



Marine Energy Platform for the Commercialization of OTEC and Seawater Battery Technologies in Papua New Guinea

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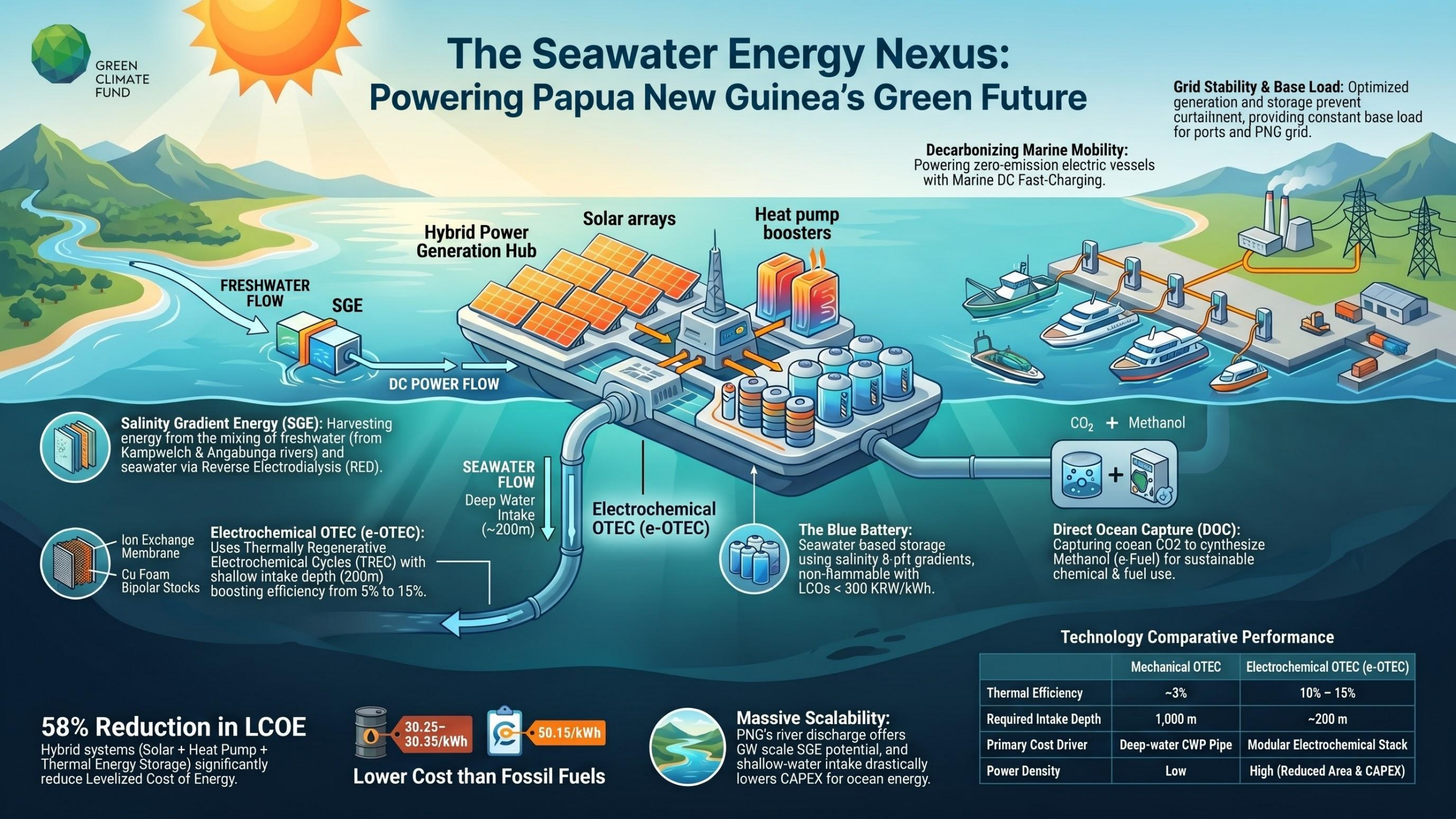
Korea Institute of Energy Research, South Korea



The Seawater Energy Nexus: Powering Papua New Guinea's Green Future

Grid Stability & Base Load: Optimized generation and storage prevent curtailment, providing constant base load for ports and PNG grid.

Decarbonizing Marine Mobility: Powering zero-emission electric vessels with Marine DC Fast-Charging.



