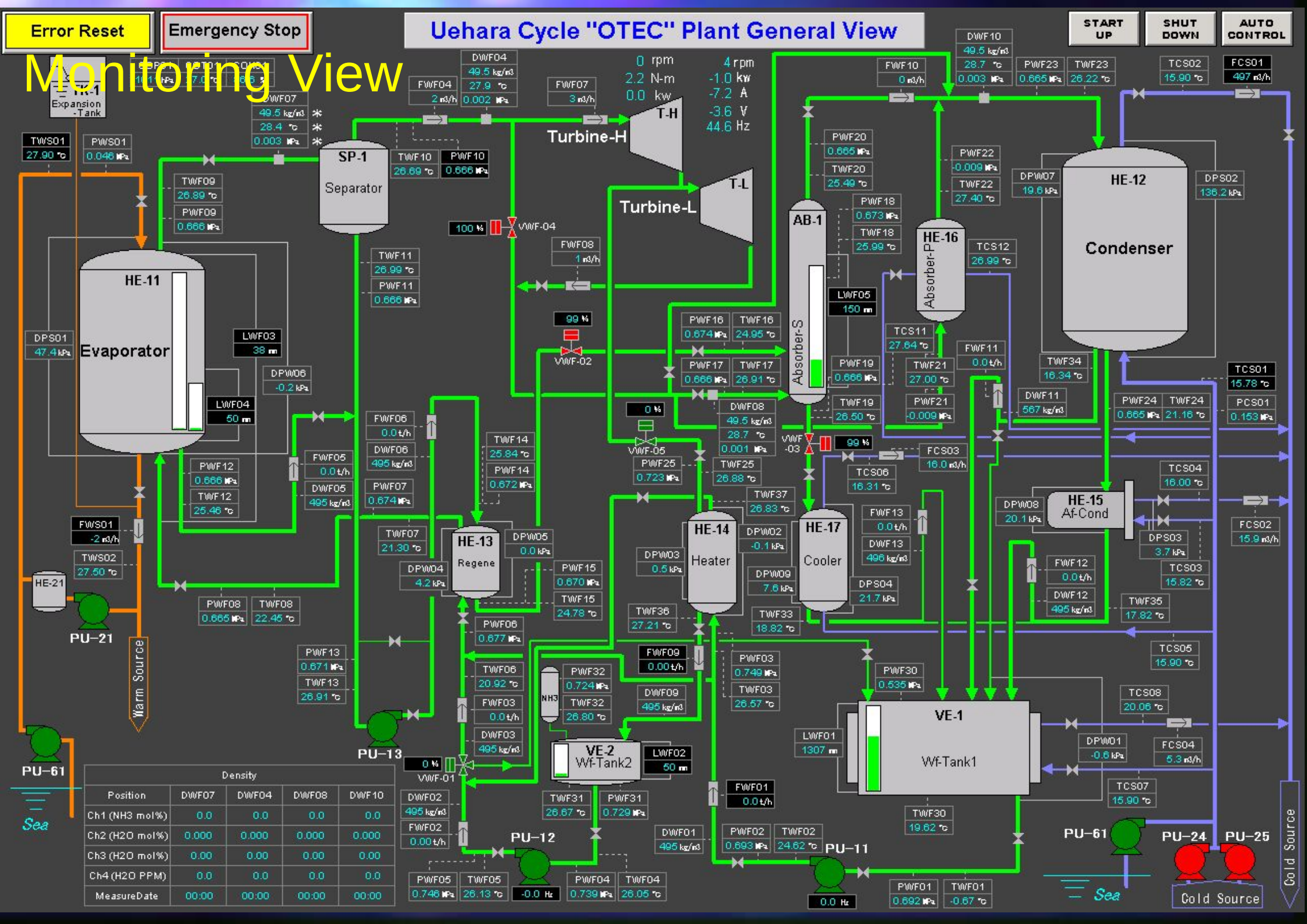
New Hybrid OTEC Experimental Plant

Completion in 2003


Multi-Purpose OTEC Laboratory Overview
OTEC Plant
Desalination Plant
Sea
Pit
Evaporator
Separator
Turbine
0.0 kw
Condenser
After-Condenser
Absorber -S
Absorber -P
Cooler
Re-generator
Heater
Boiler
Tank
Wokingfluid Tank1
Wokingfluid Tank2
Refrigerator
L-Tank
H-Tank
B-VacuumP
Deaerator
Flash chamber
A-VacuumP
Air-Condenser
Fleshwater Tank
OTEC
Desalination
Lithium Recovery
SW Tank
MFFilter
Culumn
Lithium
HCl Tank
Lithium Recovery System
Ocean Water Simulation
L-Temp Tank
M-Temp Tank
H-Temp Tank
Discharge Tank1
Discharge Tank2
Warm Water
Cool Water
Deep Ocean Simulation System
Hydrogen Production
Water Tank
MH
FC
Air
Coolant Tank
Heating Water
Hydrogen Production & Storage System

