



Marine-based Renewable Energy for small Island States -The Case of Mauritius-



*Presentation
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Overview

- ❑ A small Island in a Big Ocean
- ❑ Economic & Social Challenges
- ❑ Energy Landscape
- ❑ Marine Renewable Energy Devices—
Conventional & non-conventional
- ❑ Implications for Mauritius
- ❑ Challenges in implementation
- ❑ A way forward

An aerial photograph of a tropical island, likely Mauritius, showing a lush green interior surrounded by clear turquoise waters and white sandy beaches. The sky is blue with scattered white clouds. The text is overlaid on the upper part of the image.

Towards a Blue Economy (Mauritius)

(From green to a blue evolution)

Where is Mauritius?



Languages used in Mauritius

(The Rainbow Nation)

Multicultural

French

English

Kreol

CHINESE

پلے آن

hindi

Size 2000 kms

Population: 1.3 million



From Sugar to textile, tourism, financial services and ICT sector





Sugar & Fishing Sector



© <http://www.gov.mu>

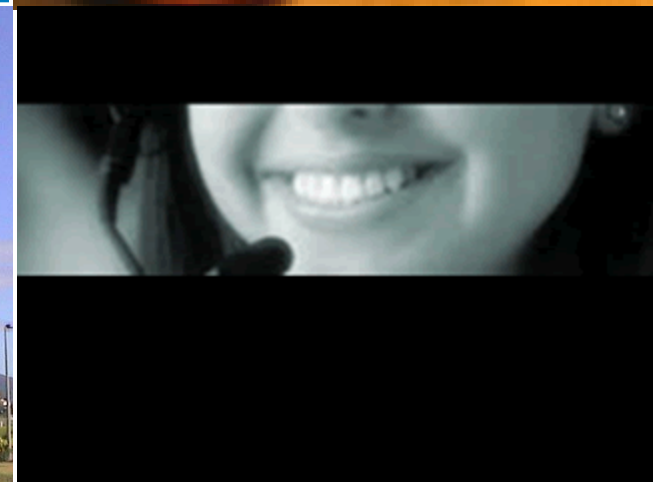


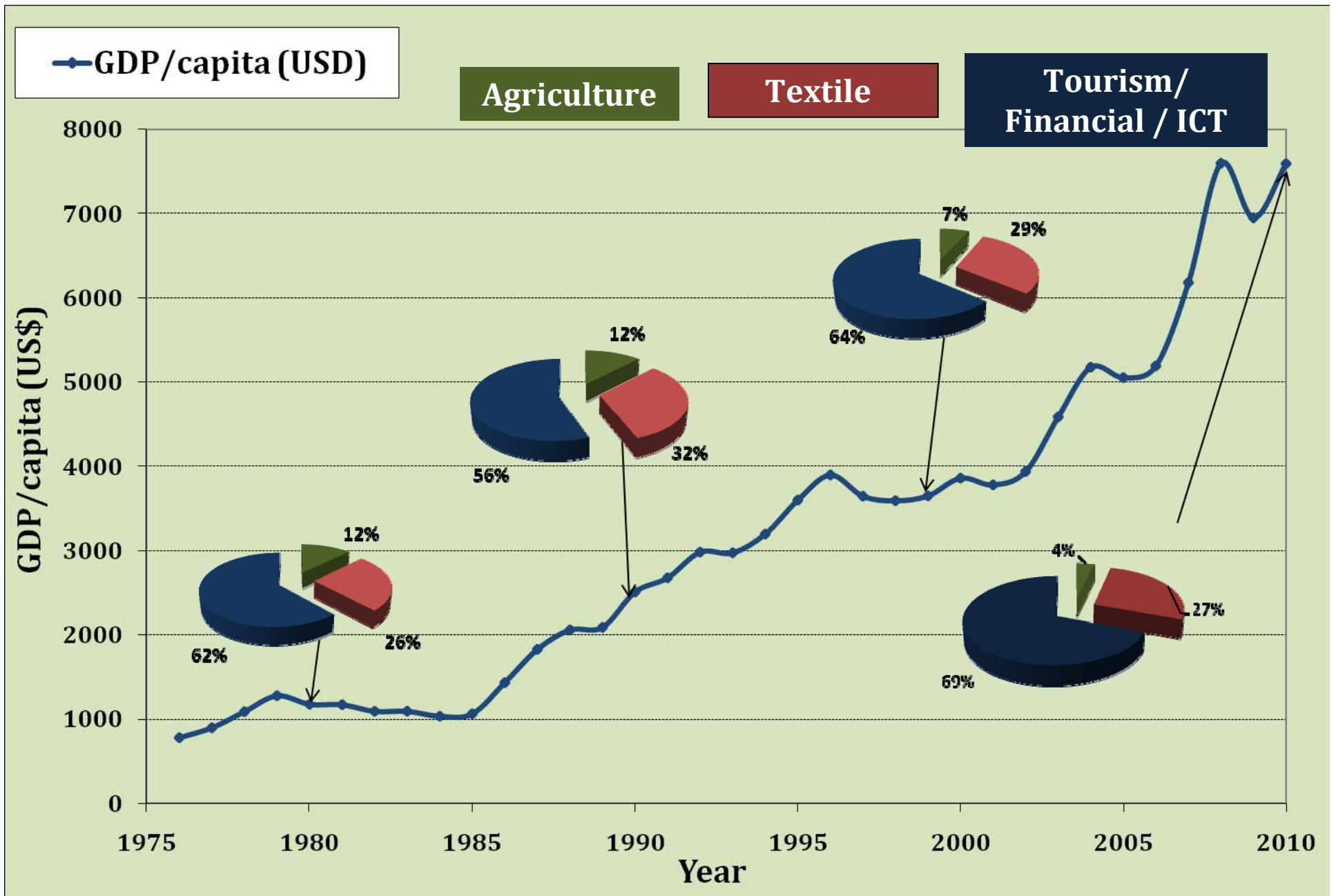
Textile/
Manufacturing Sector





Financial Services CT Sector

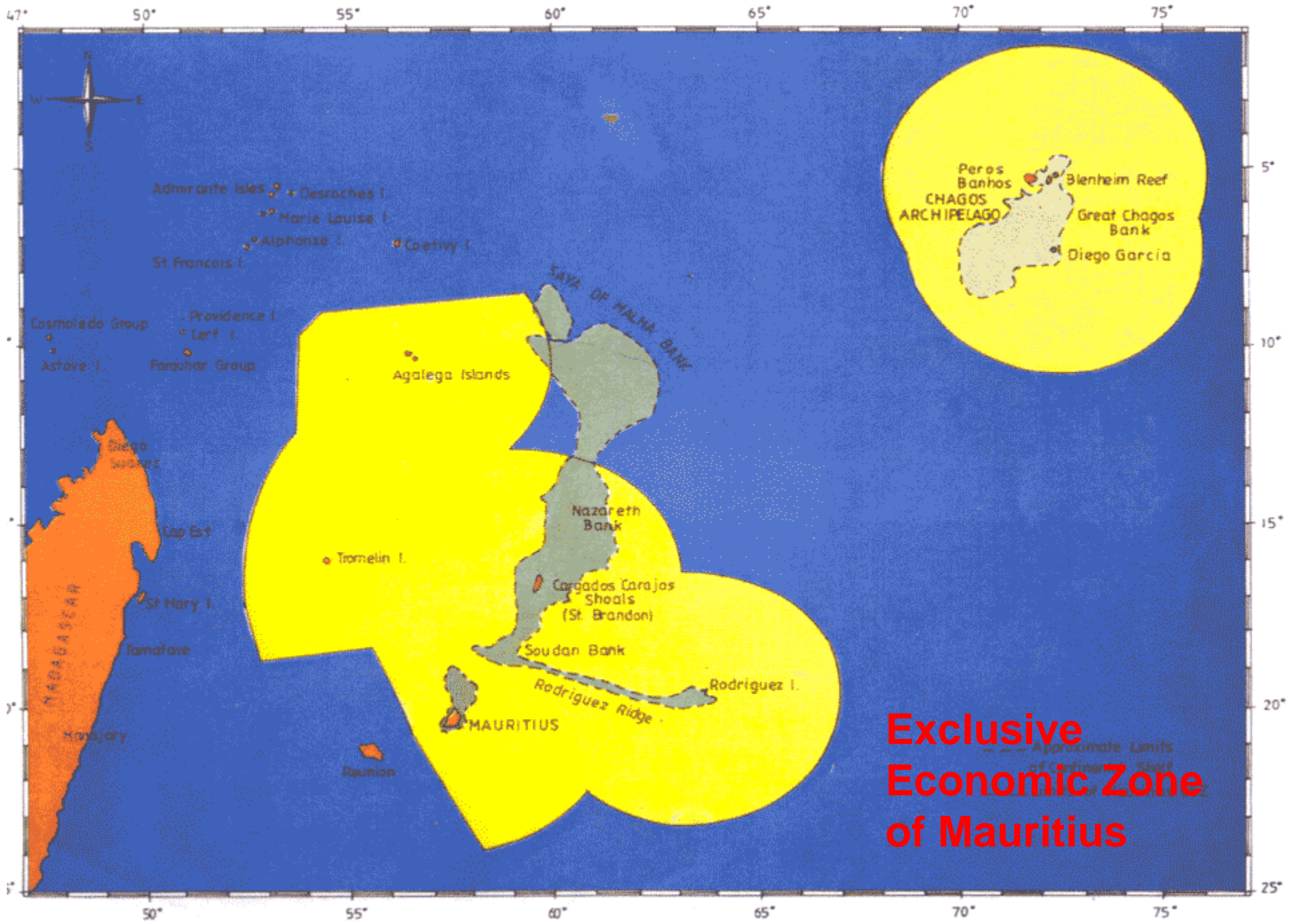




Source: Central Statistical Office, World Development Indicators

New Economic Order

- Past Economic development supported by preferential trade agreements
- Erosion of long-standing preferences (sugar, textiles)
- Regionalisation & Globalisation
- Euro-Centric Economy
- Consolidation of existing economic sectors
- Paradigm shift in economic strategy
- ***Let us turn to the Ocean !!!***



