

PECC Hawaiï Seminar

SEMINAR MARINE RENEWABLE RESOURCES

HAWAI 26 – 28 March 2012

The Reunion Island And The Atoll of Hao

Marine renewable Energies

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**MEDDTL
CGEDD**



Two examples, as case study, in the Ocean For Marine renewable energies

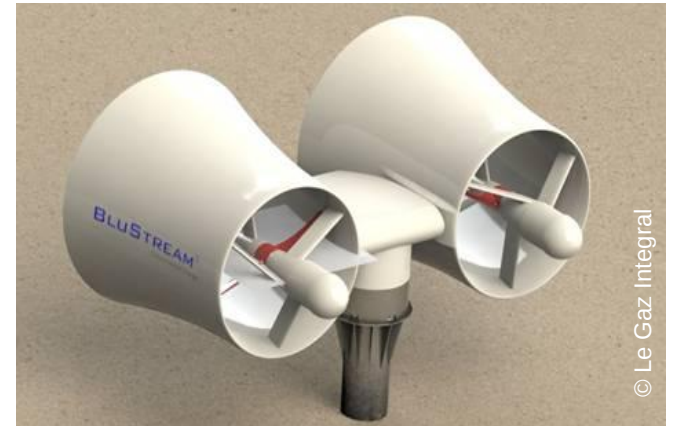
Tidal stream in an atoll pass

The Atoll of Hao in the Tuamotu archipelago

And a volcanic Island, surrounded by deep
water « **La Réunion** » Island

Tidal stream in an atoll pass

The Atoll of Hao in the Tuamotu



The lagoon of Hao Tuamotu archipelago, is one of the biggest in Polynesia, open on the Ocean by a unique pass (the Kaki pass at North extremity) (not exploited) where the tidal current may reach a speed of 20 knots (10 meters per second)

Hao, called "Island Arc" or "Island of the Harp" is an atoll located in the center of the Tuamotu Archipelago in French Polynesia, 920 km east of Tahiti. It is the fourth largest atoll in Polynesia, after Rangiroa, Fakarava and Makemo. The lagoon covers an area of 720 sq. km.

Hao atoll is 50 km long and 14 km wide, covering a total area of 47 square kilometers and a maximum altitude of 3 m. Its lagoon of 720 square kilometers is one of the largest in Polynesia, open ocean by a single pass (pass Khaki), rife with violent currents of up to 20 knots with tidal bores.

The climate is maritime, with temperatures oscillating between 23 and 32 ° C throughout the year. The lack of relief that the trade winds away the clouds, and therefore, rainfall is relatively moderate.

The main town is Otepa, with a population of 1,222 inhabitants, this is the chief town of the municipality of Hao and is served by the aerodrome of Hao. Once a french military base .