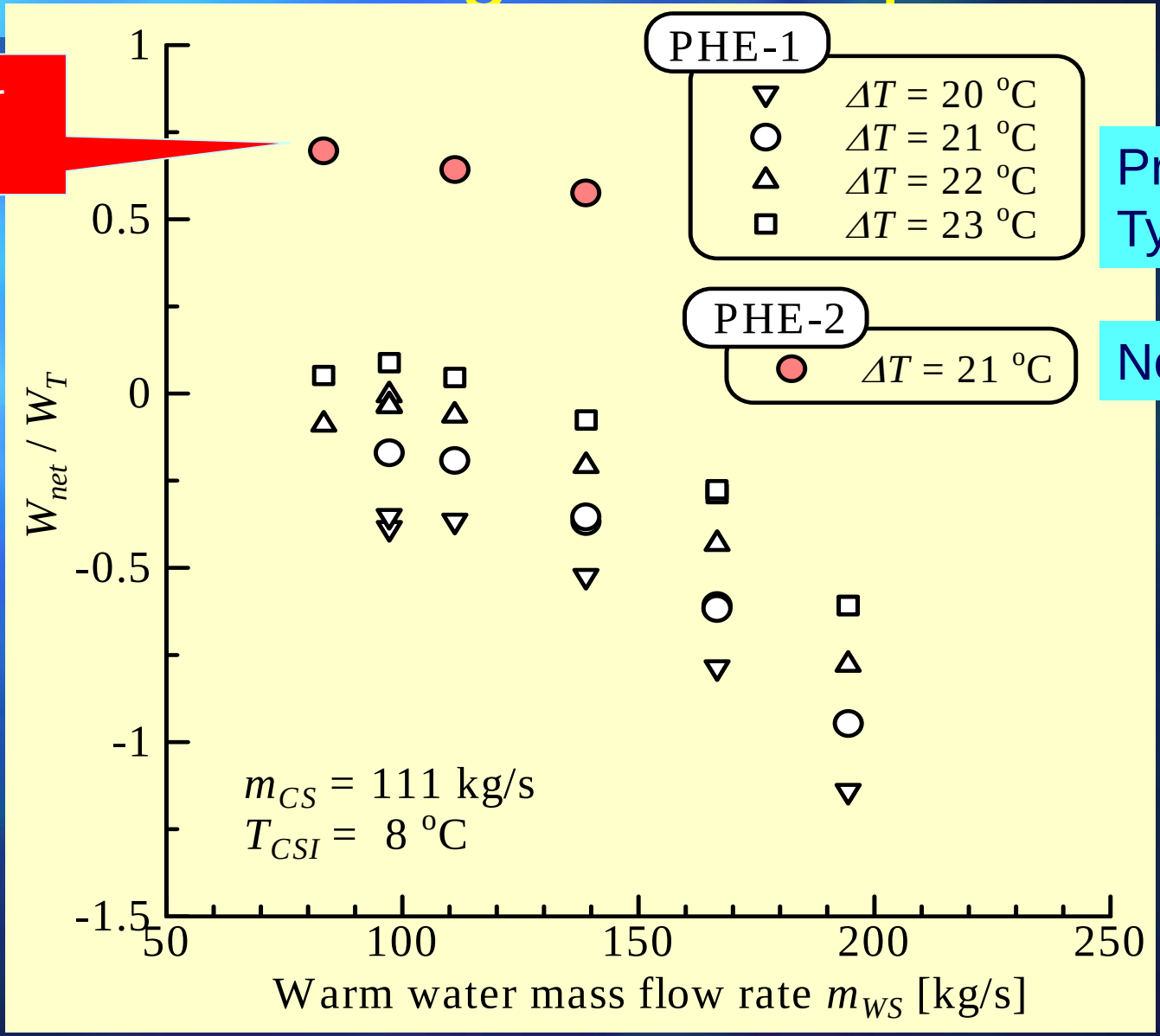
Turbine for OTEC using Ammonia/Water Mixtures as Working Fluid(30kW)




Error Reset
Emergency Stop
Uehara Cycle "OTEC" Plant General View
START UP
SHUT DOWN
AUTO CONTROL
Monitoring View
Expansion -Tank
SP-1 Separator
Turbine-H
Turbine-L
T-H
T-L
0 rpm
2.2 N-m
0.0 kw
4 rpm
-1.0 kw
-7.2 A
-3.6 V
44.6 Hz
HE-11 Evaporator
HE-12 Condenser
HE-13 Regene
HE-14 Heater
HE-15 Af-Cond
HE-16 Absorber-P
HE-17 Cooler
AB-1 Absorber-S
VE-1 Wf-Tank1
VE-2 Wf-Tank2
PU-21
PU-13
PU-12
PU-11
PU-61
PU-24
PU-25
Warm Source
Cold Source
Sea
VWF-01
VWF-02
VWF-03
VWF-04
VWF-05
Density
Position | DWF07 | DWF04 | DWF08 | DWF10
Ch1 (NH3 mol%) | 0.0 | 0.0 | 0.0 | 0.0
Ch2 (H2O mol%) | 0.000 | 0.000 | 0.000 | 0.000
Ch3 (H2O mol%) | 0.00 | 0.00 | 0.00 | 0.00
Ch4 (H2O PPM) | 0.0 | 0.0 | 0.0 | 0.0
MeasureDate | 00:00 | 00:00 | 00:00 | 00:00