**Exclusive
Economic Zone
of Mauritius**

Exclusive Economic Zone of Mauritius

The Blue Evolution

- Exclusive Economic Zone – 2.4 million sq km
- 1100 x land space of Mauritius
- 4 x size of France
- One Third size of Europe
- Mauritius is a big OCEAN STATE

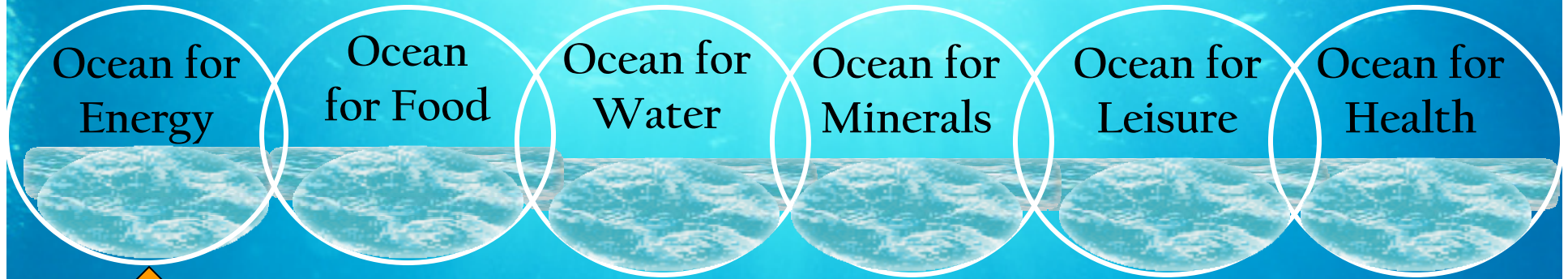
“We’ve barely scratched the surface of that Ocean”

'Blue' Developments

- Seafood Hub (Processing + logistics)
- Aquaculture (lagoon based)

- *Seaweed Industry*
- *Ocean Economy*
- *Ocean State*
- *“The Ocean for Energy”*

The Ocean State



SUSTAINABILITY

Marine Based Renewable Energy Potential

- Solar
- Offshore Wind**
- Wave**
- Tidal
- Saline Power
- Marine under water Currents
- Marine Deep Sea Currents
- Deep sea water thermal gradients**
- Marine Biomass
- Integrated Approach***