Salinity Gradient Energy (SGE): Harvesting energy from the mixing of freshwater (from Kampwelch & Angabunga rivers) and seawater via Reverse Electrodialysis (RED).

Electrochemical OTEC (e-OTEC): Uses Thermally Regenerative Electrochemical Cycles (TREC) with shallow intake depth (200m) boosting efficiency from 5% to 15%.

SEAWATER FLOW
Deep Water Intake (~200m)

Electrochemical OTEC (e-OTEC)

The Blue Battery: Seawater based storage using salinity 8-pft gradients, non-flammable with LCOs < 300 KRW/kWh.

CO₂ + Methanol



Direct Ocean Capture (DOC): Capturing ocean CO₂ to synthesize Methanol (e-Fuel) for sustainable chemical & fuel use.

58% Reduction in LCOE
Hybrid systems (Solar + Heat Pump + Thermal Energy Storage) significantly reduce Levelized Cost of Energy.

Lower Cost than Fossil Fuels
30.25-30.35/kWh vs 50.15/kWh

Massive Scalability: PNG's river discharge offers GW scale SGE potential, and shallow-water intake drastically lowers CAPEX for ocean energy.

Technology Comparative Performance

	Mechanical OTEC	Electrochemical OTEC (e-OTEC)
Thermal Efficiency	~3%	10% - 15%
Required Intake Depth	1,000 m	~200 m
Primary Cost Driver	Deep-water CWP Pipe	Modular Electrochemical Stack
Power Density	Low	High (Reduced Area & CAPEX)

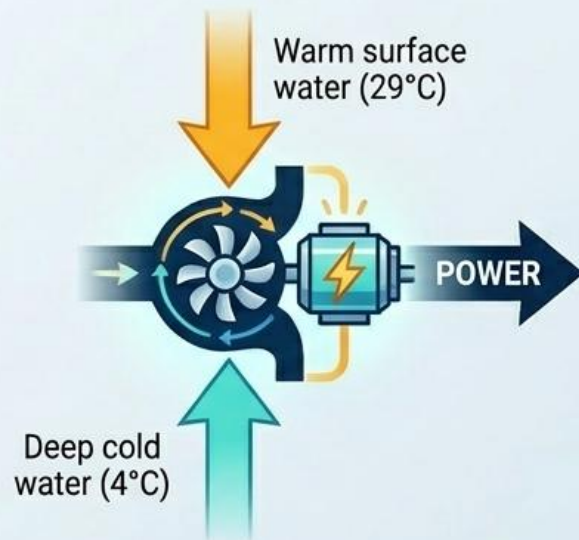
Introduction

- **CTCN TA:** Country-wide Feasibility Study on the Potential of Ocean Technology Energy Conversion (OTEC) in Papua New Guinea
- **Request Title:** Pre-feasibility study on Salinity Gradient Energy Technology
- **Climate Objective:** Mitigation of Climate Change
- **Sector:** Energy
- **Link to CTCN Programme of Work:** Energy Systems
- **Main results expected from TA:**
 - a) Increase capacity on non-GHG action-based Targets (under the PNG's NDC – increase data availability);
 - b) Enhance data collection on OTEC potential in PNG;
 - c) Increase penetration of OTEC in the country's energy mix;
 - d) Develop National Policy on OTEC in PNG;
 - e) Training and Capacity Building on OTEC in PNG.

Working Principles

HARNESSING THE SEA: CONTINUOUS & STABLE GENERATION

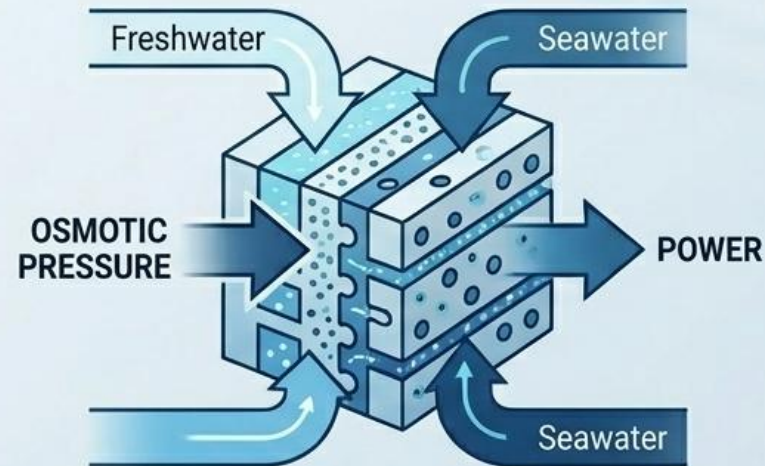
e-OTEC (Thermal Gradient)



Input: Deep cold water (4°C) + Warm surface water (29°C).

