

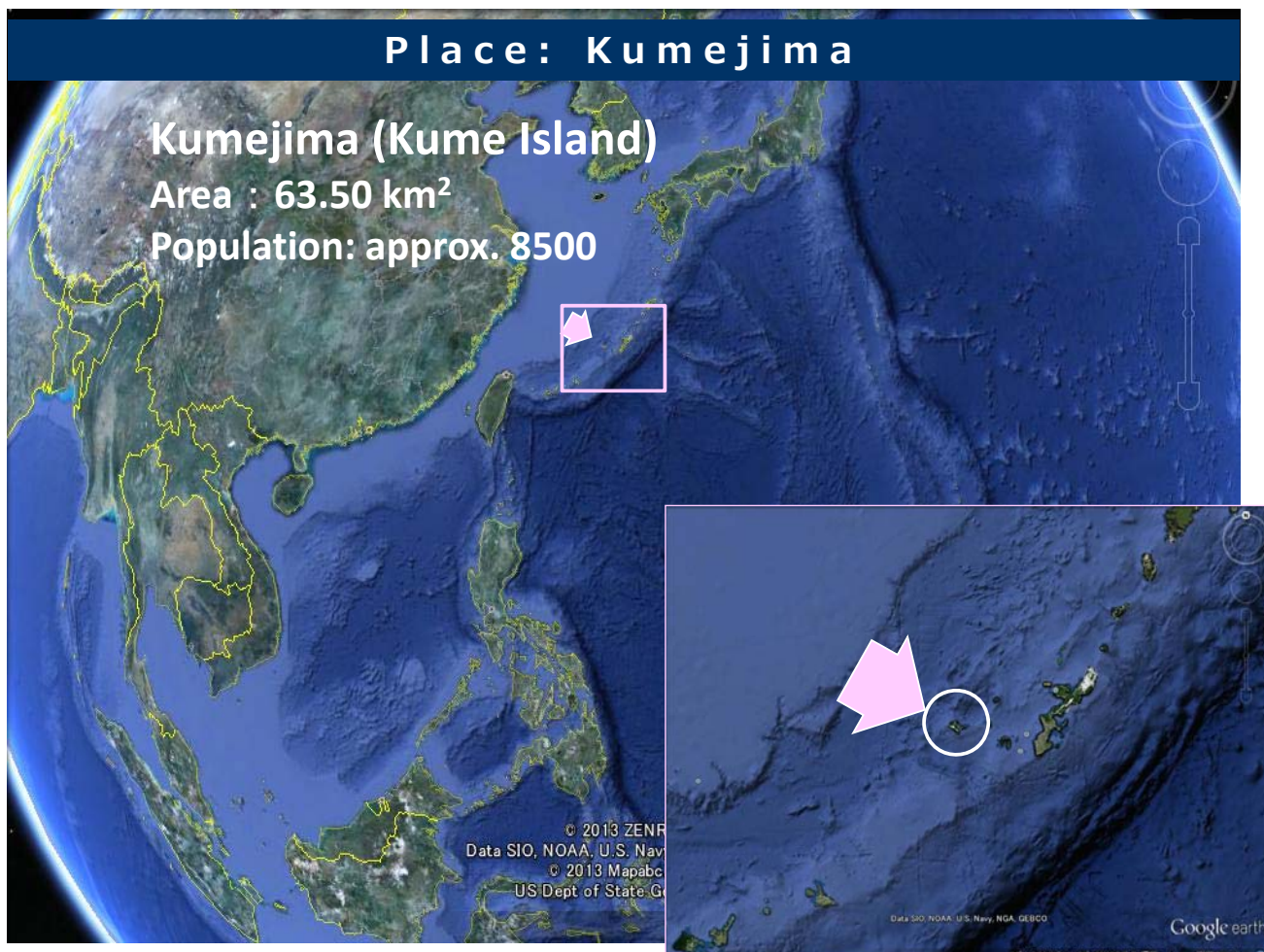
OTEC Demonstration Facility in Kumejima (Okinawa pref., Japan)