Offshore Wind Energy



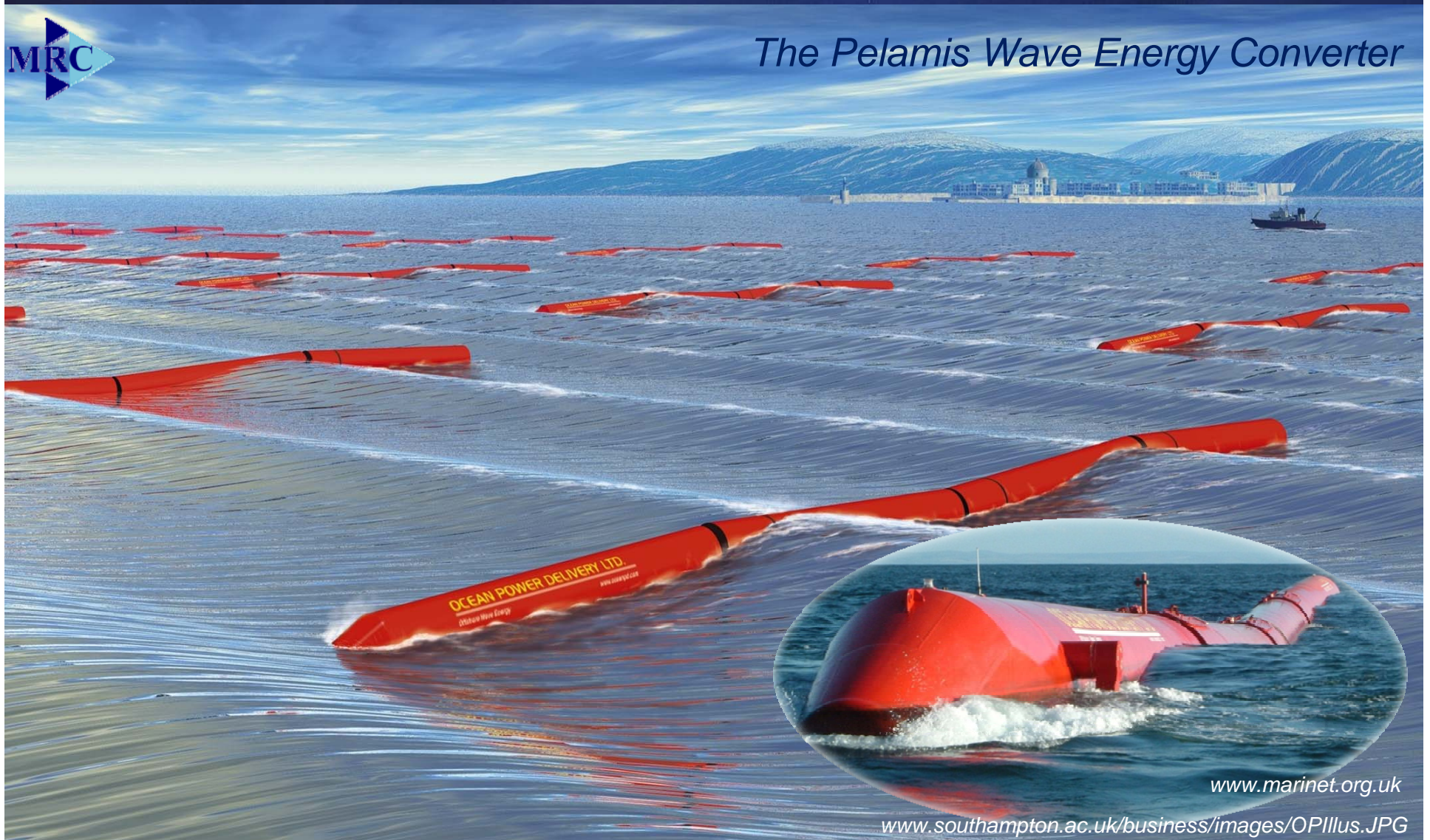
Offshore Wind Turbines



Ocean Wave Energy Device - Pelamis



The Pelamis Wave Energy Converter

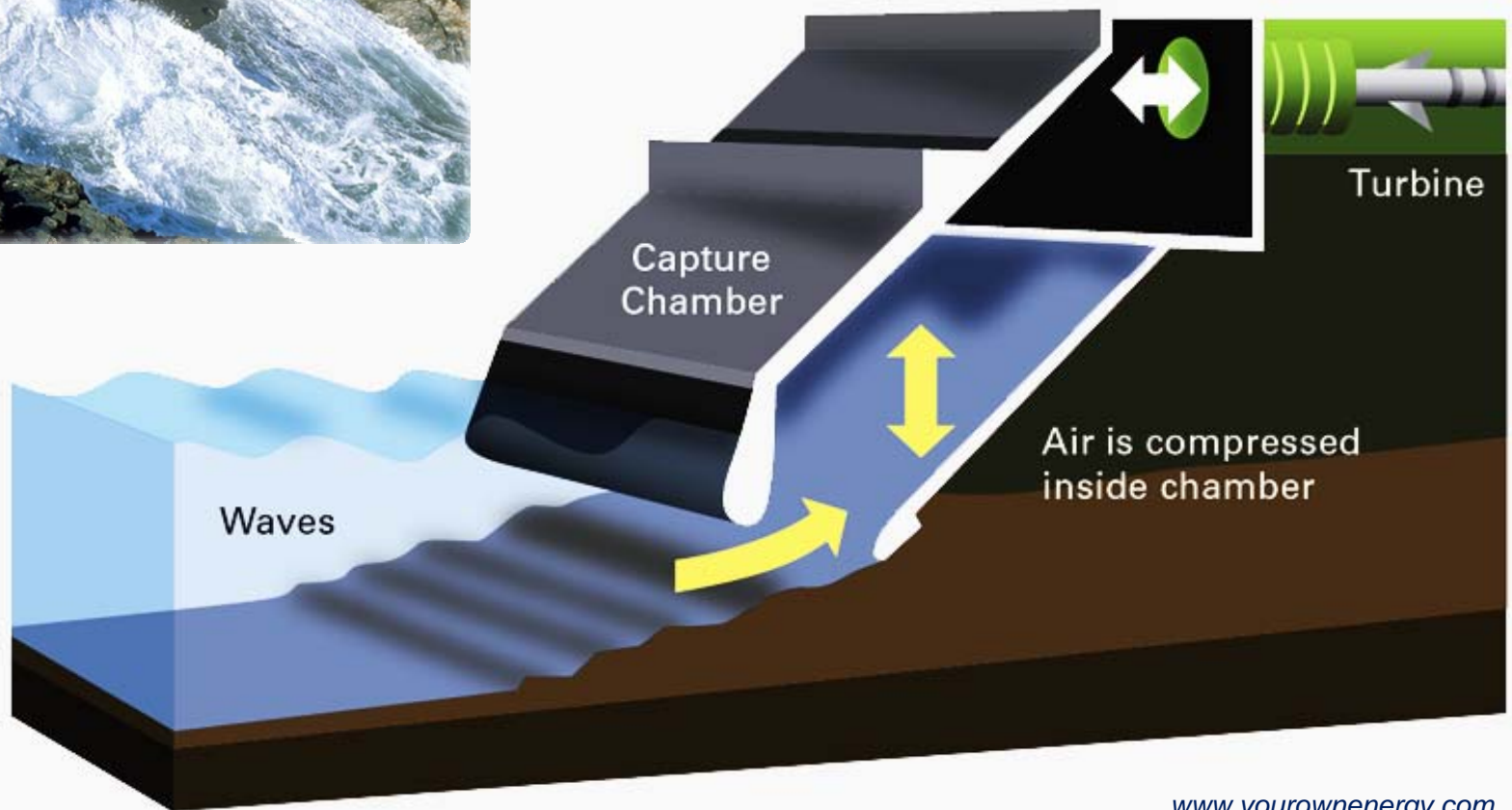


www.marinet.org.uk

www.southampton.ac.uk/business/images/OPillus.JPG

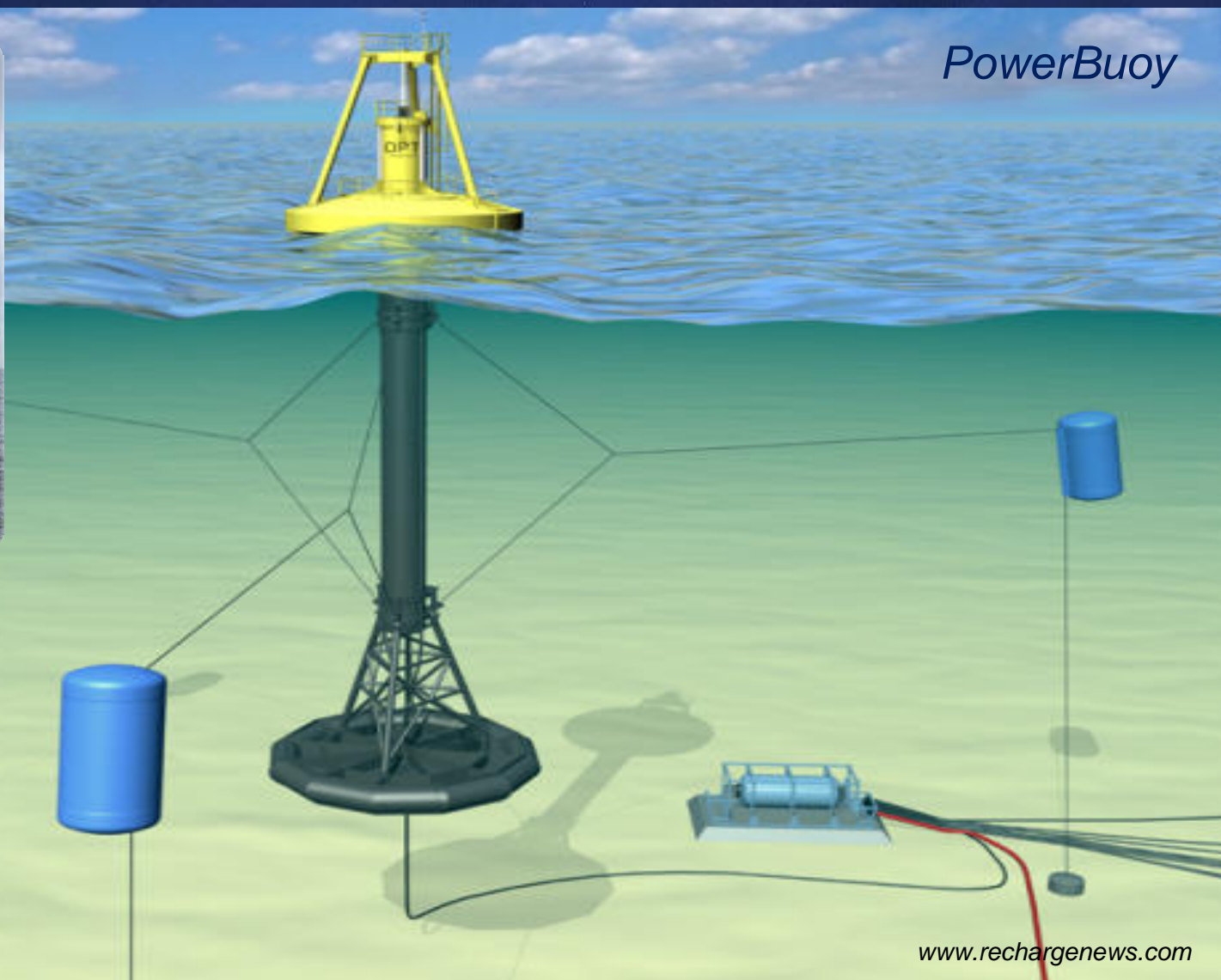
Ocean Wave Energy / Wells Turbine

WaveGen Oscillating Wave Column



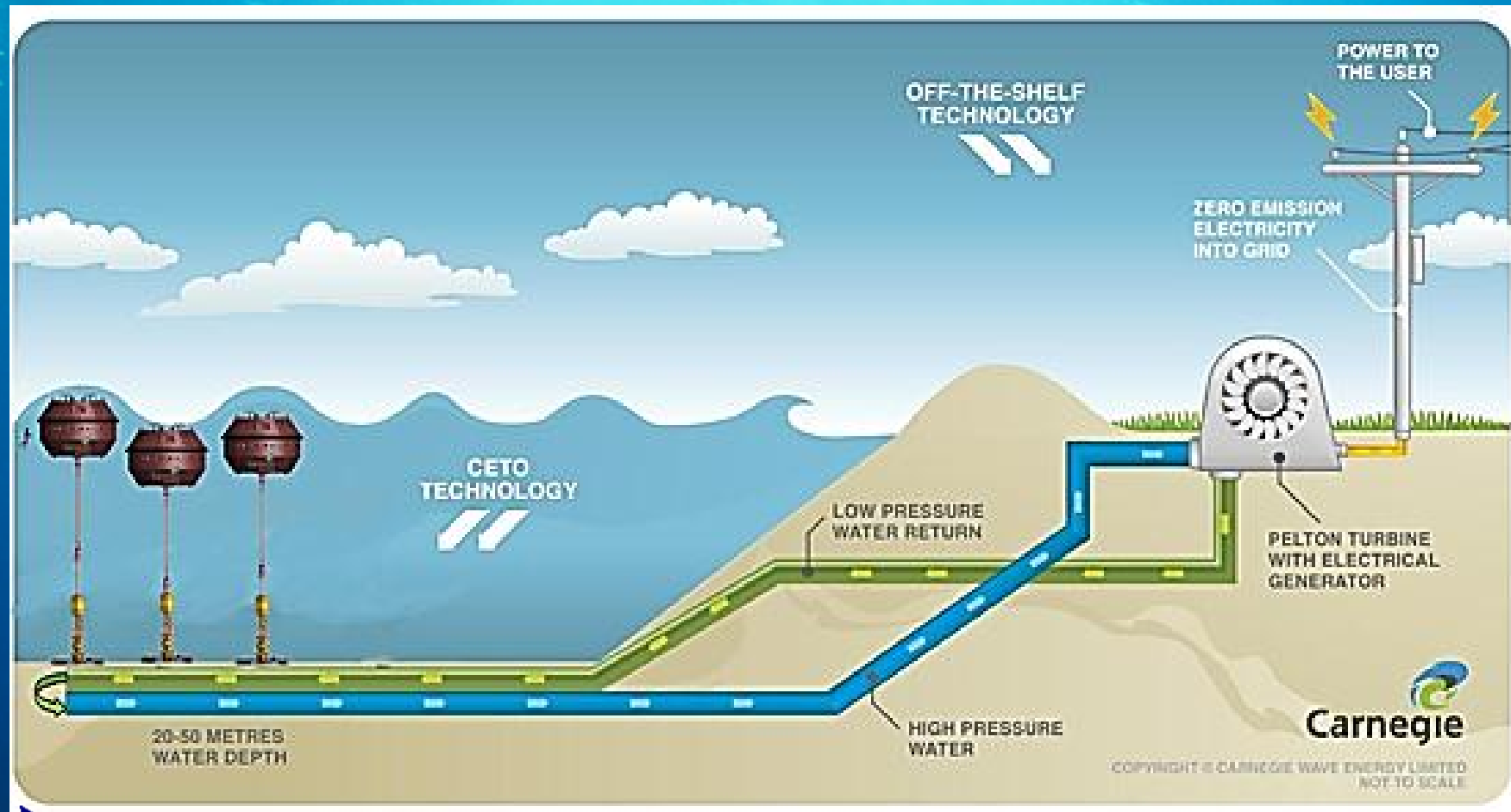
Ocean Wave Energy – Oscillating water column