Tidal stream in an atoll pass The Atoll of Hao

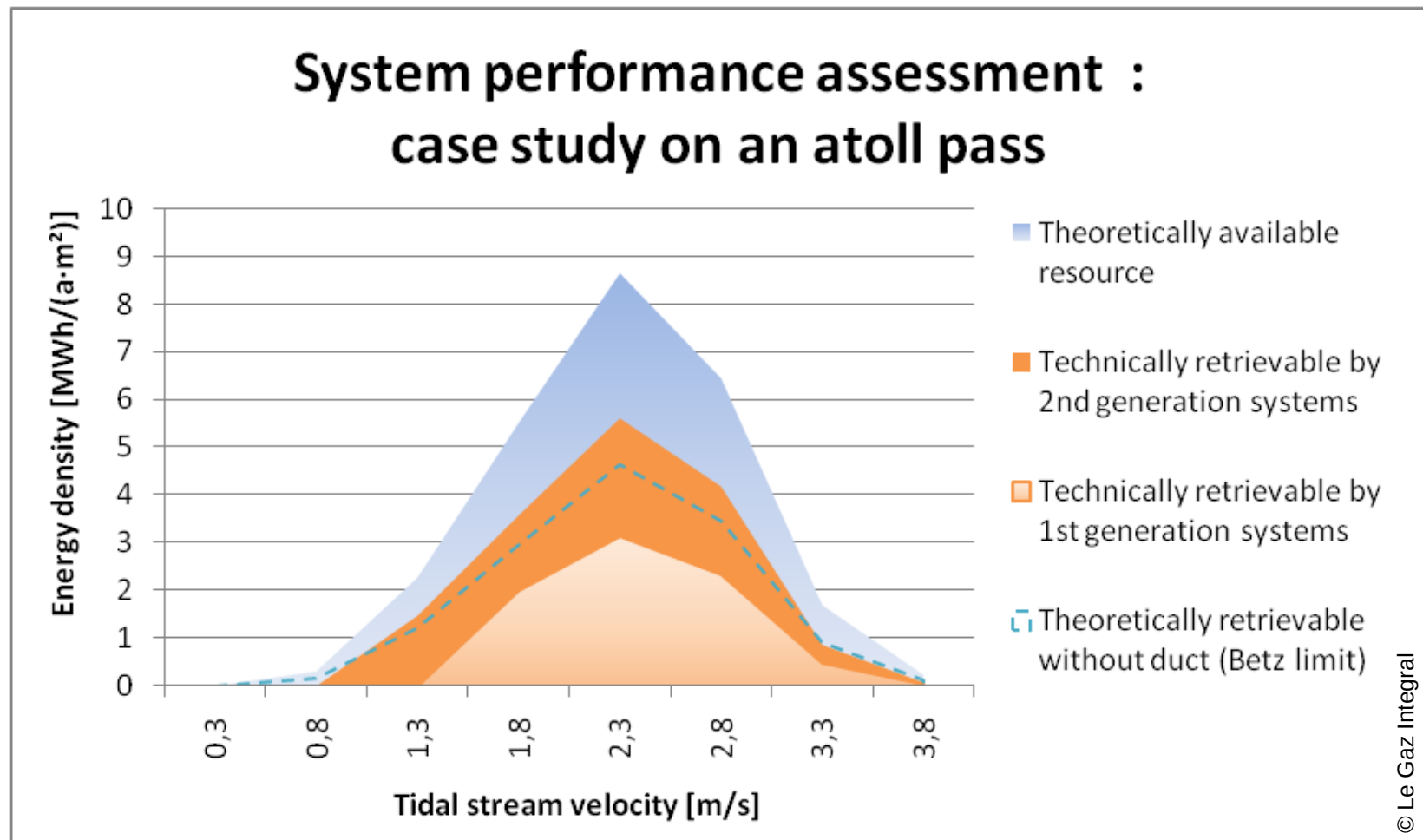
open on the Ocean by a unique pass (the Kaki pass at North extremity) (not exploited)
where the tidal current may reach a speed of 20 knots (10 meters per second)



Technology maturation

Target : $\Rightarrow$ improved energy extraction

$\Rightarrow$ lowered cost of electricity generation (LCOE)