Role: Steady, dispatchable power supply.

Salinity Gradient Power

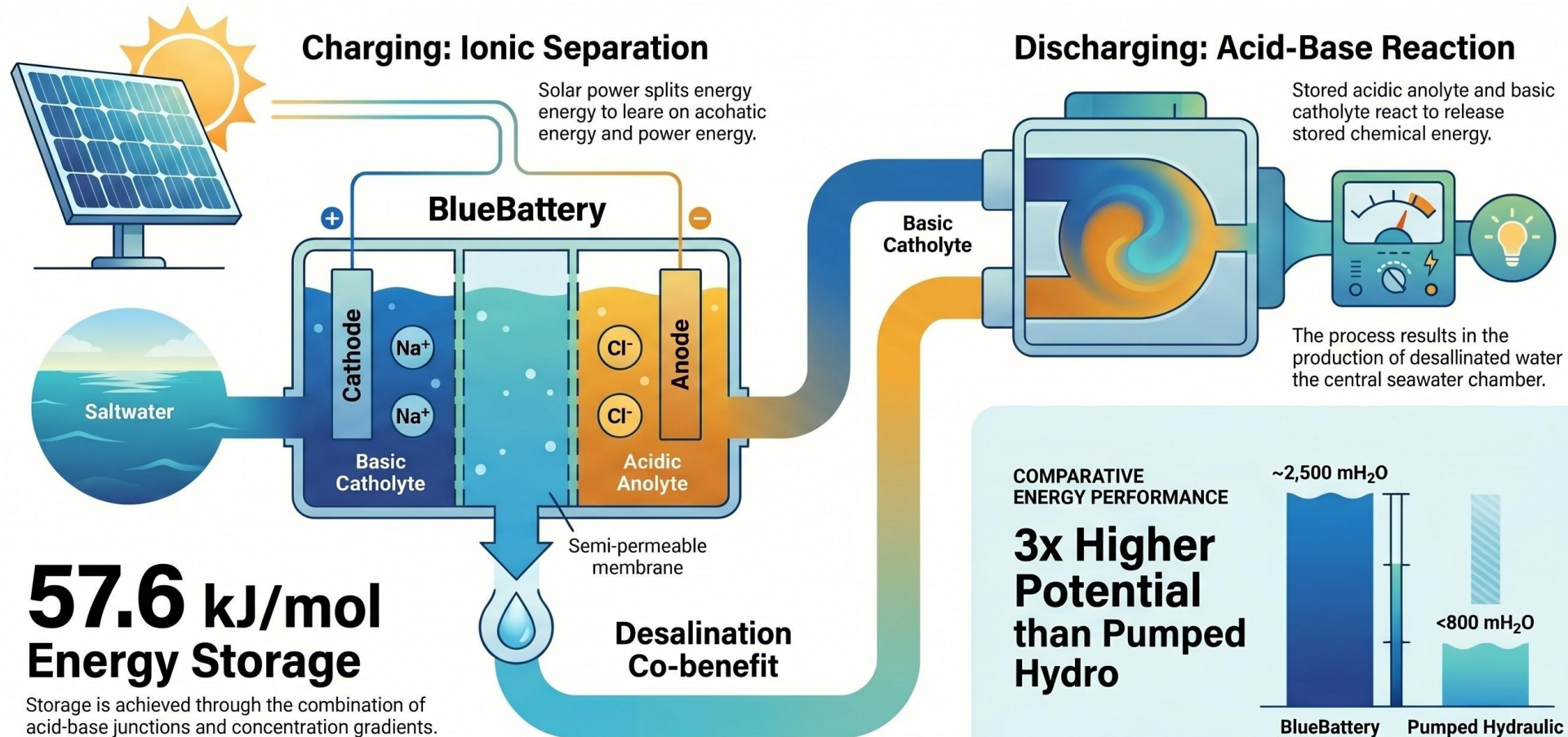


Input: Osmotic pressure difference between freshwater and seawater.