Okinawa Prefectural Deep Sea Water
Research Institute, since June 2000



13 September, 2013
4th Ocean Energy Workshop, Kona

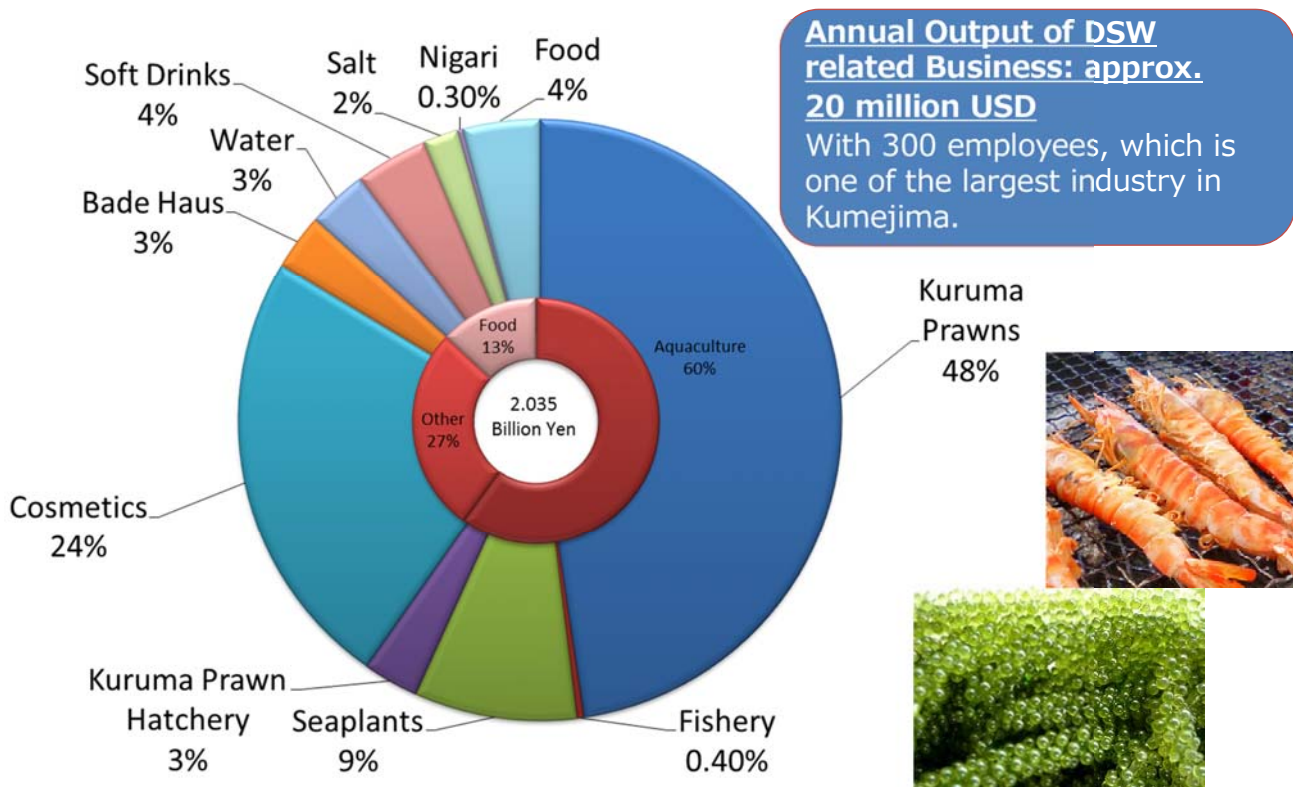


Okinawa Prefectural Deep Sea Water Research Center and Business Park



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

Okinawa Prefectural Deep Sea Water Research Center and Business Park



2.035 Billion yen is roughly equivalent to 21 Million US Dollars @ 97.78 rate

出典：久米島海洋深層水複合利用基本調査 報告書

Kumejima as OTEC Site

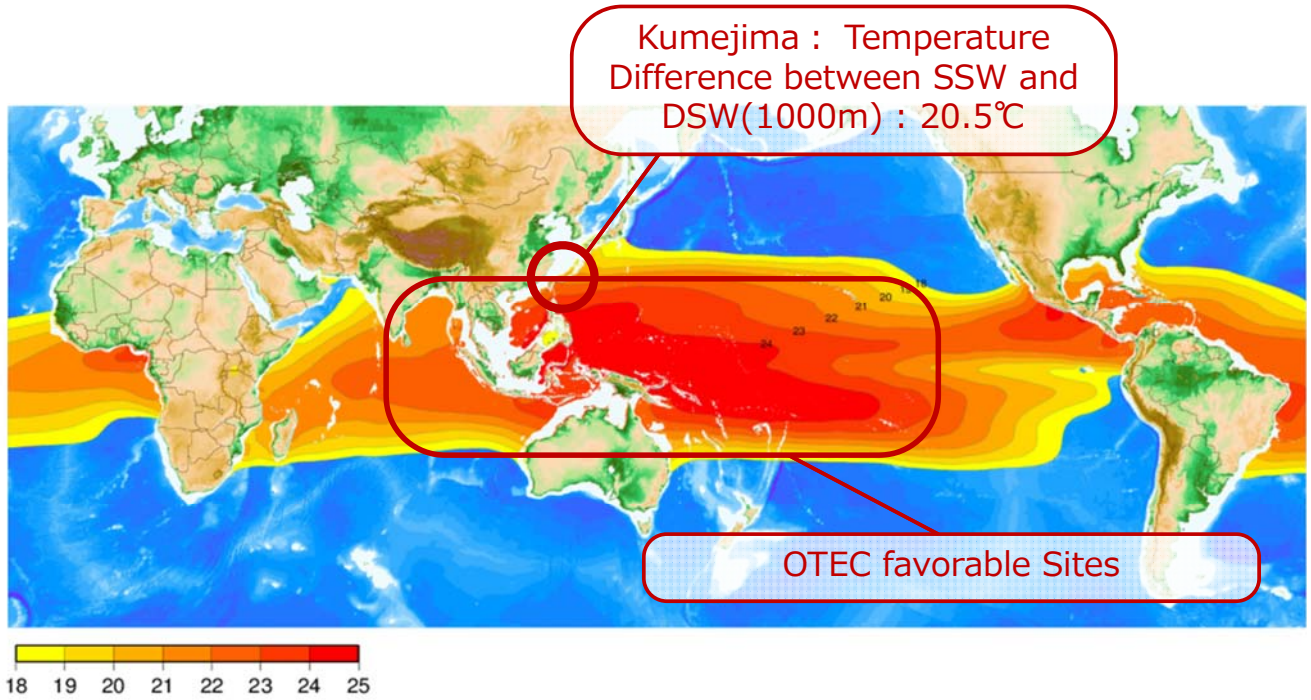
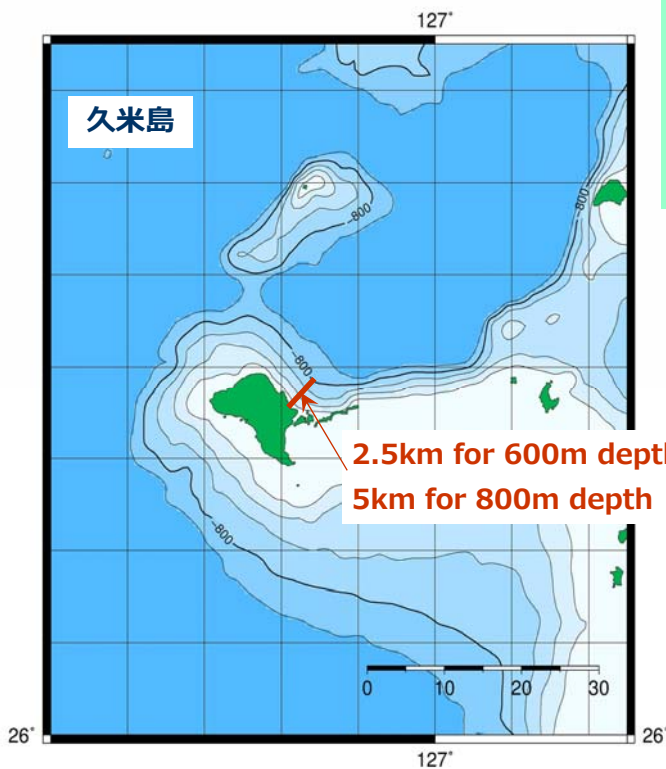