PowerBuoy

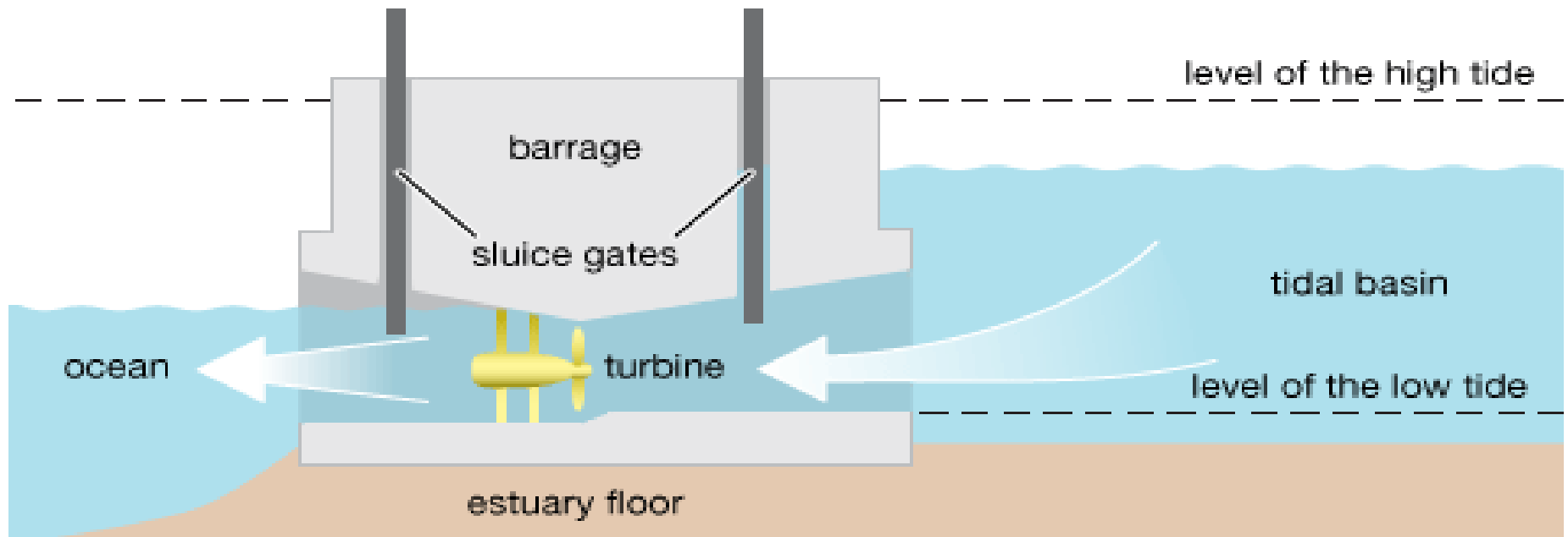
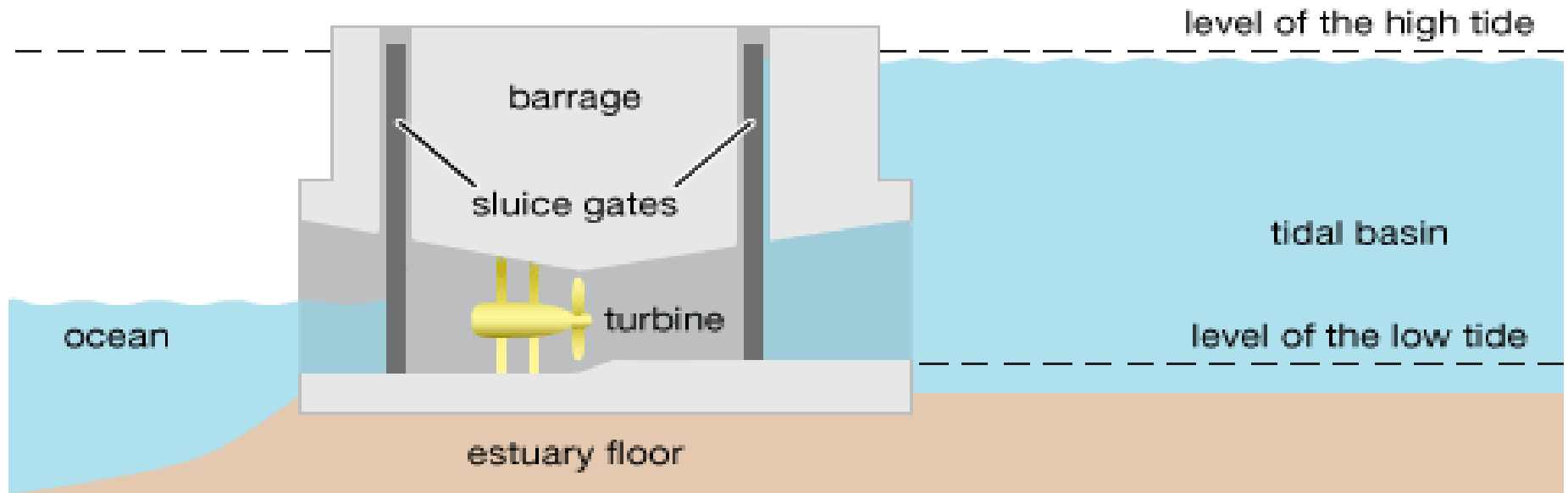


Ocean Wave Energy (CETO)

CETO



TIDAL ENERGY



Ocean Tidal Energy



Sihwa Tidal Power Station, Korea



http://pemsea.org/eascongress/international-conference/presentation_t4-

Ocean Current Energy

SeaGen Turbine



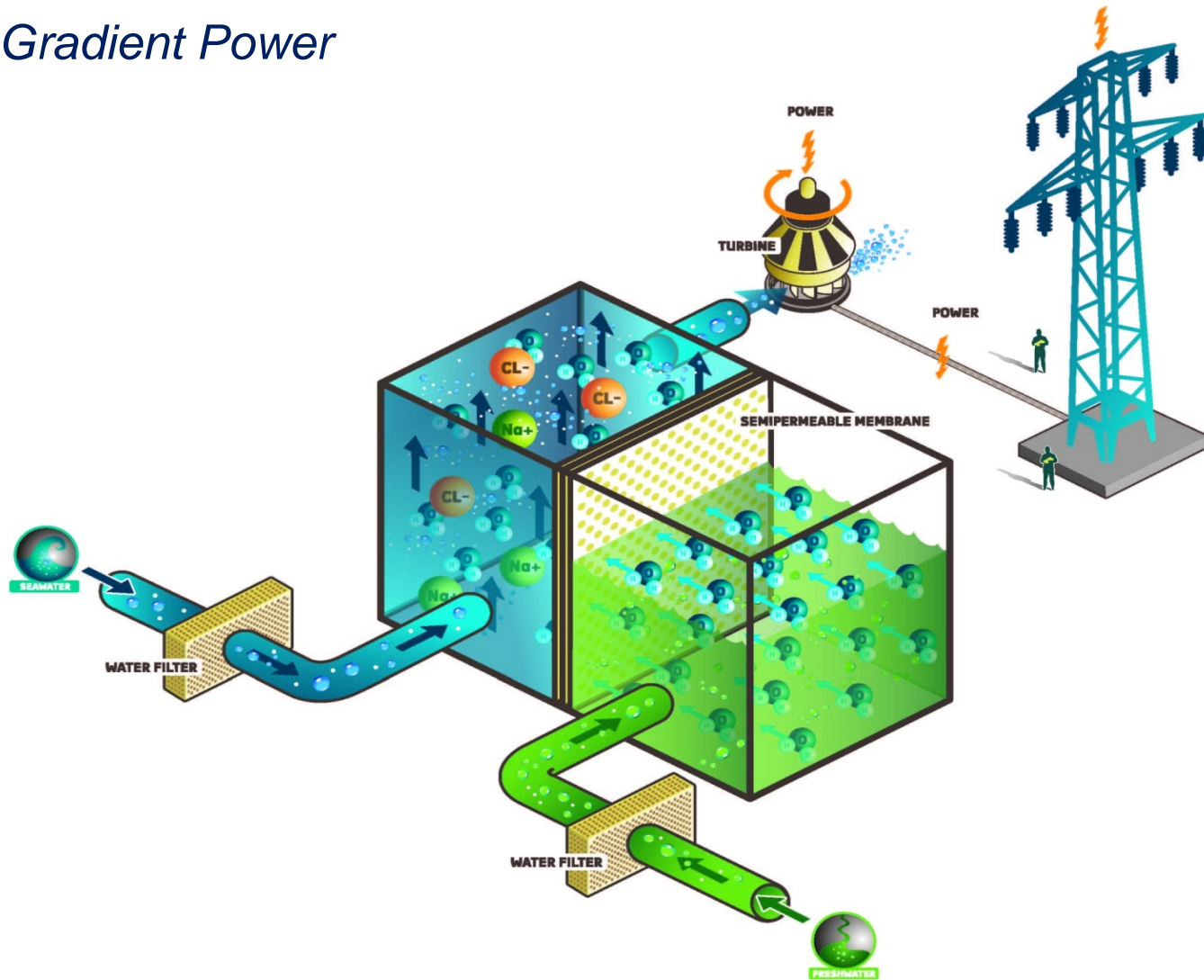
Ocean Current Energy

OpenHydro Turbine



Ocean Salinity Gradient Power

Salinity Gradient Power



Offshore Energy Conversion Devices

Power Rating

Offshore Wind Turbines

3-5 MW

Pelamis Wave Energy Converter

0.75 MW

*WaveGen Oscillating Wave
Column*

500 kW

PowerBuoy

150 kW

SeaGen Turbine

1.2 MW

OpenHydro Turbine

1 MW

An underwater photograph showing sunlight filtering through the water surface, creating a bright, shimmering effect at the top of the frame. The water is a deep blue color, and the light rays create a sense of depth and clarity.