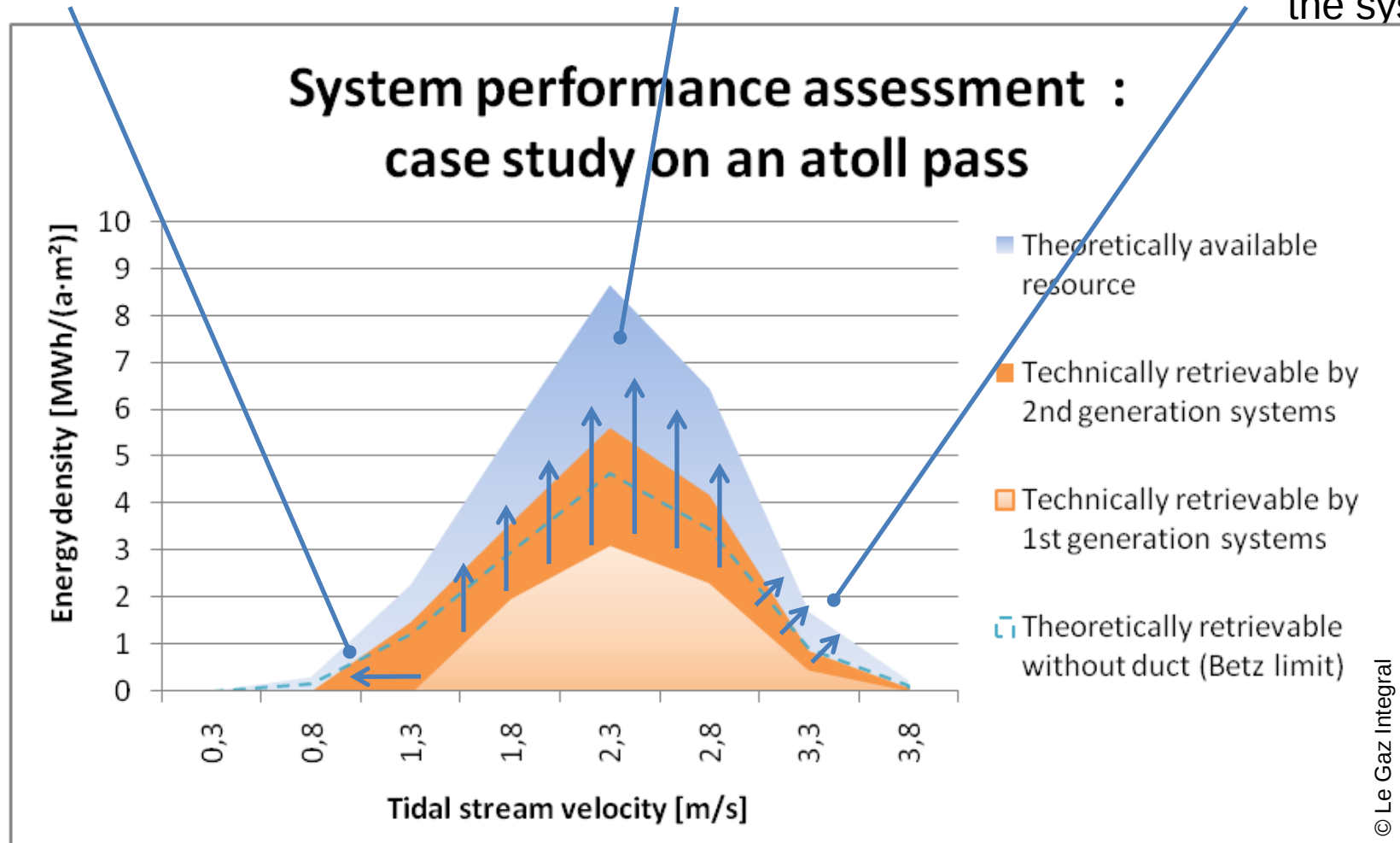


Technology maturation

Recover economically
the low velocity
energy

Optimize the power
coefficient and increase
global efficiency

Recover the high velocity
energy without
penalizing the cost of
the system



The case of Reunion Island, **GERRI** and Marine Renewable Energy

Réunion Island is a French island located in the Indian Ocean, east of Madagascar, about 200 kilometers (120 miles) south west of Mauritius, the nearest island.

Administratively, Réunion is one of the overseas departments of France. Réunion is also one of the 27 regions of France. Réunion is an outermost region of the European Union..

Population was 800,000 inhabitants in 2008, over 1 million by 2030

Reunion Island is a French overseas and tropical region with important resources for various Marine Energies.

100% Renewable energy mix is targeted by 2030.

8 experimental marine energies projects currently being carried out

The GERRI project, steered by the French Government, Regional Council, Department Council and economic actors, is aimed at making Reunion Island a demonstration ground for all sustainable development technologies of interest for the society of the future.

GERRI is to be implemented along 5 priority lines :

Transport (private and public)

Energy production

Energy storage

Town planning and construction

Tourism

GERRI, a project of mutual interest for Reunion Island and its population, a pilot test for Planet Earth

GERRI Green Energy Revolution Reunion Island and Energy production :

Without recourse to nuclear power or connection to large-scale continental networks, Reunion Island must reach energy self-sufficiency through GERRI.