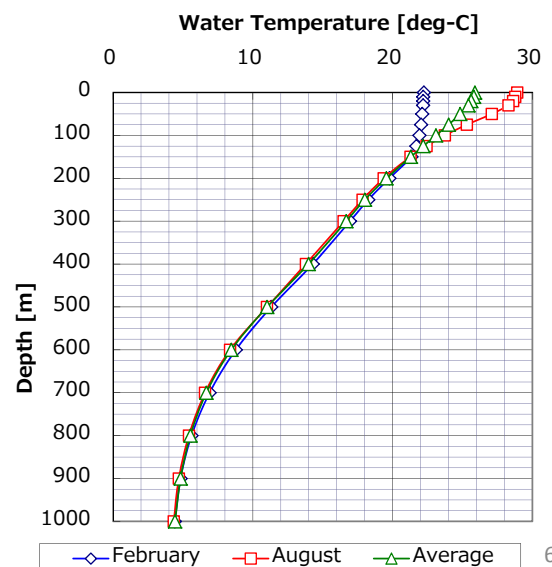
Fig.: Temperature Difference between Surface Seawater and Deep Seawater

Kumejima as OTEC Site



Kumejima Electricity

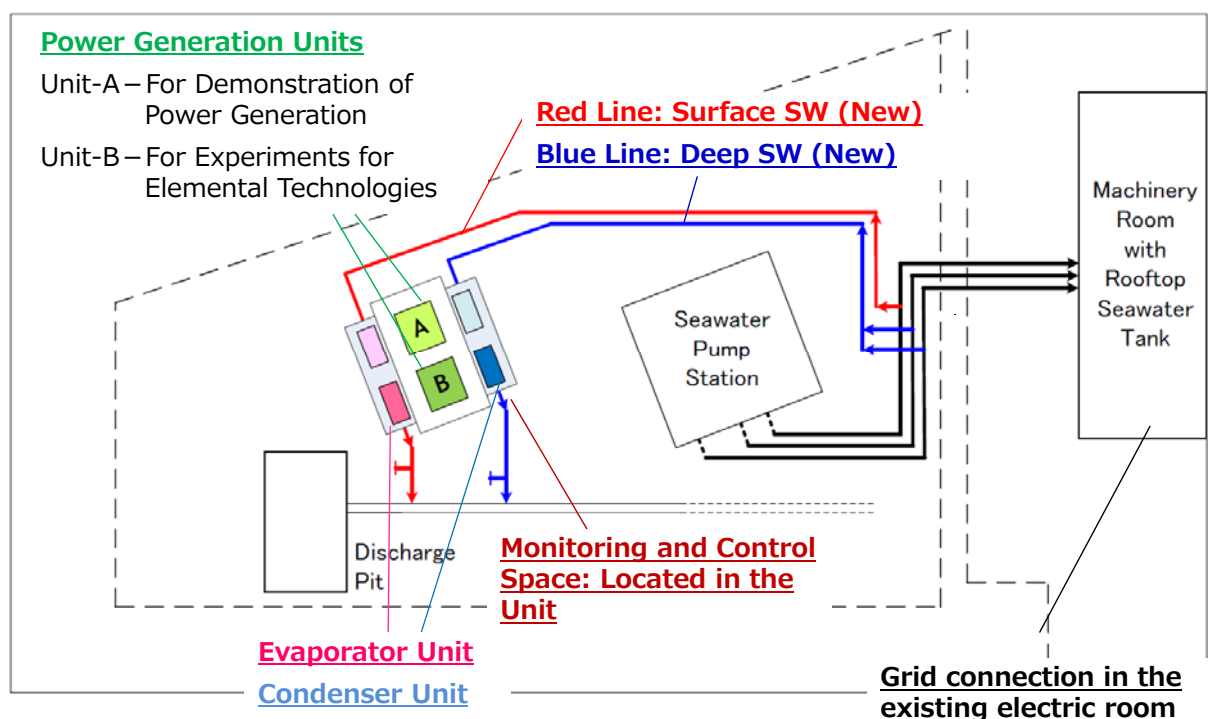
Population: **approx. 8,500**
 Power Plant: Kumejima Power Plant
 Capacity **18,500kW**
 Diesel Engine Generator (HFO)



Location



General Arrangement



OTEC Demonstration Facility in Kumejima (Okinawa)

Power Generation Unit

Unit A for Power Generation Demonstration (max.50kW)