DEEP SEA WATER STRATEGY

Deep Ocean Water, Mauritius

Because of the Great Conveyor Belt that arrives in our EEZ, our Deep (>1000m) Sea Water is:

very cold (5 to 6 C)

very old

free from pathogens/pollutants

very pure

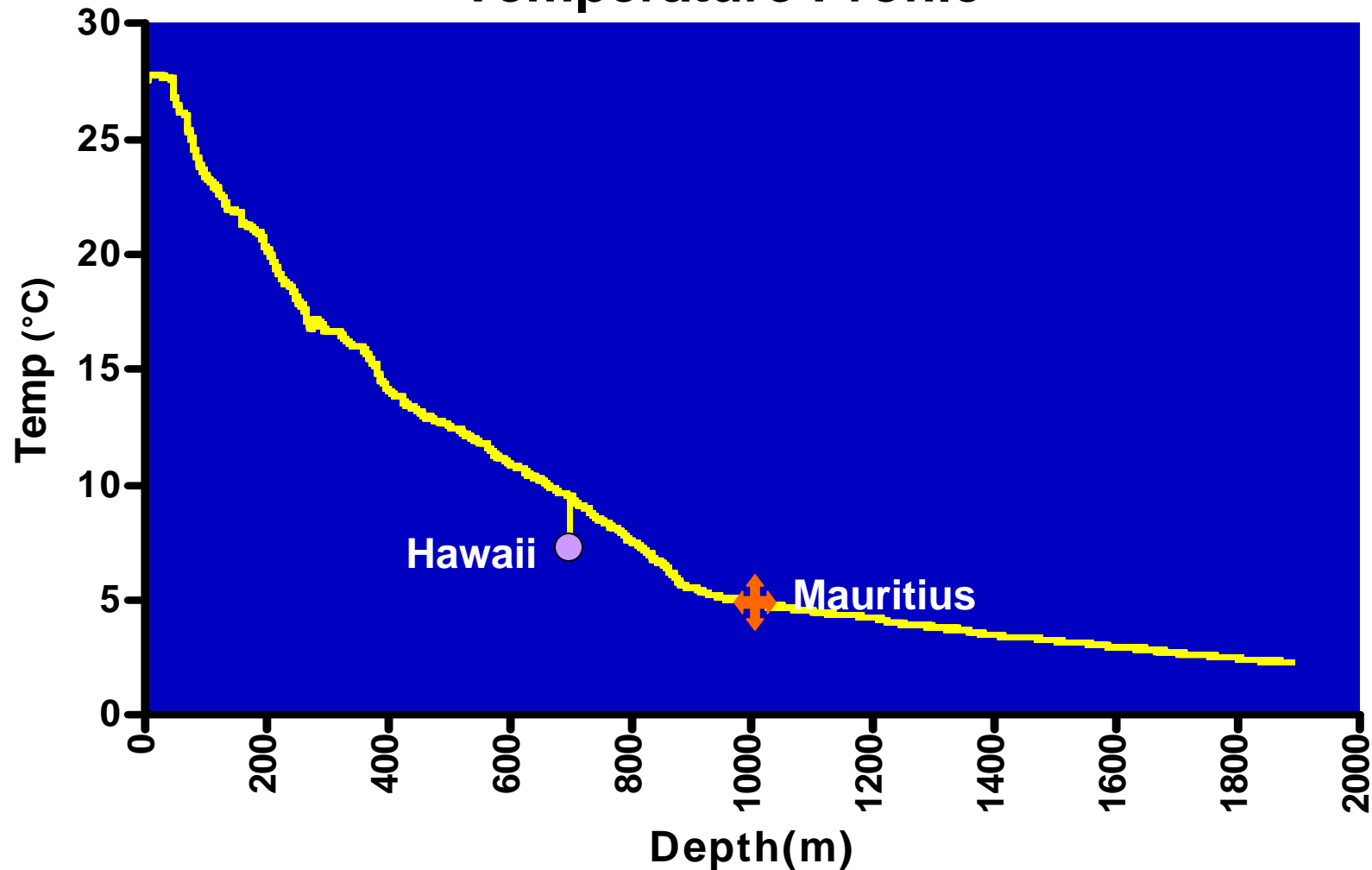
rich in minerals

rich in nutrients



Mauritius Deep Sea Water

Temperature Profile



Mineral content - Mauritius

MINERALS (mg/L)

**DEEP
SEAWATER
(Averaged)**

Calcium

400

Magnesium

1,367

Sodium

10,667

Potassium

420

Bicarbonate

137

Sulphate

2300

Chloride

19,670

Nitrate

0.37

Nitrite

< 0.005

Age of Deep Sea Water

Carbon 14 Dating in Perth, Australia
(94.18%MC)