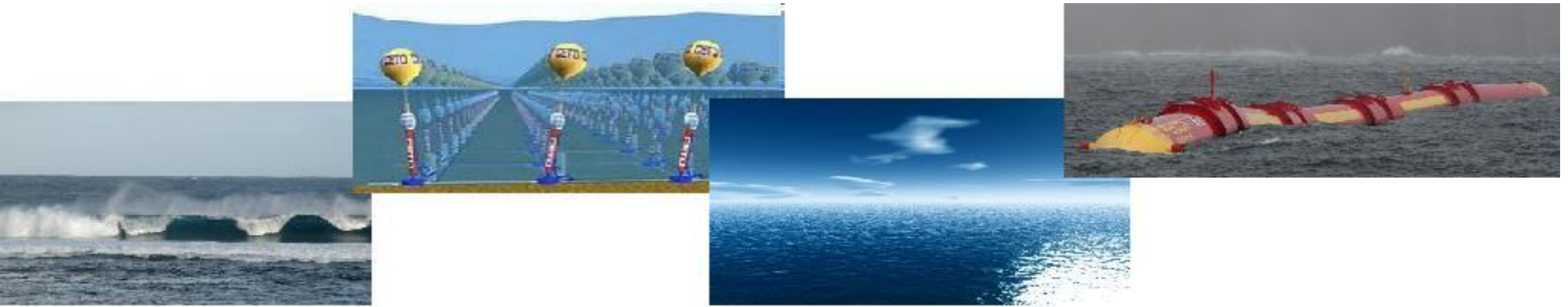
This objective requires the development of photovoltaic electricity—the only renewable mass energy currently available on the island—and quick implementation of experiments on hydraulic micro-turbines,

Wave and sea thermal energy (Ocean Thermal Energy Conversion), offshore wind turbines or the harnessing of geothermal resources.

Actions carried out in the framework of Energy Management (MDE) will be continued and amplified.

. Energy storage in Reunion Island:

GERRI will involve building a testing area for all energy storage systems. Embedded storage must be studied in depth and innovative technology models implemented (removable batteries, liquid hydrogen, fuel cells). In a remote island having mostly intermittent renewable energy resources (wind, PV), mass storage is the only limit to energy self-sufficiency known to date. Projects developed in the framework of GERRI must be instrumental in overcoming this constraint.



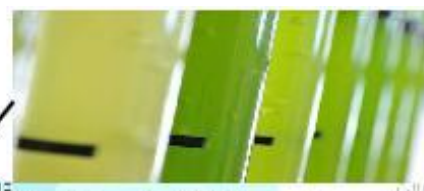
A Panorama of the Marine renewable energy Projects in Reunion Island

Reunion is endowed with important resources for various Marine Energies. 100% Renewable mix is targeted by 2030.

8 experimental marine energies projects are currently being carried out



SWAC 40 MW
GDF Suez. Fin 2013



Projet algues-biocarburant
ALBIUS. BAO. 2014

Centrale ETM Offshore.
DCNS. Horizon 2020



Proto houlomoteur basé sur
CETO. EDF EN. 2012

Proto houlomoteur basé sur
PELAMIS. SEAWATT. 2013



PAT ETM
DCNS, 2012



Projet d'énergie
osmotique



Houlomoteur onshore



Reunion Island/ Indian Ocean: Experimental key region for Marine Energies

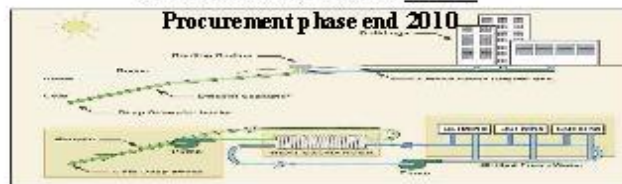
Reunion Island is a French overseas & tropical region with important resources for various Marine Energies. 100% Renewable mix is targeted by 2030.