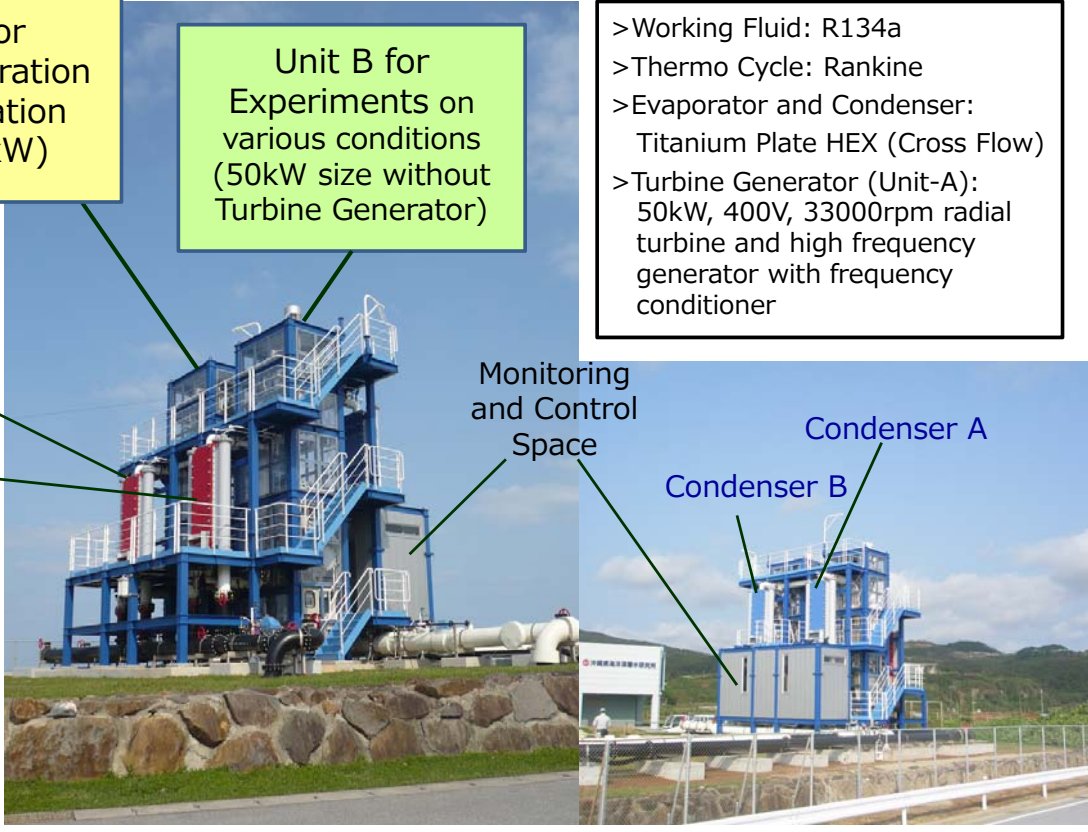
Unit B for Experiments on various conditions (50kW size without Turbine Generator)

- >Working Fluid: R134a
- >Thermo Cycle: Rankine
- >Evaporator and Condenser: Titanium Plate HEX (Cross Flow)
- >Turbine Generator (Unit-A): 50kW, 400V, 33000rpm radial turbine and high frequency generator with frequency conditioner

Evaporator A
Evaporator B

Monitoring and Control Space

Condenser A
Condenser B



OTEC Demonstration Facility in Kumejima (Okinawa)

Deep and Surface Water System



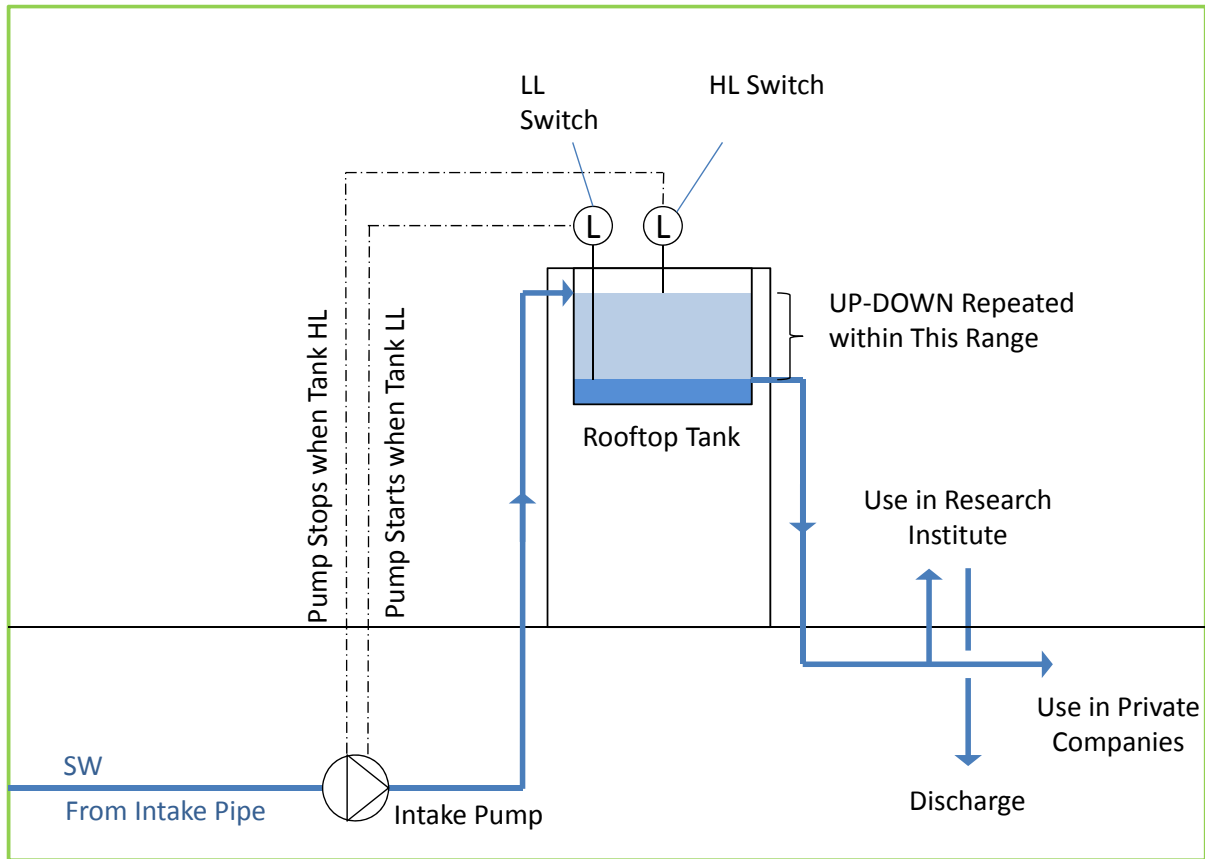
SURFACE WATER

- Flow Rate: Max. 13,000 t/d (540t/h) by the existing SW intake pipe and pump
- Temperature: annual ave. 25.8 °C, summer 29°C, winter 23°C