Role: Constant Base Load for the port hinterland.

Working Principles

BlueBattery: Powering Energy Storage with Seawater



Seawater-Energy Nexus

THE BLUE BATTERY HUB: ERADICATING CURTAILMENT

Core Function:

Redirects excess solar and wind energy from onshore arrays into massive seawater-based storage systems, ensuring 100% utilization of harvested power.



EXCESS SOLAR
& WIND ENERGY



STORED
POWER FOR GRID
& SHIPPING



Density: **10 Wh/L**

Levelized Cost of Storage (LCOS):
< 300 KRW/kWh

Implementation Plans

SYSTEM ARCHITECTURE: THE 3-LAYERED ECOSYSTEM

Surface & Onshore
(Grid & Distribution)

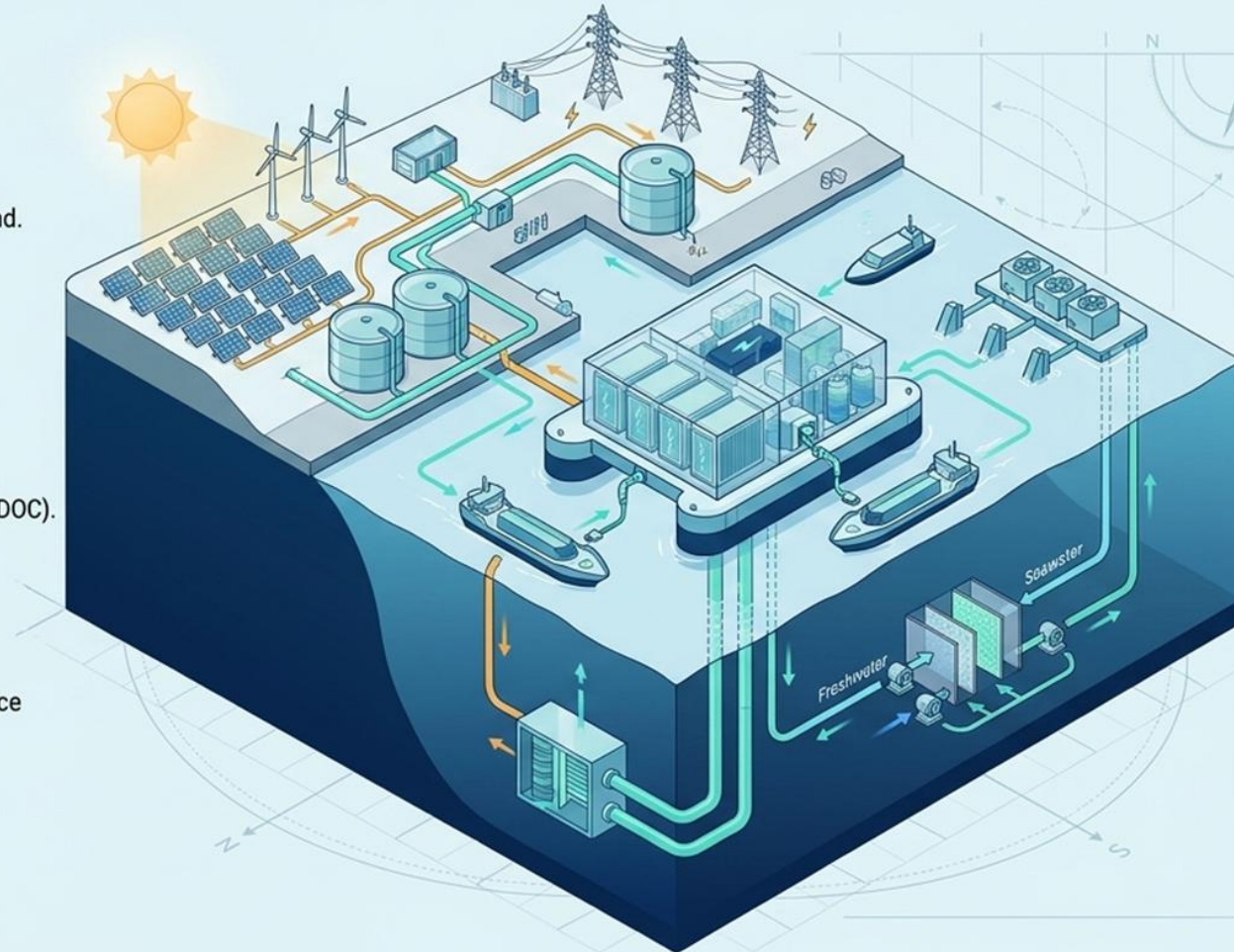
- Captures Solar PV & Wind.
- Seawater-originated Energy Storage Tanks bridge offshore harvesting and onshore demand.