Efficiency of Net Power ($=W_{NET}/W_G$) using New Evaporator

Efficiency of Net Power = about 70%

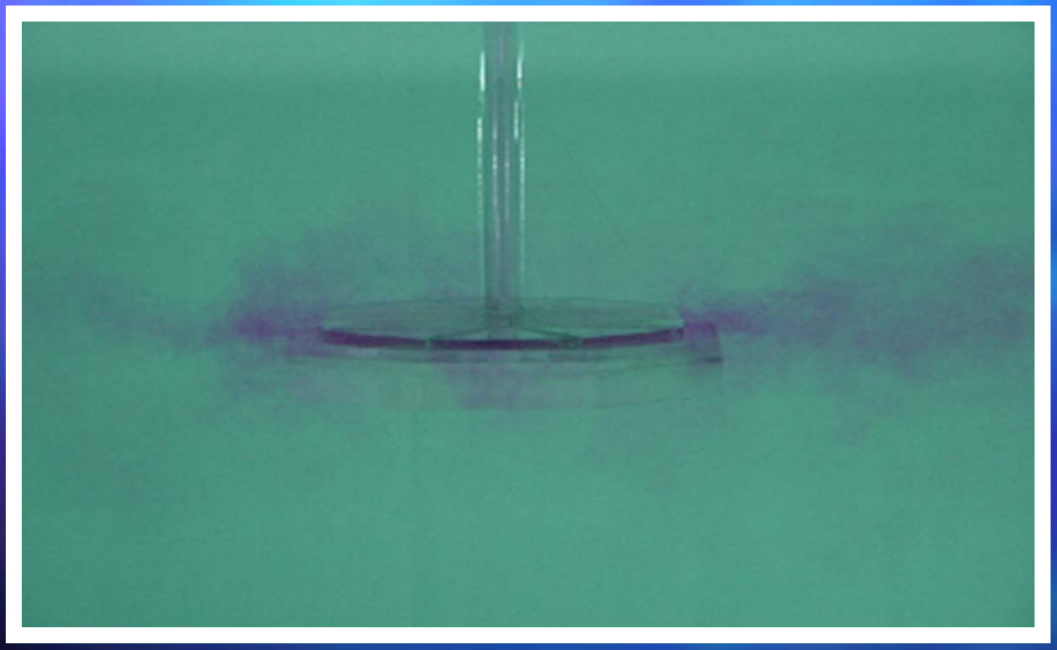


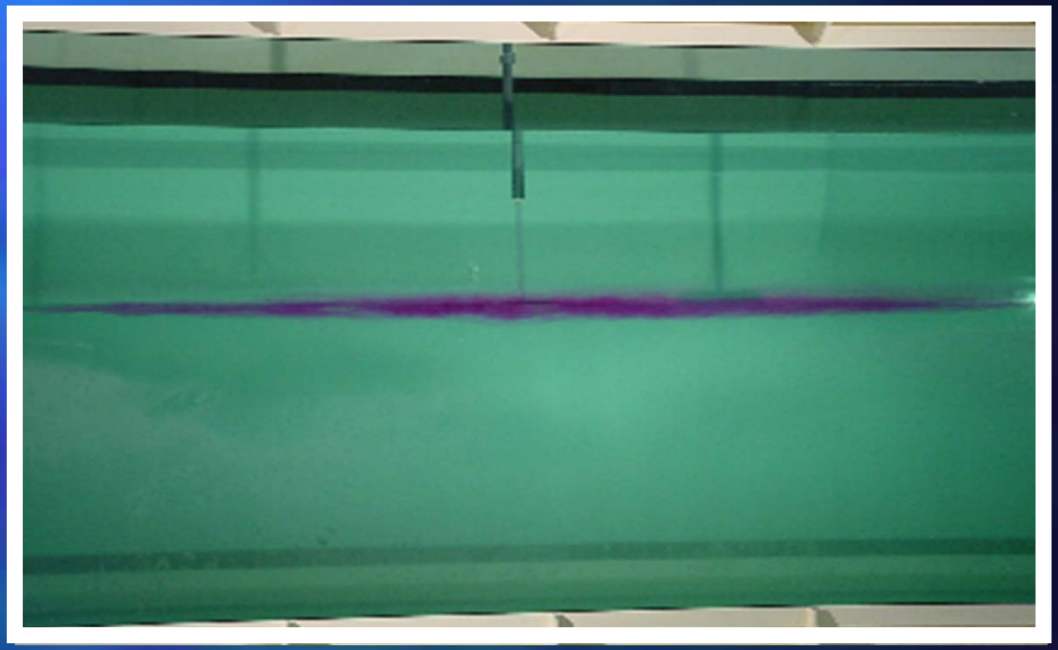
Hydrogen Energy

Left ; Hydrogen Generator(PEM Type) : 1.0 Nm^3/h, 20 N l/min
Right;Hydrogen Storage Tank (Metal Hydride Type)
: 10 Nm^3/h,1Nm^3/h