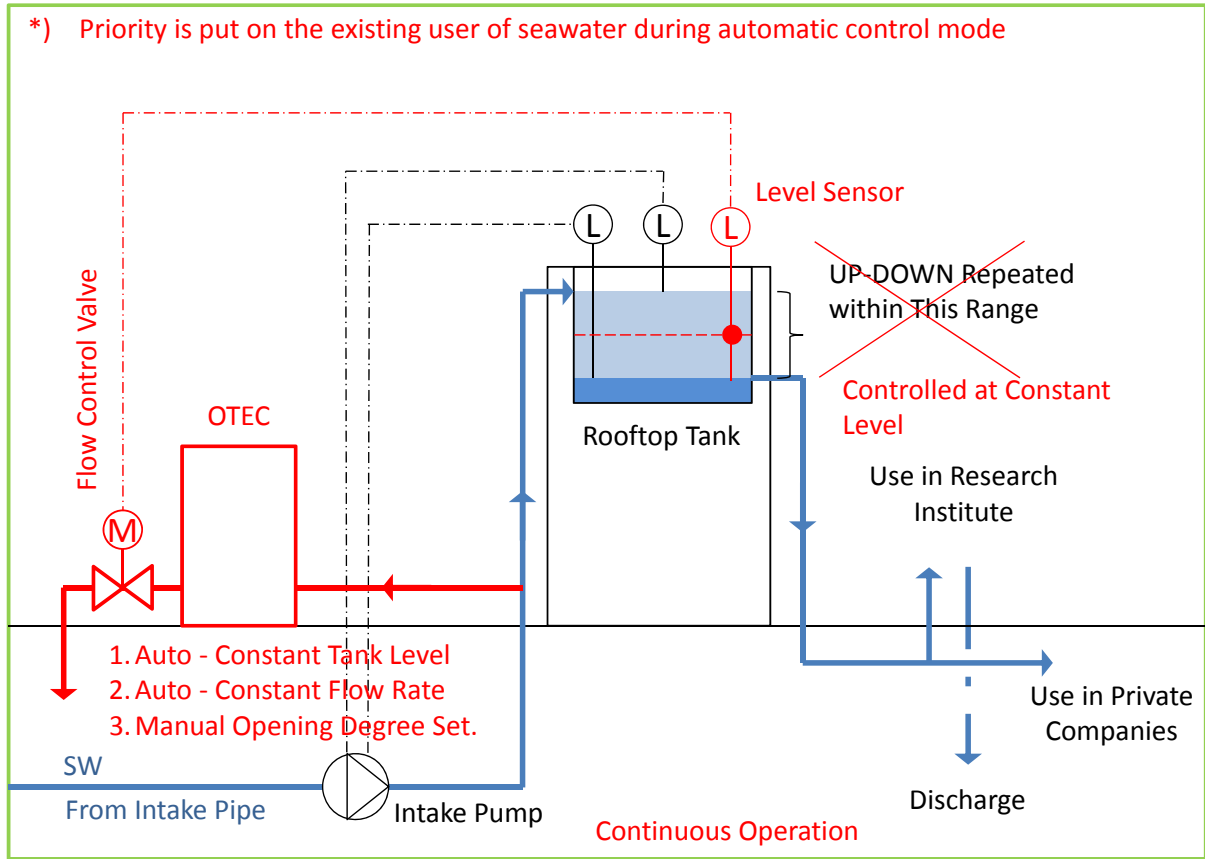
DEEP WATER

- Flow Rate: Max. 13,000 t/d (540t/h) by the existing SW intake pipe and pump
- Intake Depth: 612m by the existing SW intake pipe
- Temperature: annual ave. 9°C