Sea Level
(Storage & Transport Hub)

- The Blue Battery Central Hub (Density: 10 Wh/L, LCOS < 300 KRW/kWh).
- Powers Zero-Emission Electric Ships & Direct Ocean Capture (DOC).

Subsurface
(Deep Sea Energy Source)

- e-OTEC: Harvests thermal gradients between warm surface and cold deep water.
- Salinity Gradient: Leverages osmotic pressure differentials.

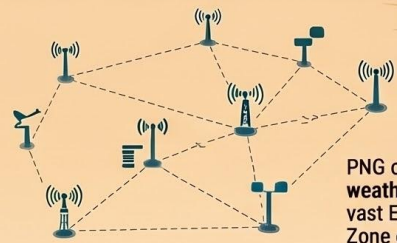


e-OTEC energy potential assessment

Beyond the Data Desert: Powering Papua New Guinea's Blue Economy

The "Data Desert" Crisis

A Crippled Observation Network



Economic Paralysis from Scientific Blindness



Lack of data caused unpredictable dam droughts and mining shutdowns, forcing expensive shifts to diesel power.

The Infrastructure Deficit



Rugged terrain and brain drain have paralyzed traditional ground-based environmental monitoring.

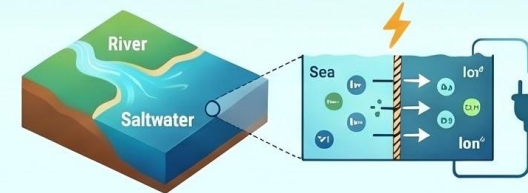
The Reanalysis Solution & Ocean Energy

From 2D Surface to 3D Depth



Harvesting the "Free Energy of Mixing"

Salinity Gradient Energy (SGE) converts the salt difference between rivers and seas into electricity.



Strategic Site Selection

Success requires stable river estuaries with low "fouling" risk to protect sensitive energy membranes.



	Traditional Observation	HYCOM Reanalysis (ESPC-D-V02)
Data Continuity	Uneven & prone to gaps	Gap-free 3-hourly time series
Spatial Scope	Limited to surface "skin"	3D Vertical Profiles (0m - 5000m)
Resolution	Low / Fragmented	High-precision 1/12° (approx. 8-9 km)

Capacity building



Collaborative RD&D



Seawater Energy Nexus : Future works

The Seawater-Based Energy Ecosystem: From Storage to Zero-Emission Transport

THE BLUE BATTERY HUB & STORAGE



High-Efficiency Energy Storage

Seawater-based batteries achieve 10 Wh/L density with costs under 300 KRW/kWh



Curtailment Prevention

Surplus solar and wind energy is captured into seawater-originated storage tanks.



Integrated Resource Recovery

The system facilitates **Direct Ocean Capture** to produce **Methanol** (e-Fuel)

DECENTRALIZED ON-OFFSHORE APPLICATIONS

Fossil-Free Maritime Transport

Electric ships utilize seawater secondary batteries and e-Fuel to eliminate air pollution



Multi-Gradient Power Generation

Salinity and thermal (e-OTEC) gradients provide consistent "Base Load" power for ports



Environmental Protection Measures

Integrated ballast water management prevents water pollution during energy and transport cycles