500 Years Old
5 Centuries



Healthcare Products



Desalinated Mineral Water



Renewable Energy



**Aquaculture
Salmon, Trout, Oysters**



Pharmaceuticals

Deep Ocean Water Applications

Seaweed Culture



Aquaponics



Pearl Culture

**Environment Friendly
ORGANIC**

Thalassotherapy

Science & Technology Driven

**Jobs & Wealth Rev: Rs 5 billion yearly
(Foreign Currency)**

Democratisation of Economy



Inland Tourism

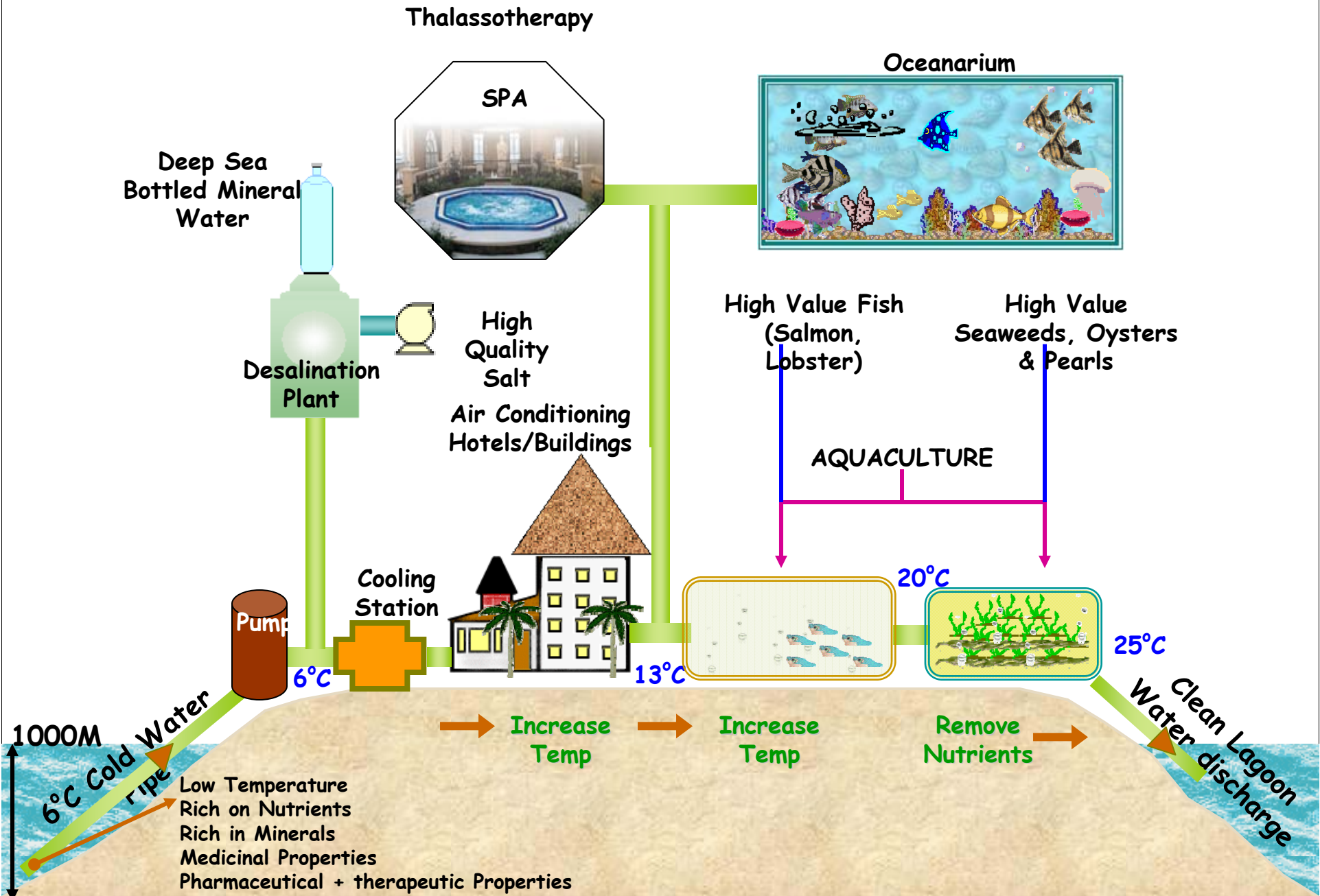


High Purity Marine Salt

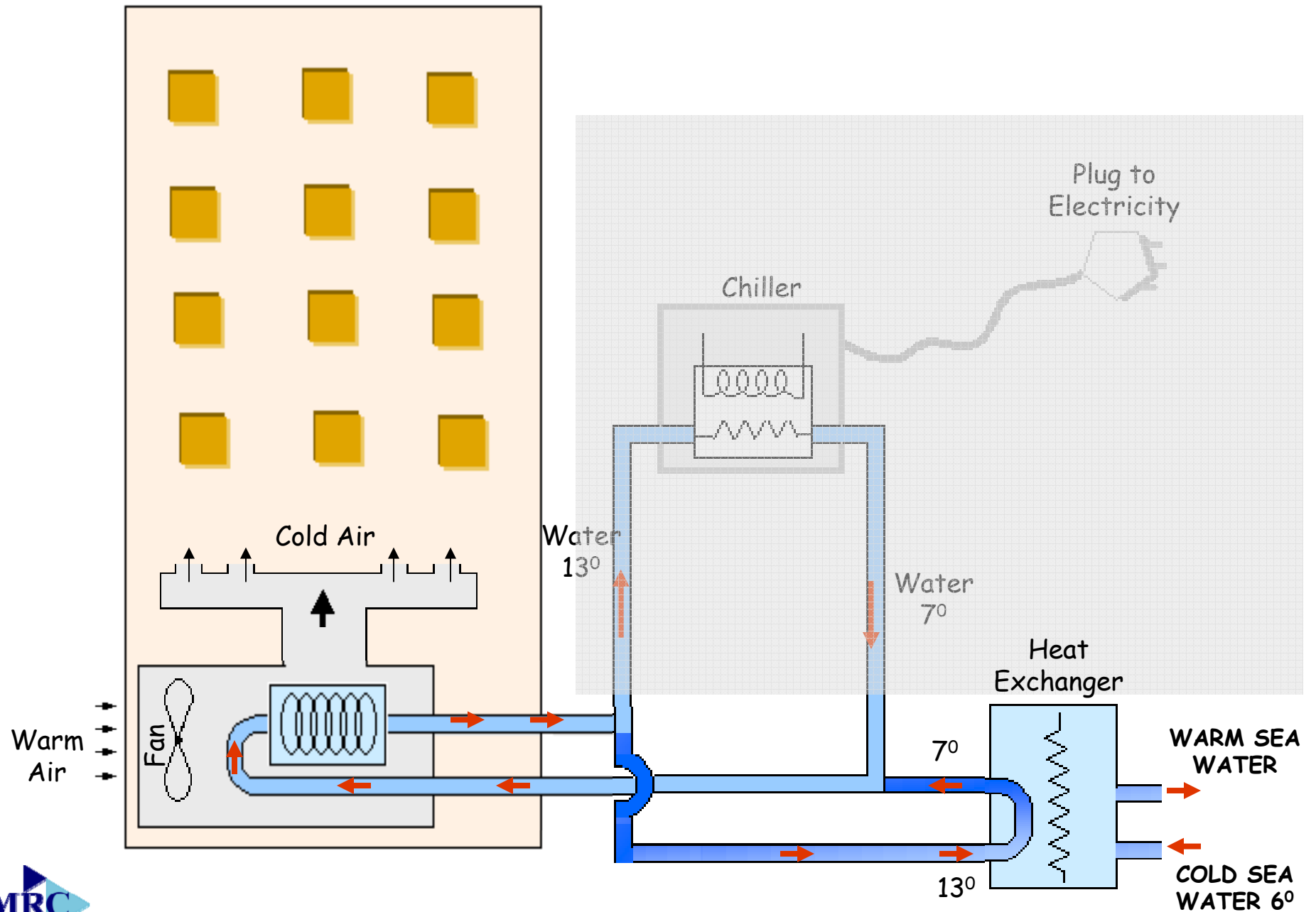


Cosmetics

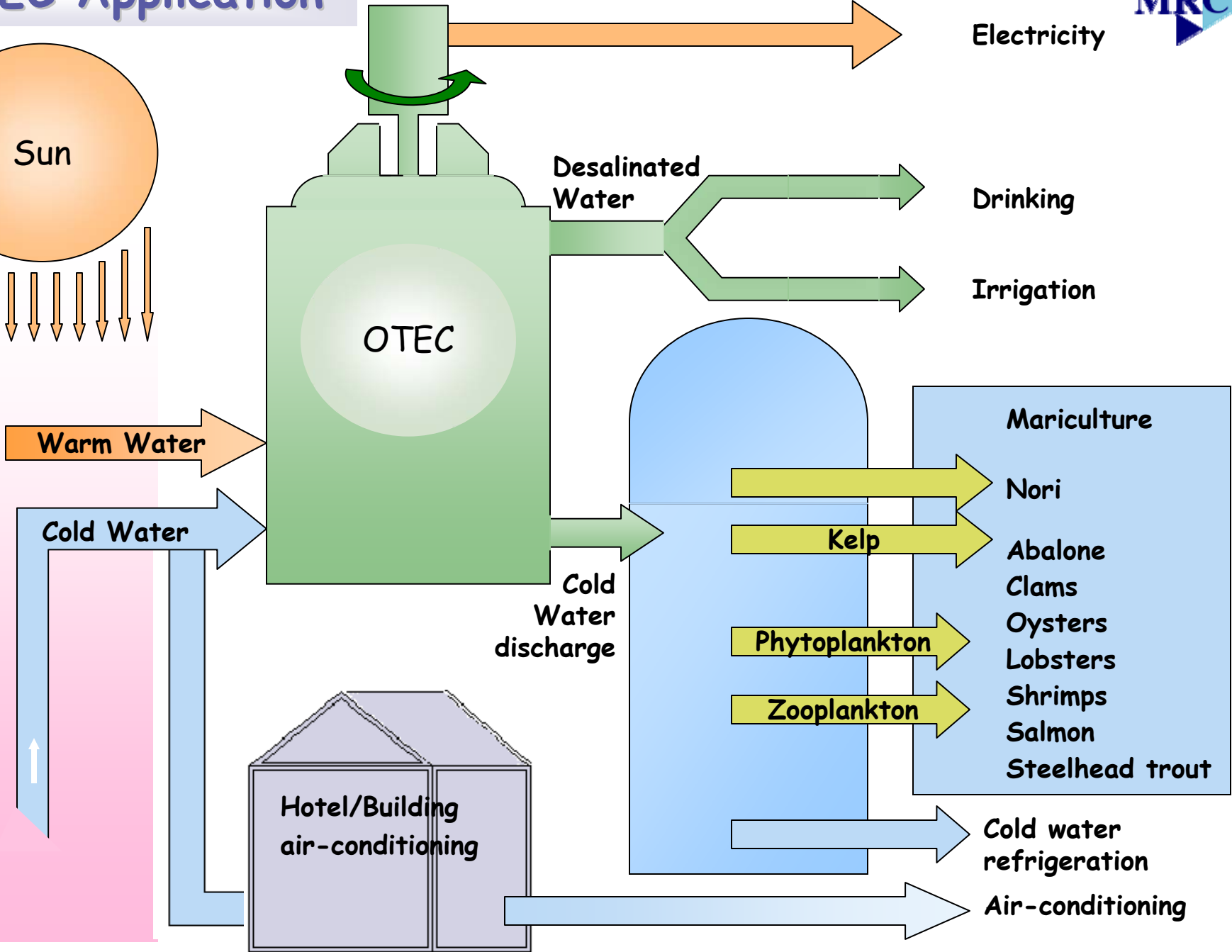
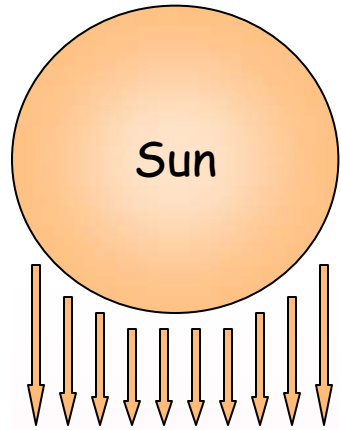
A Land Based Oceanic Industry



Air Conditioning



OTEC Application



Source: National Renewable Energy Laboratory

Electricity from Deep Sea Water (OTEC)



Power Generation 1

Heat from warm surface water boils liquid ammonia, producing steam which drives turbine generators, producing electricity. Chill from cold deep water condenses ammonia steam back into liquid form so the cycle can be continuously repeated for production of 24/7 (base-load) electricity.