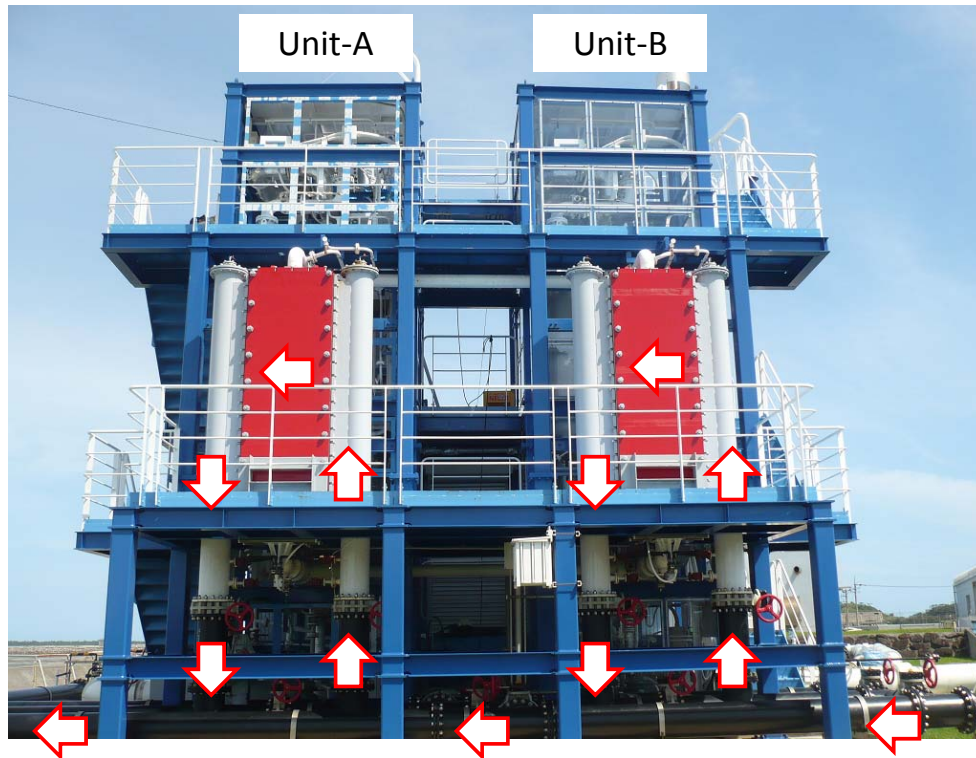
Seawater Flow BEFORE OTEC



Seawater Flow AFTER OTEC

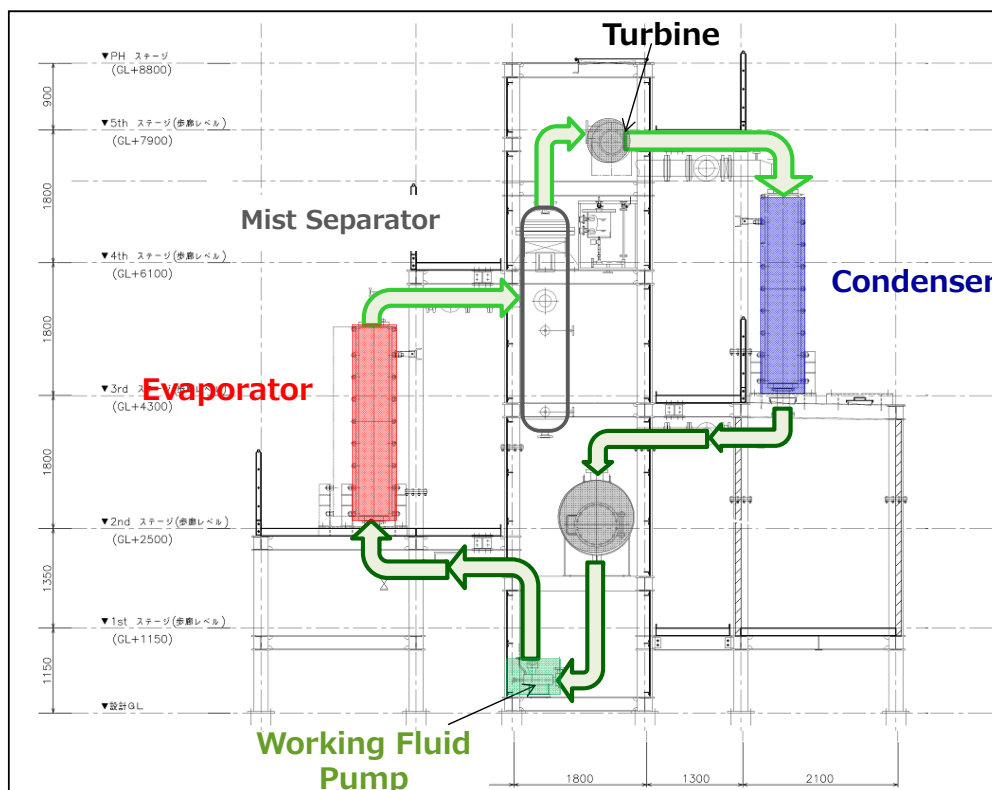


Seawater Flow in the OTEC Facility



Flow Mode: (1) Cascade (A-> B), (2) Cascade (B > A), (3) Parallel, (4) A only (B bypass), (5) B only (A bypass)

WF Flow in the OTEC Facility



Topic: Working Fluid

- The facility was designed and manufactured for both HFC134a and Ammonia.
- The current working fluid: HFC134a

Japanese deregulation for small binary power generation facility in April, 2012

For facilities fulfilling the all conditions below:

- Heat source: hot water or steam in atmospheric pressure
- **Working Fluid: Inert gas**
- Structure preventing people from anoxia in case of leakage
- Design temperature < 250 deg-C
- Design pressure < 2MPa
- Power output < 300kW
- Turbine and Generator are in a body
- Shelter or equivalent against turbine accident

Deregulation about the below requirements:

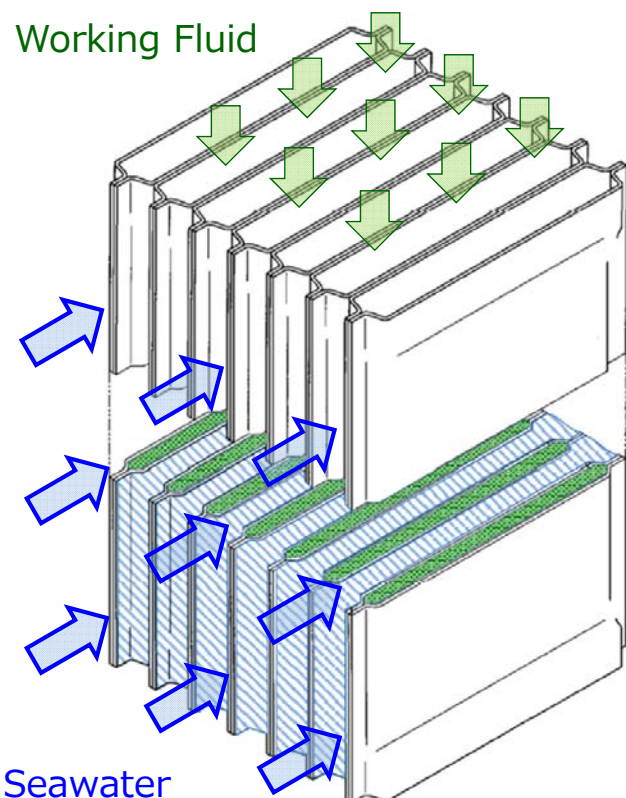
- Submission of various documents
- Inspection by certified authority regarding both equipment and whole facility
- **Distance from public street/road or building outside**
- **Stationed personnel with national certification about boiler and turbine**

**Next Step (1MW):
Ammonia will be used**

Heat Exchanger



Cross Flow Plate Heat Exchanger



Next Step (1MW):

- Same plate size
- Increase the number of plates per unit
- 4 or 5 units for each evaporator and condenser

Turbine Generator and WF Pump

Turbine

Radial, 33000 rpm, without reduction gear

Generator

50kW 400V, 550Hz (33000rpm) with frequency conditioner



Next Step (1MW):

Radial Turbine & Generator with R.Gear Already Commercialized for Binary Power Plants

WF Pump

Commercialized canned type (manufacturer: Nikkiso)



Next Step (1MW):

Same type commercialized pump, with more common SPEC (larger capacity, but almost same head)

<<PR by Kumejima Town Office>>

For More Details, Please Visit Kume Island !