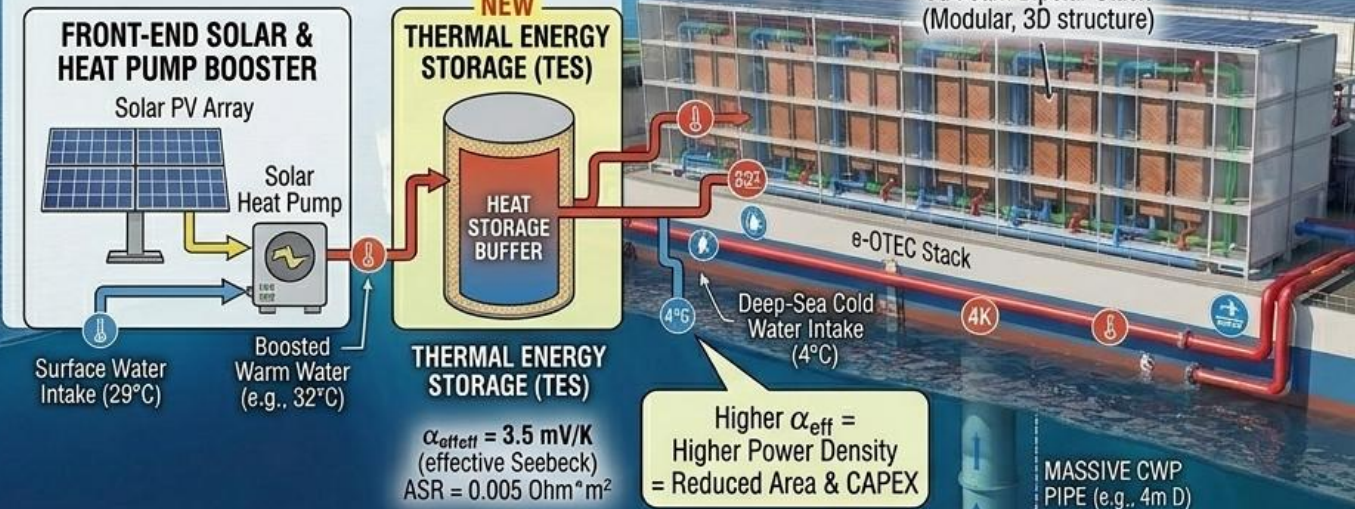
Seawater Energy Nexus : Future works



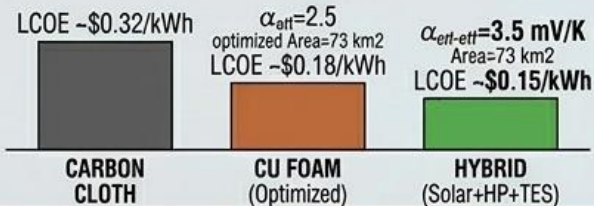
PNG HYBRID e-OTEC PILOT PROJECT: Accelerated Decarbonization and Lower LCOE

Business Proposal for GCF 10 MW NET OUTPUT, PNG PILOT PLANT (Port Moresby) GCF Proposal #23021

I. HYBRID SYSTEM SCHEMATIC



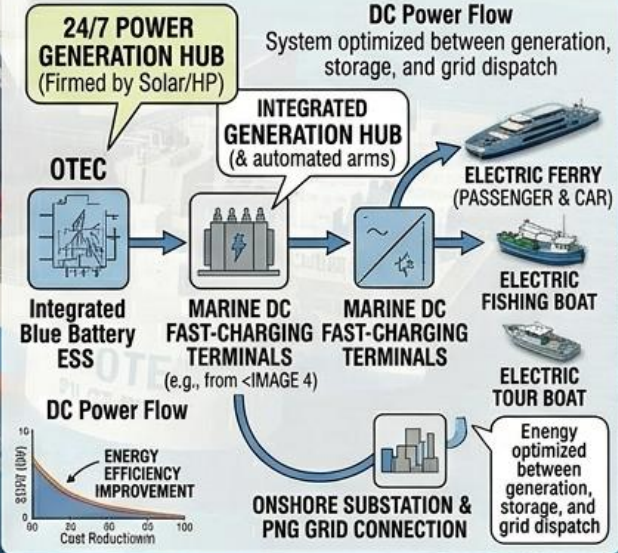
III. PERFORMANCE & COST PITCH



\$58%
LCOE Reduction from CC

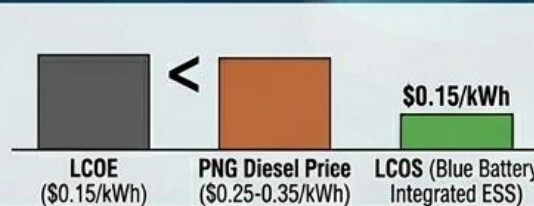
II. INTEGRATED OPERATION CONCEPT

Optimized operations – (e.g., from <IMAGE 3>)



GCF ALIGNED IMPACTS

- ✓ Decarbonize Marine Mobility
- ✓ Lower Electricity Tariff in PNG
- ✓ Community Acceptance
- ✓ Local Green Job Creation



Thank you for your attention