Fuel Cell(PEM Type)
: Output = 900 W

Simulator for Discharge Seawater



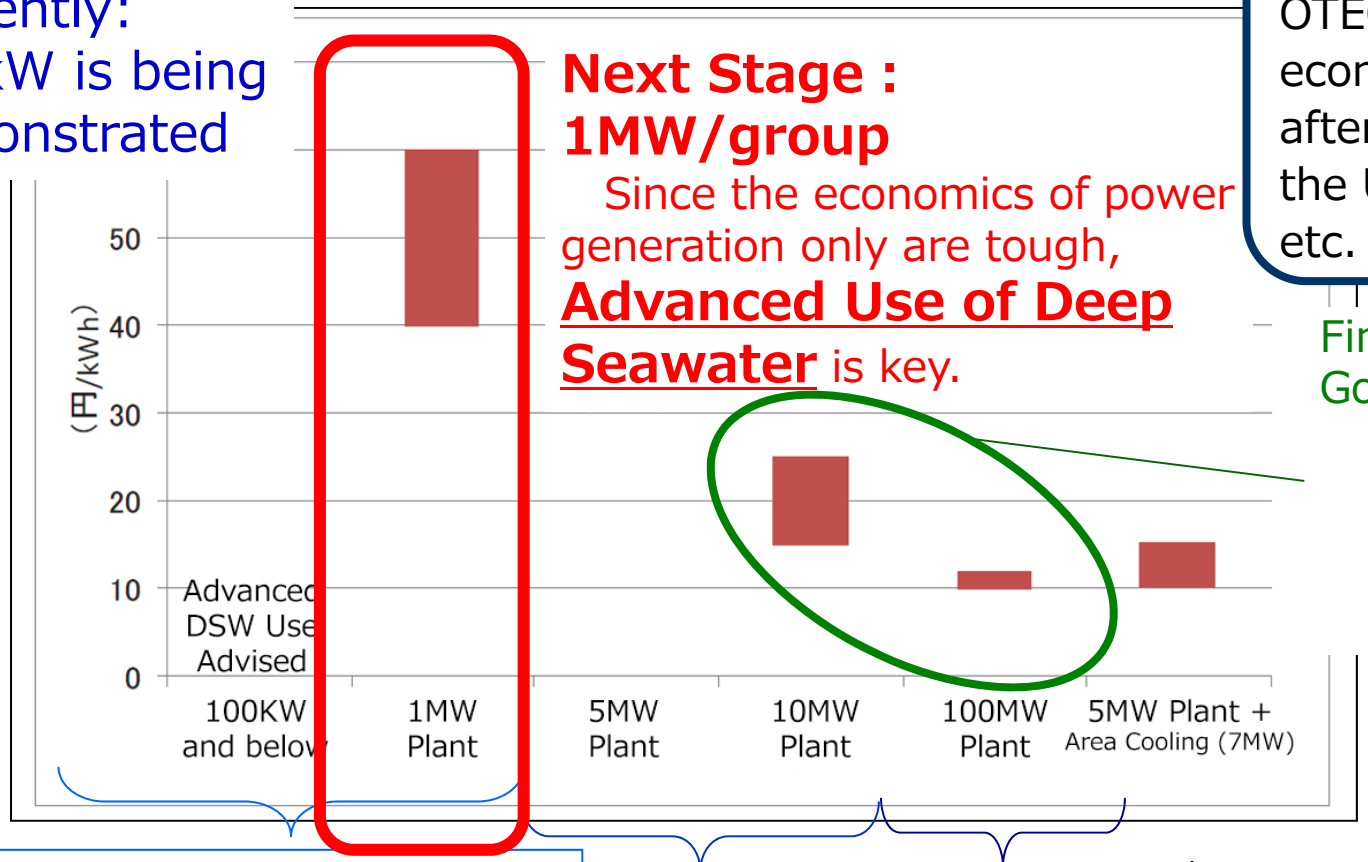


OTEC Commercialization, Expansion of Scale for Cost Reduction

OTEC Power Generation Cost Outlook

(Estimated Values by the OEA-J marine Energy Resource Use Promotion Organization)

Currently:
100kW is being demonstrated



Next Stage : 1MW/group

Since the economics of power generation only are tough, **Advanced Use of Deep Seawater** is key.

Large cost reductions in OTEC technologies due to economies of scale is sought after by not only Japan, but the US, France, South Korea, etc.

Final Commercial Scale Goal : 100MW/group

US, France, South Korea, etc. aim for 100MW commercial plant through 10MW demonstration plant (Attachment).

Graph Source: NEDO "Renewable Energy Technology White Paper," July 2010

Targets deployment in islands and remote areas as Advanced Deep Seawater Use Plant

Power plant for islands: deployment as alternative to the current high-cost petroleum diesel generators

Deployment as commercial power plant intended for areas with large-scale demand. Deployment as a floating energy production base.

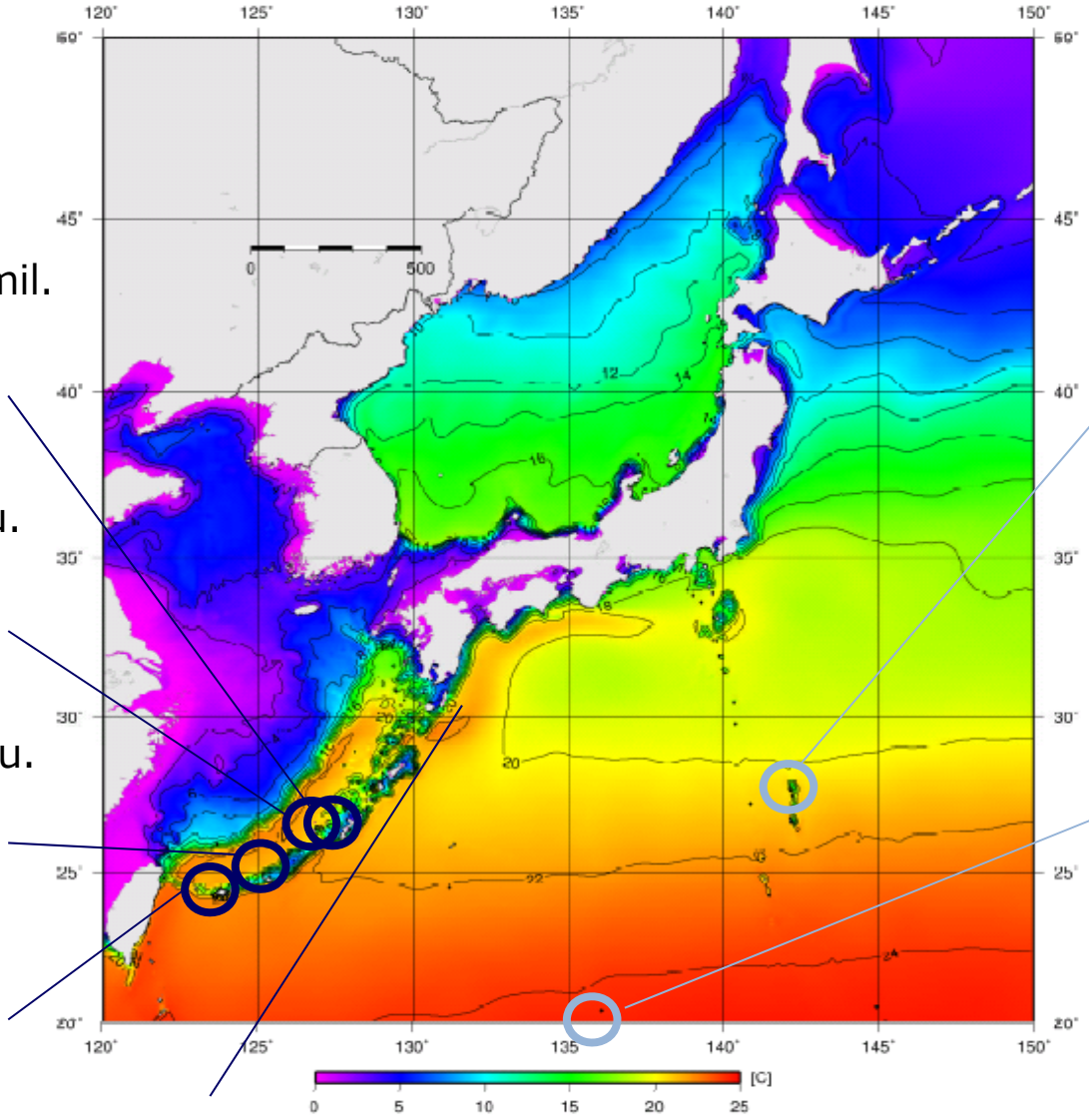
Power Demands in Okinawa

Okinawa Mainland
Population : approx.1.25mil.
Total Capacity of Existing
Power Plant : 1733MW