<http://kumeguide.com/>



Native English Speaker Guide Is Available Now!



History

Mile Stones

Jan. 2013

Feb. 2013

Mar. 2013

Apr. 2013

May. 2013

Jun. 2013

28 Jan.
Construction
Started at Site



30 Mar. / 1st Power Generation Test Succeeded

Surface Water: 23.5 °C, 330t/h
Deep Water: 9.3 °C, 250t/h
Power Output: 3.1kW (for Test)



15 Apr.
Official
Operation

16 Jun.
Opening Ceremony



History



28 Jan. Kanegusuku Port, Kumejima



History



30 Jan. The Site, Kumejima

History



1 Feb. The Site, Kumejima

History



4 Feb. The Site, Kumejima

History



8 Feb. The Site, Kumejima

History



11 Feb. The Site, Kumejima

History



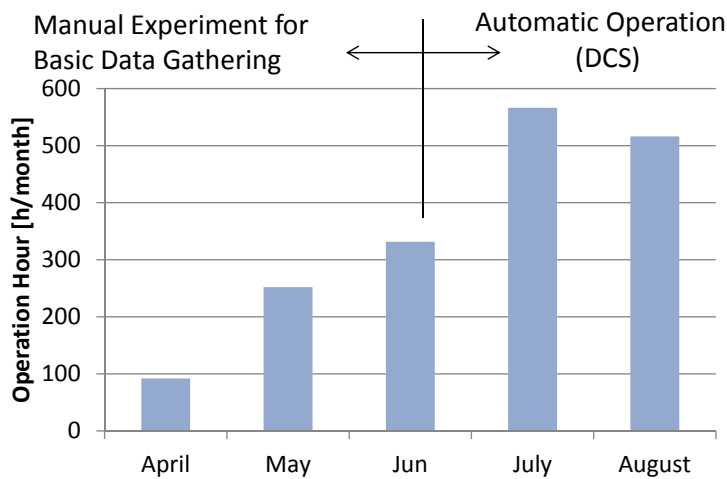
8 Mar. The Site, Kumejima

History

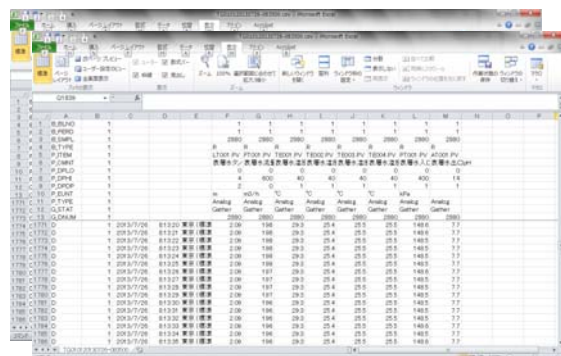


8 Apr. The Site, Kumejima

Operation



Continuous Data Gathering per 1 Second as CSV form



Operation

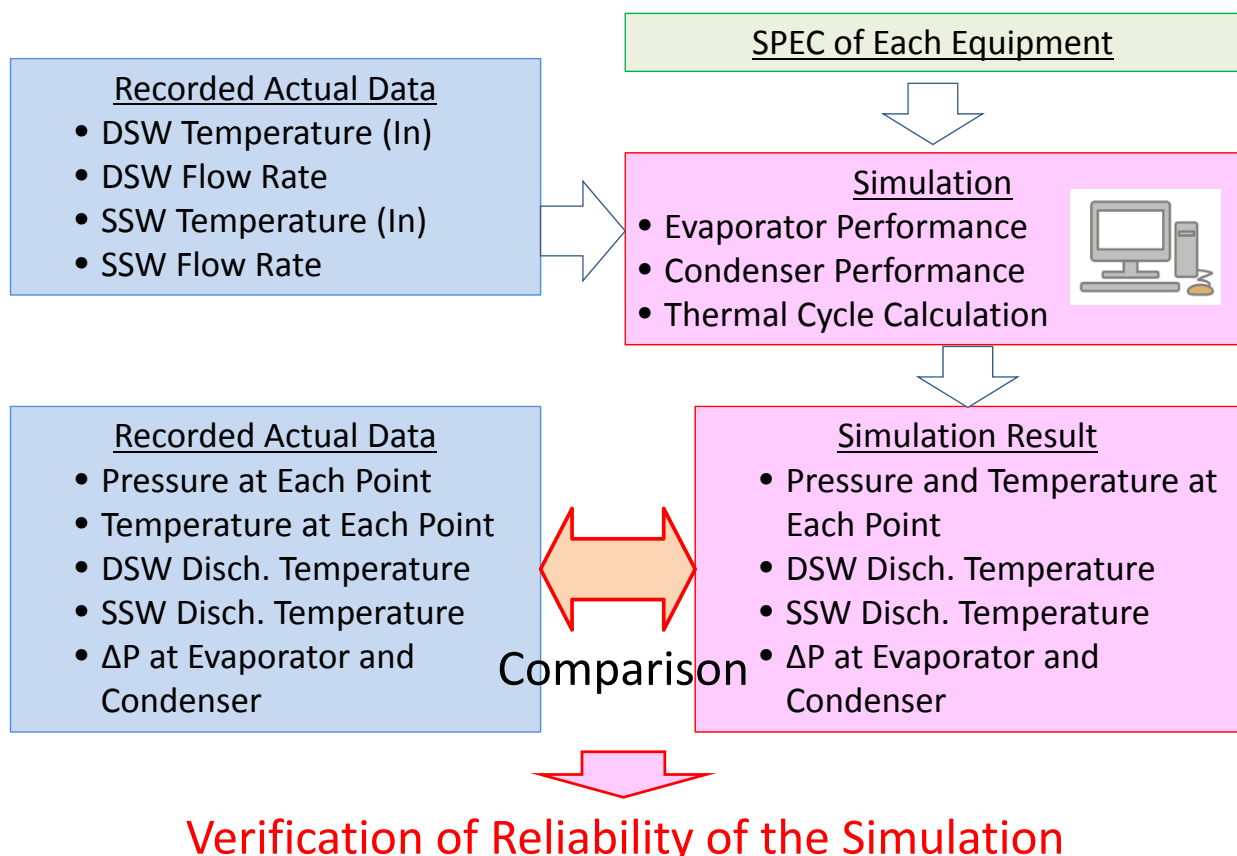
Achieved up to the Present

- ✓ Continuous Automatic Operation of Unit-B (Unit for Experiment) : 2weeks (continuing now)
- ✓ Continuous Automatic Operation of Unit-A with Turbine Generator Bypassed: 2weeks (continuing now)
- ✓ Comparison: Simulation vs. Actual Operation in various conditions
- ✓ 15kW Electric Power when approx.40% Load (30-40% seawater can be used continuously)

To do next