Desalination 3

A portion of the OTEC energy production can be diverted to produce large quantities of potable water according to local needs.



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THERMAL
ENERGY
CORPORATION**

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Warm Water Intake

Warm Water Discharge

Cold Water Intake

Cold Water Discharge

Irrigation for Agricultural Enhancement 4

Refrigeration/Seawater District Cooling 2

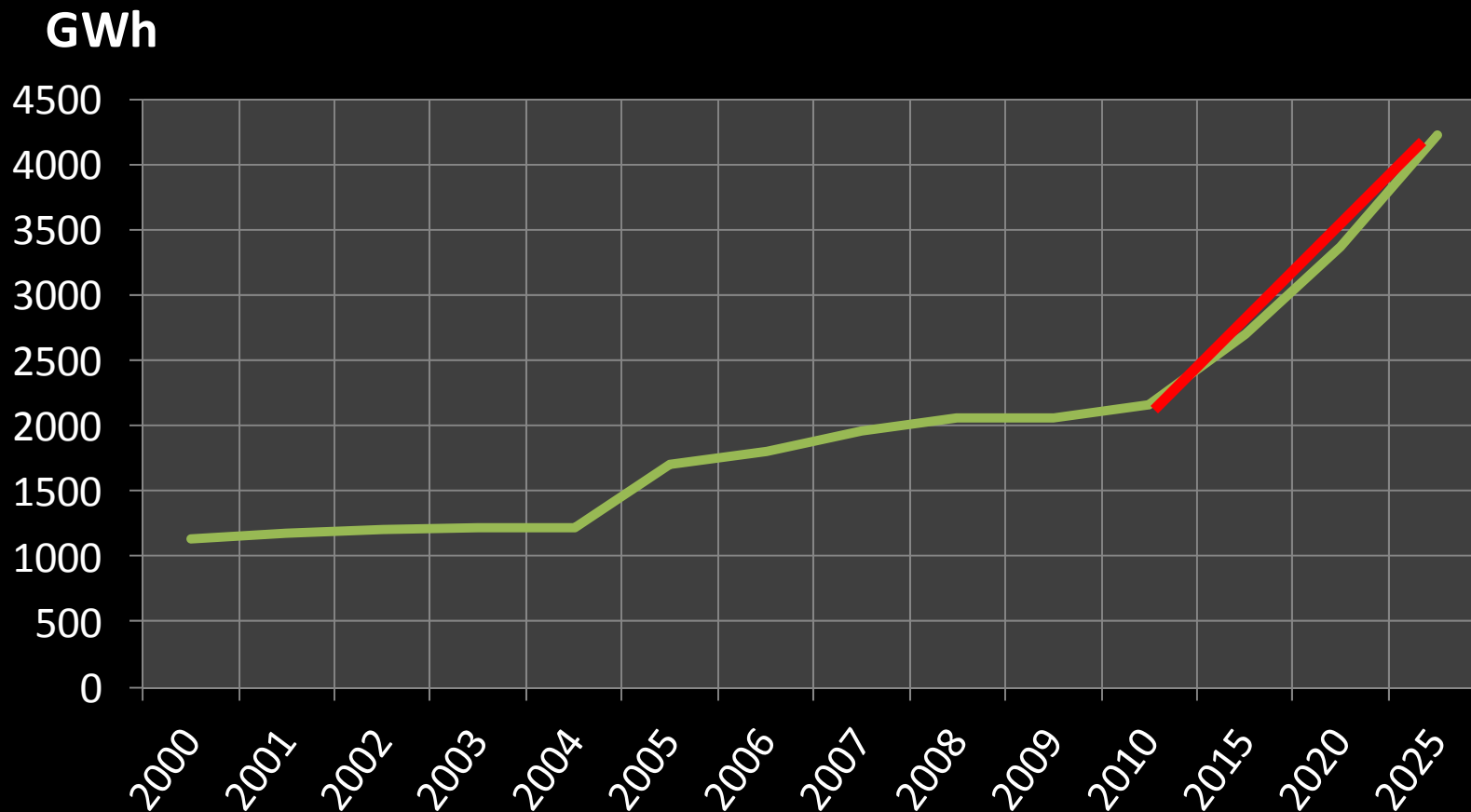
Seawater District Cooling (SDC) is a proven clean method of air-conditioning buildings, using cold deep seawater in place of electricity and polluting standard refrigerants. SDC systems can reduce electricity usage by up to 90% when compared to conventional air-conditioning, thereby substantially decreasing carbon emissions in our environment and saving hundreds of millions of dollars in electricity costs over the lifespan of such systems.

Onshore OTEC Plant

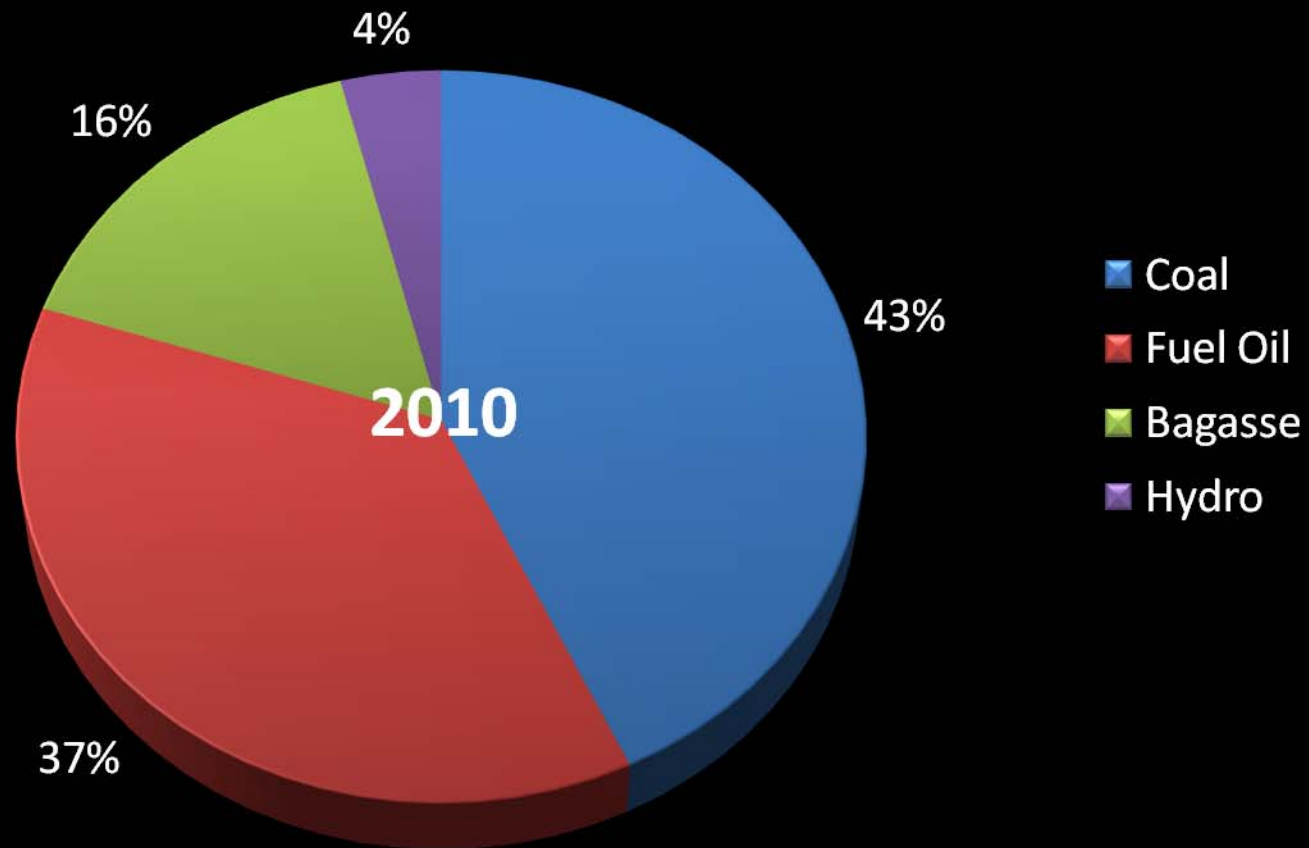
An underwater photograph showing sunlight filtering through the water, creating a bright, shimmering effect at the top of the frame. The water is a deep blue color, and the light rays create a sense of depth and clarity.