Kumejima
Population : approx.9thou.
Total Capacity of Existing
Power Plant : 19.2MW

Miyakojima
Population : approx.50thou.
Total Capacity of Existing
Power Plant : 76.5MW

Ishigakijima
Population :
approx.45thou.
Total Capacity of Existing
Power Plant : 69MW



Kuroshio Current Area

Chichijima
Population : approx.2 thou.
Total Capacity of Existing
Power Plant : 4.3MW

Minamitorishima
(Out of this map:
24°17'N 153°59E)

Okinotorishima

REFERENCE：NEDO「海洋エネルギーポテンシャルの把握に係る業務」（平成23年3月）における温度差分布図（5年間平均値）に追記

National Project on OTEC
by NEDO(New Energy and Industrial Technology Development Organization)

KOBELCO
KOBE STEEL GROUP

Further development of HEET ™ to make effective use of energy

National project by NEDO

R&D of core technology for 10MW OTEC (Kobe Steel , Saga Univ.)

by courtesy of Okinawa prefectural office

High heat transfer

-with higher strength

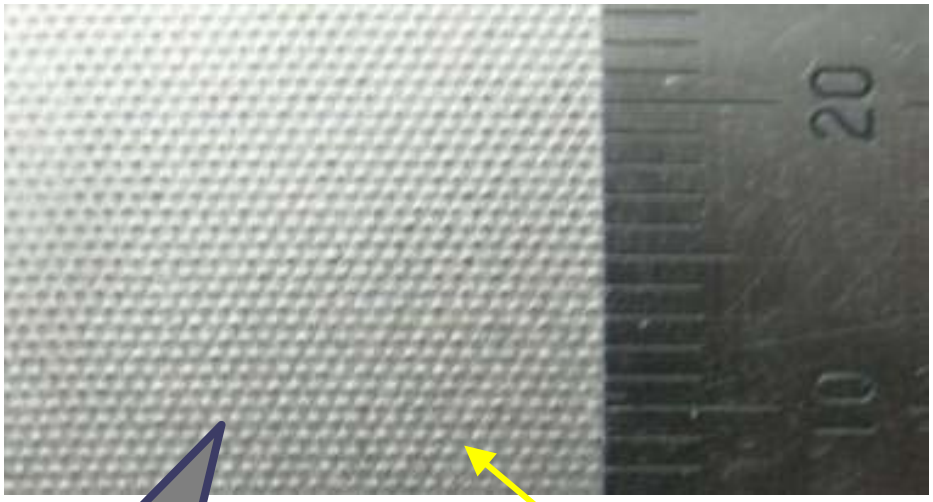
-for condenser

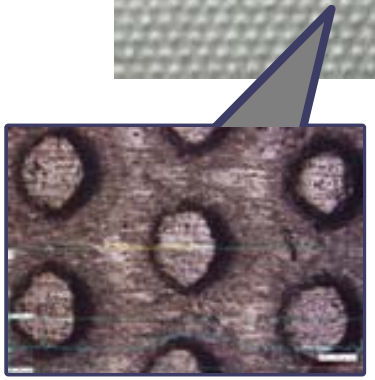
By Akio OKAMOTO

"Cavity" made in rolling process increases heat transfer

Normal surface

Special surface



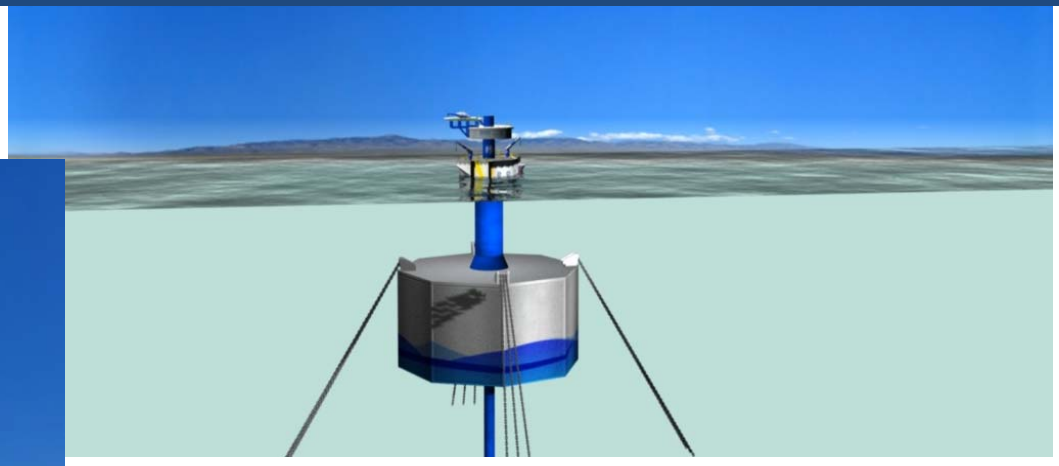


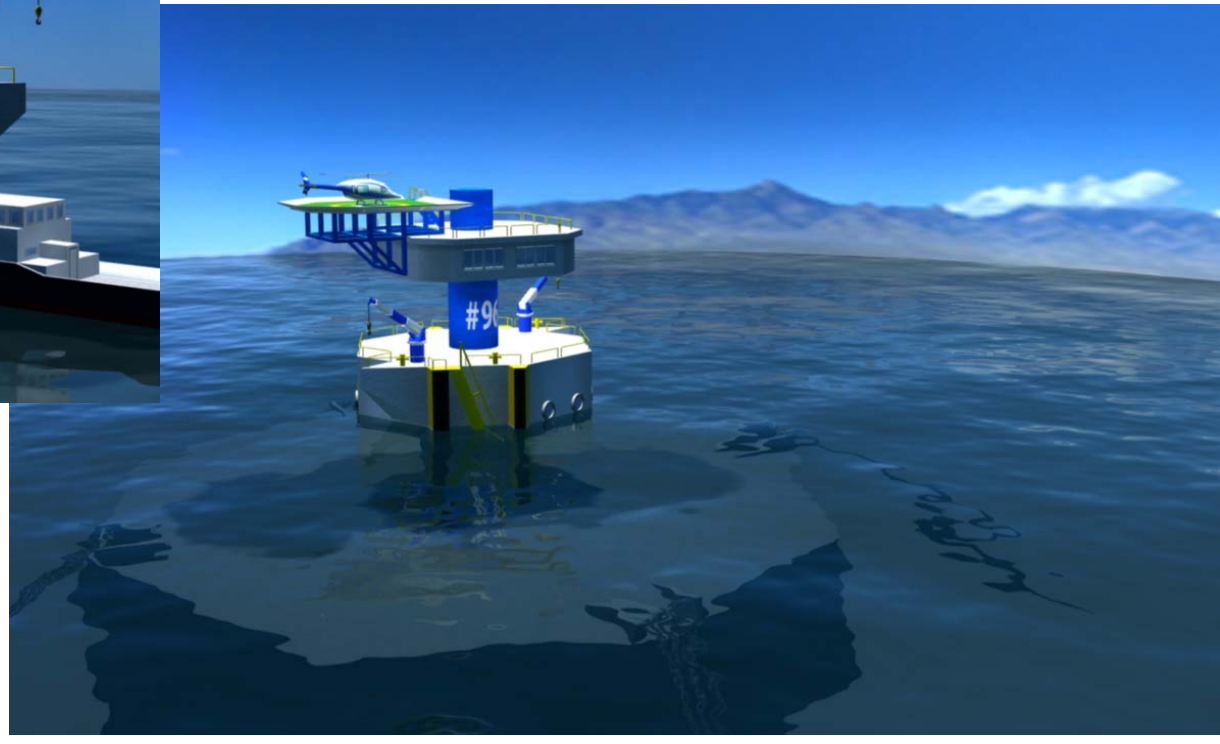
Special surface treated sheet

Grade : 1

Thickness : 0.4~0.6mm

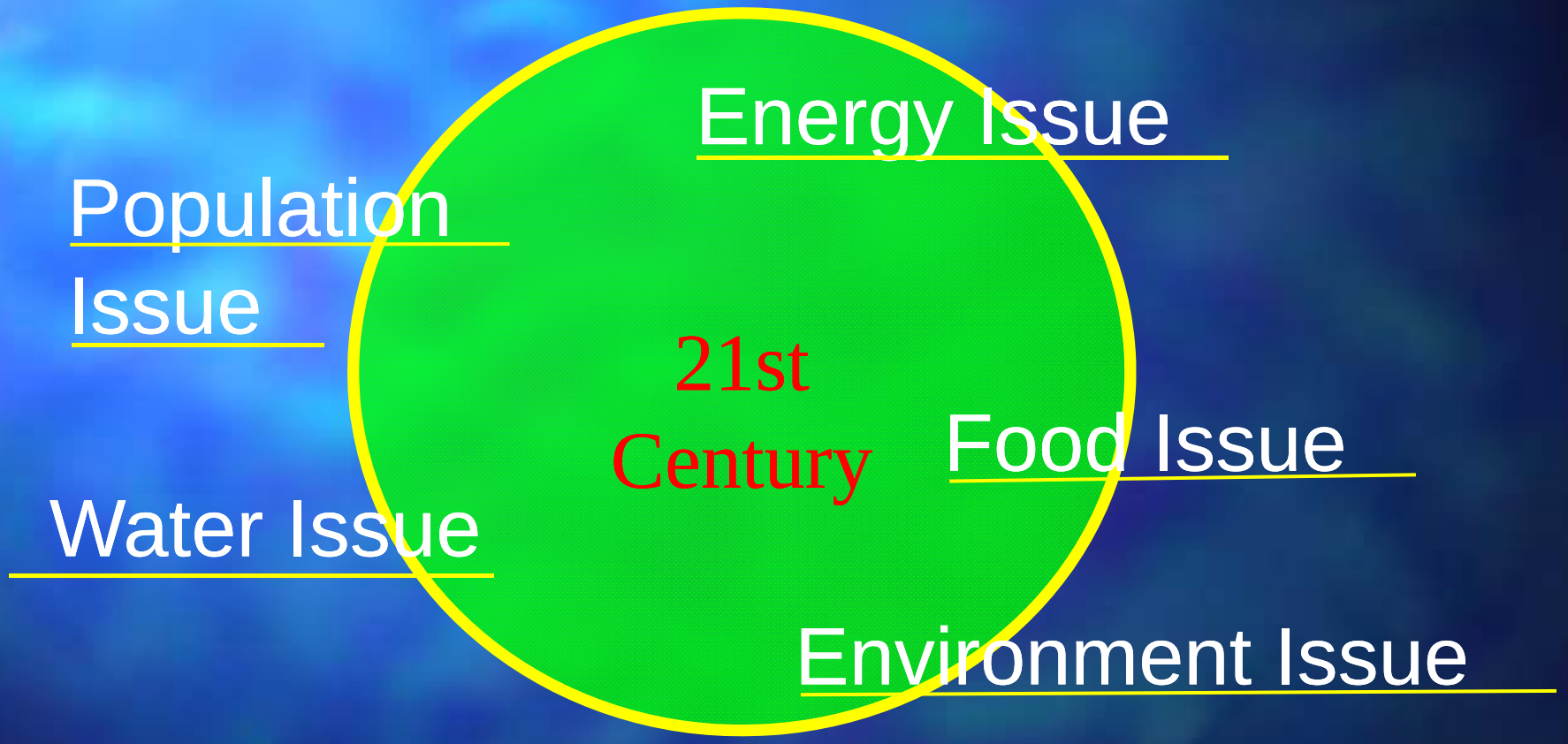
Nippon Kaiji Kyokai (known as ClassNK) has issued its first Approval-in-Principle (AIP) for Totally Submerged OTEC floating power plant model of JMU(Japan Marine United Corp.)