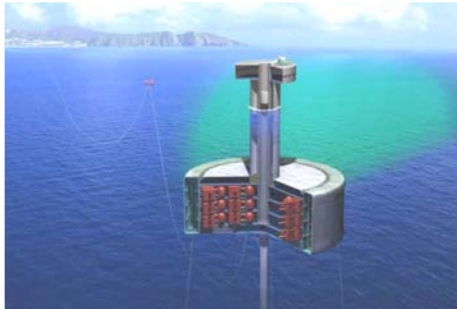
- ✓ Continuous Automatic Operation of Unit-A with Power Generation Connected with Grid
- ✓ Larger Power Generation Using More Seawater

Analysis "For Next Stage!"



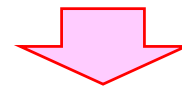
Analysis "For Next Stage!"

Design Parameters for Larger Plant



Simulation based Design And Optimization

- Evaporator Performance
- Condenser Performance
- Thermal Cycle Calculation



- ✓ Estimation on Power Output in High Reliability
- ✓ Reduction of Technical Risk for Larger Plant

Education "For Future"



- ✓ Over 100 Students and Children Have Visited the Facility in this 4 months.
- ✓ System Configuration of OTEC Is Similar to Conventional Steam Turbine Power Plant such as Coal Fired Thermal or Nuclear...Basic Concept of Power Generation Can Be Learned.

People's Awareness

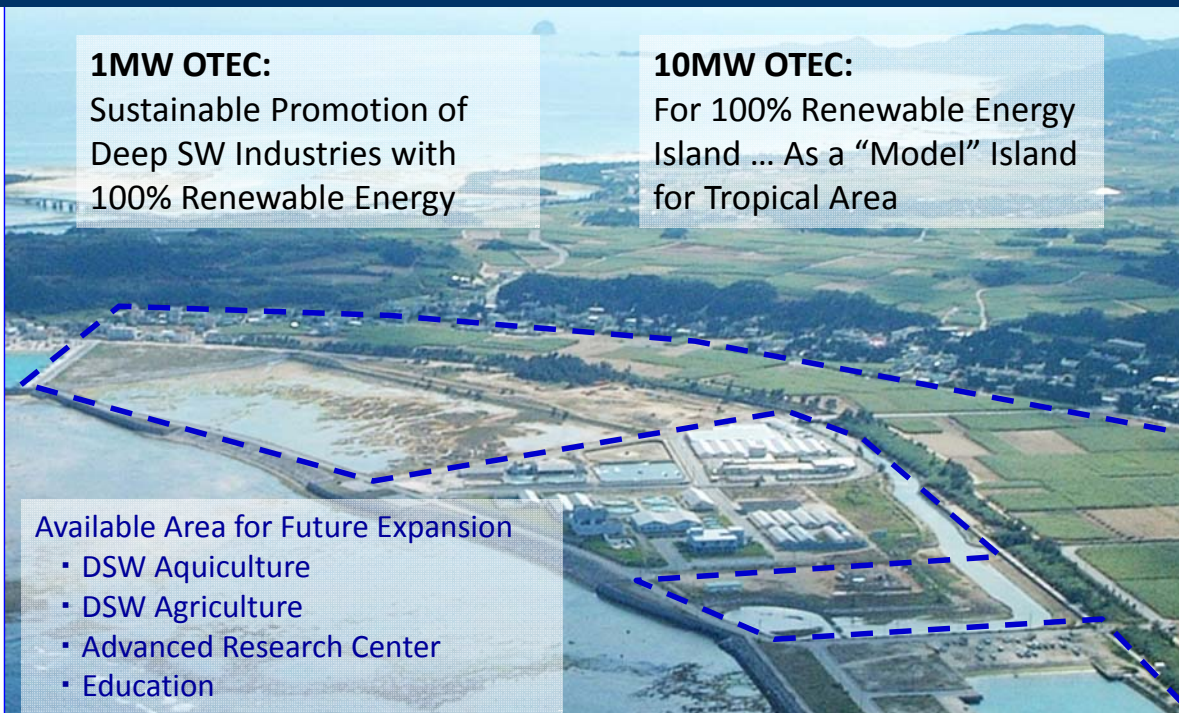


「夢の扉」南の楽園より“半永久的発電”



- ✓ One of the Most Popular TV Show in Japan Introduces OTEC focusing on This Project: <http://www.youtube.com/watch?v=gOMe6hWHokc>
- ✓ Appearances of OTEC in TV Programs and Newspapers Increases Dramatically after Start of this Project.

Kume Island's Future Plan



We believe this project contributes to acceleration of OTEC commercialization leading sustainability in Hawaii, Okinawa and Other Tropical Island!