The Energy Landscape in Mauritius

Electricity Consumption 2000 – 2010- 2025




Electricity Generation 2012



OCEAN WIND & WAVE POTENTIAL ENERGY RESOURCES



Mauritius Offshore Wind Power Density [W/m²]

Height h = 80m							
Longitude		57.00 E	57.25 E	57.50 E	57.75 E	58.00 E	
Latitude		A	B	C	D	E	
19.75 S	1	442.498		495.551	515.574	522.690	
20.00 S	2	458.301		500.606	524.400	539.237	
20.25 S	3	462.001		510.847	570.753	569.039	
20.50 S	4	475.254		485.738	521.429	570.129	558.399
20.75 S	5	475.815		506.190	534.517	542.900	536.577

Simulation of small Offshore wind farms



Conceptual Offshore Wind Farm Flic en Flacq



Sea surface area <50m deep	~	5 Square km
Turbine Type		Repower 5M
No. of turbines		11
Rated power	PeR	5075 kW
Diameter	D	126 m
Offshore cut-in wind speed	Vc	3.5 m/s
Offshore cut-out wind speed	Vf	30 m/s
Rated wind speed	Vr	14 m/s
Site Mean Weibull wind speed	Vavgw	9.189103486 m/s
c		9.704479395
k		8.984847526
Capacity Factor	CF	0.4797871
Annual No. of Operating hours		2000 hrs
Average power output		27 MW
Annual Energy Output		54 GWh

30%* of power consumption
for Black River



* Assuming average islandwise load distribution to be same as peak power

Conceptual Offshore Wind Farm Mahebourg



Sea surface area <50m deep	~	16	Square km
Turbine Type		Repower 5M	
No. of turbines		22	
Rated power	PeR	5075	kW
Diameter	D	126	m
Offshore cut-in wind speed	Vc	3.5	m/s
Offshore cut-out wind speed	Vf	30	m/s
Rated wind speed	Vr	14	m/s
Site Mean Weibull wind speed	Vavgw	9.763878391	m/s
c		10.3812766	
k		7.791622483	
Capacity Factor	CF	0.529792517	
Annual No. of Operating hours		2000	hrs
Average power output		59	MW
Annual Energy Output		118	GWh

71%* of power consumption
for East of Mauritius



* Assuming average islandwise load distribution to be same as peak power demand

Conceptual Offshore Wind Farm Southern Coast of Mauritius



Sea surface area <50m deep	~	12 Square km
Turbine Type		Repower 5M
No. of turbines		15
Rated power	PeR	5075 kW
Diameter	D	126 m
Offshore cut-in wind speed	Vc	3.5 m/s
Offshore cut-out wind speed	Vf	30 m/s
Rated wind speed	Vr	14 m/s
Site Mean Weibull wind speed	Vavgw	9.763878391 m/s
c		10.3812766
k		7.791622483
Capacity Factor	CF	0.529792517
Annual No. of Operating hours		2000 hrs
Average power output		40 MW
Annual Energy Output		81 GWh



**32%* of power consumption
for South of Mauritius**



* Assuming average islandwise load distribution to be same as peak power

Offshore Wave Energy Potential for Mauritius

- **180 km** of waveline at 1km from the reef
- Average wave power density of about **40 kW/m**
- Theoretical wave power potential of **7.2 GW**

Conceptual Offshore Wave Farm South Coast of Mauritius



- 20 km of shoreline with an average wave power density of 41.5 kW/m
- Depth of 10 – 50 m which allows a number of different devices
- Few ship traffic
- No coral reef and no lagoon - so no interference with the tourism sector
- It has the best statistics for wave power

Conceptual Offshore Wave Farm South Coast of Mauritius

Based on **Pelamis Wave Technology**



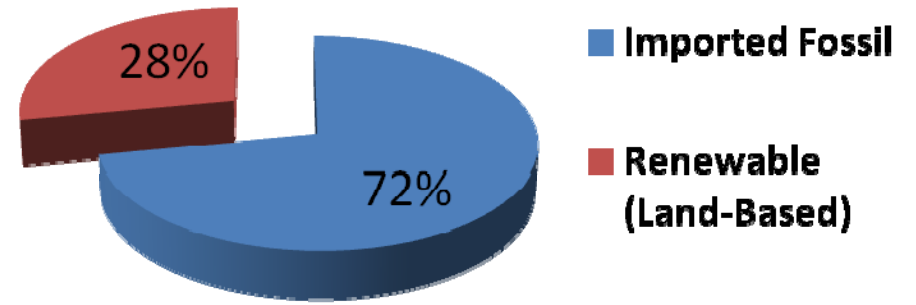
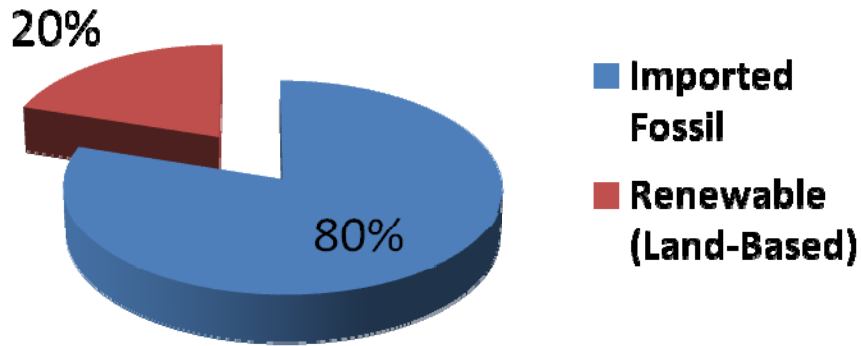
Source:
www.marinet.org.uk

Total installable power = 37.5 MW

**About 90% of power requirement for the south of
Mauritius**

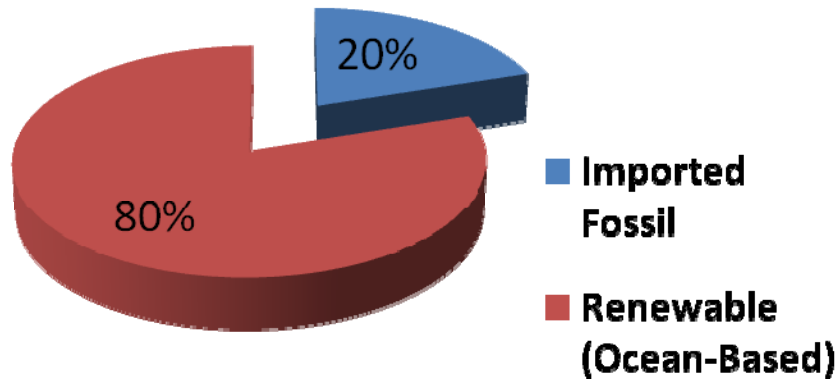


2012 Incremental Approach → 2020 Land-Based Strategy for Renewable

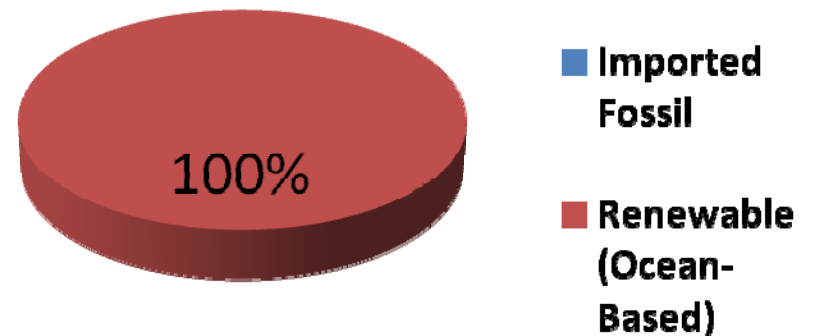


A Possible Reversal Strategy

2020 Ocean-Based Strategy for Renewable



Potential Long Term



Towards An Energy Positive Island

Ocean Energy Predictability

- Solar – Semi-predictable
- Wind - Semi predictable
- Wave – Semi-predictable
- Marine current – predictable
- OTEC – Predictable
- Tidal – Predictable
- Saline Power – predictable

Challenges & Way Forward

- Reduce Waste
- Change Mindset for Ocean Technology
- Disinvest in land-based fossil fuel – Compensate
- Sorted out Grid Balancing Issues
- Promote Portfolio of Energy Sources
- Need for Ocean Energy Resources Assessments
- Need Scientific knowhow, data, & equipment
- Require international collaboration
- Adjust legal framework for offshore development
- Adopt the precautionary principle.
- An island Role-Model ??

Critical Success Factors

- A Change Management Exercise
- A Situation of Emergency
- A Champion
- Unfreeze old ways of doing things
- Introduce new ways – Communications

**SCIENCE + POLICY + FUNDING + EQUITY = TECHNOLOGY + BUSINESS
(WEALTH & JOBS & LESS CO2)**

Community/Participating
Approach with shared
responsibilities

Global & Regional
Responsibilities

Managing for
uncertainty/Adaptive
Management

Informed policy-
making based on
scientific evidence

Guiding Principles

Ecosystem integrity with
economic/social/environ-
mental/cultural concerns

Duty of care &
Stewardship

Precautionary
Principle

Polluter Pay
Principle

*Integrated in Lisbon Principles for Sustainable Ocean Governance in 1999
(USA, Sweden, Australia, Solomons, UK, Portugal)*

The Ocean Economy

- Government's Programme (2012 – 2015)
 - **Clauses 15-24 (Chapter 1, Prosperity)**
- EEZ of 2.3 million Km²
- Further submissions to the UN with respect to other parts of our continental shelf
- Expansion of our spatial boundaries, development of scientific knowledge and business opportunities
- Exercise of our rights can give us access to vast natural and mineral resources
- Extending the economic space for investors, businesses, workers, entire population by setting out a concrete and practical plan for developing the Ocean economic space
- High productivity jobs and improving living standards
- Exploitation of land/marine resources, land/sea transportation, cargo/port services
- Need for effective regulatory regime and skills

An underwater photograph showing sunlight filtering through the water, creating a shimmering, ethereal effect. The water is a deep blue color, and the light rays are visible as bright, wavy patterns. The overall mood is serene and peaceful.

Thank You for your attention