On September 2nd ,2013

Five Issues in 21st Century for Island



OCEAN ENERGY SYSTEMS

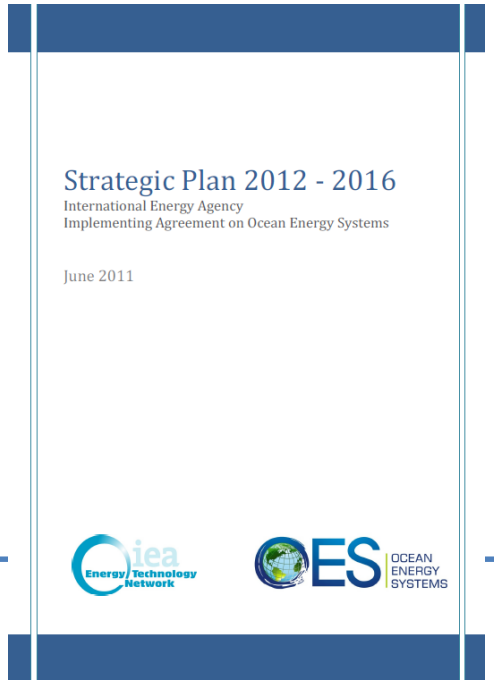
An IEA Technology Initiative

Implementing Agreement on Ocean Energy Systems

OES Vision

The Ocean Energy Systems Implementing Agreement (OES):

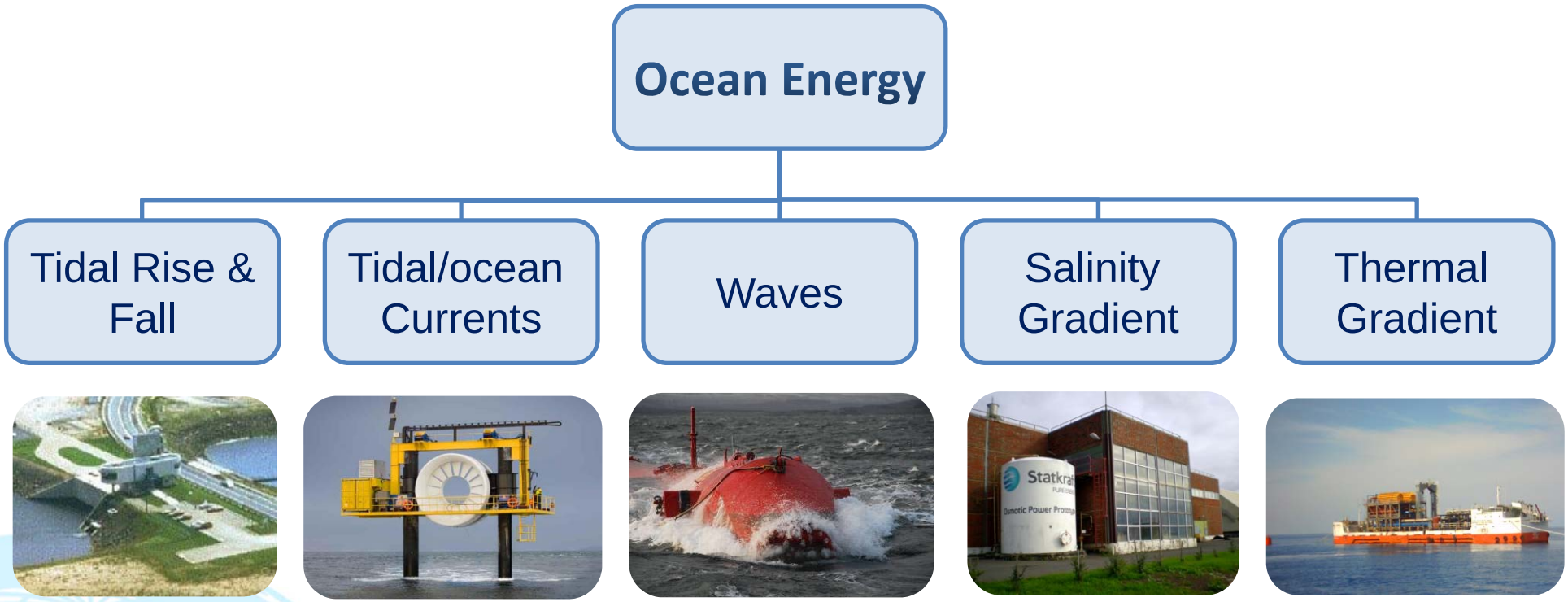
- Intergovernmental collaboration between countries
- Operating under a framework established by the International Energy Agency (IEA) in Paris.



VISION

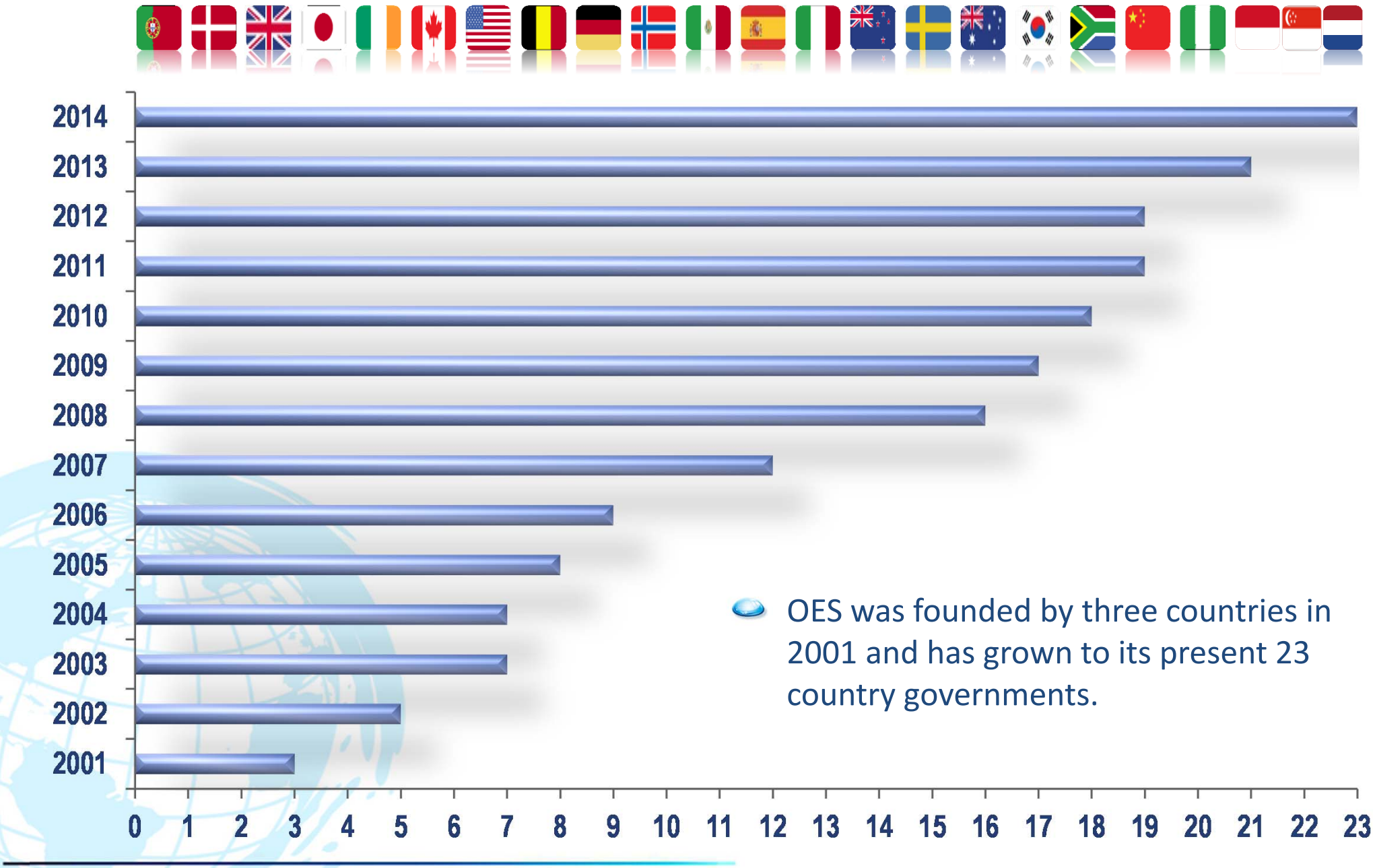
"As the authoritative international voice on ocean energy we collaborate internationally to ***accelerate*** *the viability, uptake and acceptance of ocean energy systems in an* ***environmentally*** *acceptable manner."*

Sources of Ocean Energy



- OES covers all forms of ocean energy, including submarine geothermal, but NOT offshore wind - seawater must be the motive power
- Products can include: electricity, heat, cooling, water (drinking and pressurized), biofuels, chemicals
- Ocean energy is a nascent but truly international industry

Outreach in Membership



- OES was founded by three countries in 2001 and has grown to its present 23 country governments.

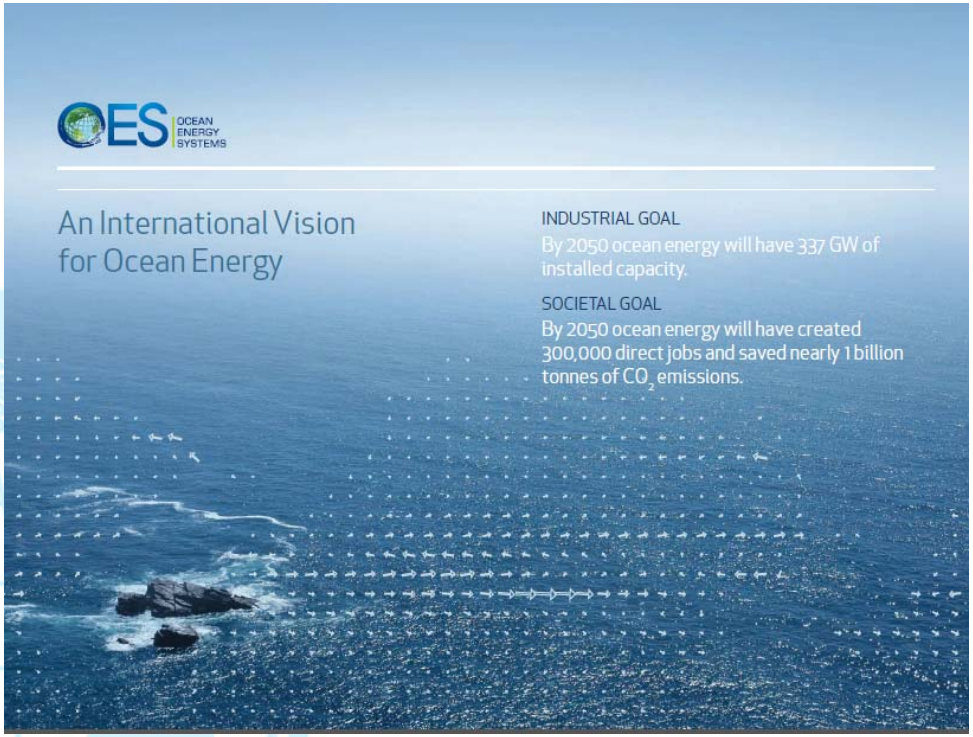
International Vision for Ocean Energy

INDUSTRIAL GOAL

By 2050 ocean energy will have 337 GW of installed capacity

SOCIETAL GOAL

By 2050 ocean energy will have created 1.2 million direct jobs and saved nearly 1 billion tonnes of CO2 emissions



- Facts and figures as well as scenarios to 2050
- All forms of ocean energy in proportion to their present status
- Updated costs figures
- People, water and energy nexus
- Simple, contestable scenarios for market growth
- MARKAL modelling with IEA Modelling Group in Paris

Energy for Island

Blue Revolution from IEA

Thank you

Arigato （感謝）