8 experimental marine energies projects are currently being carried out

OTEC
Pilot 10 MW power plant
DCNS
Le Port. 2015



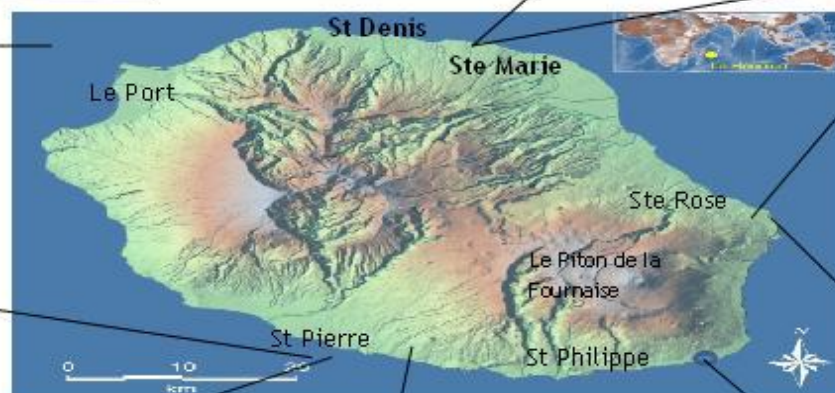
SWAC
Project for huge Urban air-conditioning network 40 MW_{cool}
Saint Denis-Sainte Marie **SIDEO**
Procurement phase end 2010



MICRO-ALGAE & 3rd generation biofuels
Project to grow Micro algae under PV solar green houses
St Denis or Ste Rose.
BIOALGOSTRAL IGV
2011



NEARSHORE WAVE Energy
Full-scale experimental CETO prototype (At sea, not grid connected)
EDF EN & DCNS
St Pierre/Pierrefonds.
2012



OSMOTIC Energy
Site identification study: ARER 2009
Potential 7 MW base load
Sainte Rose.



OFFSHORE WAVE Energy
PELAMIS (2nd gen.): 5 grid connected devices
SEAWATT
St Pierre/Pierrefonds.
By 2012.



OTEC
1st European onground OTEC prototype
DCNS, Reunion University.
St Pierre Mid- 2011



ONSHORE WAVE Energy
Site identification study: ARER 2010

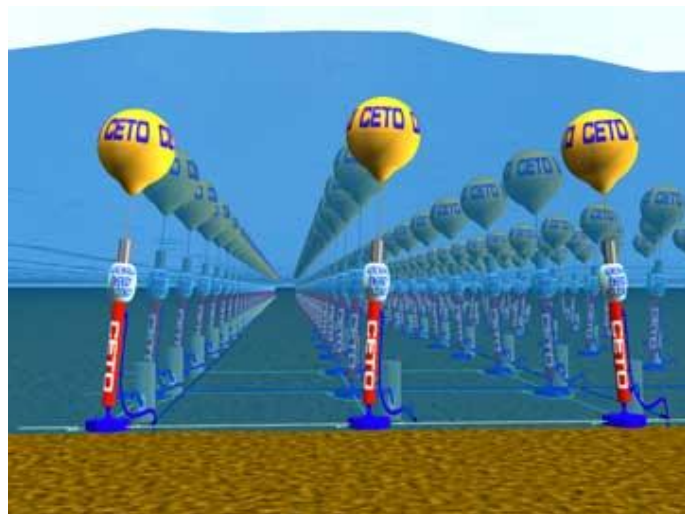
Acknowledgements to:



La Réunion Nearshore Wave Energy

Nearshore Wave Energy Full-scale experimental CETO prototype (At sea, not grid connected) EDF-EN & DCNS, at St Pierre/Pierrefonds.

The project is a Joint Venture project between Carnegie and EDF Energies Nouvelles. It will initially consist of the deployment of a single, autonomous commercial scale unit (stage 1) which will be followed by a 2MW plant (stage 2) and a further expansion of the project to a nominal 15MW installed capacity (stage 3). Stage 1 of the project has been awarded \$5M of French Government funding.



OVERALL POWER AND WATER SCHEMATIC



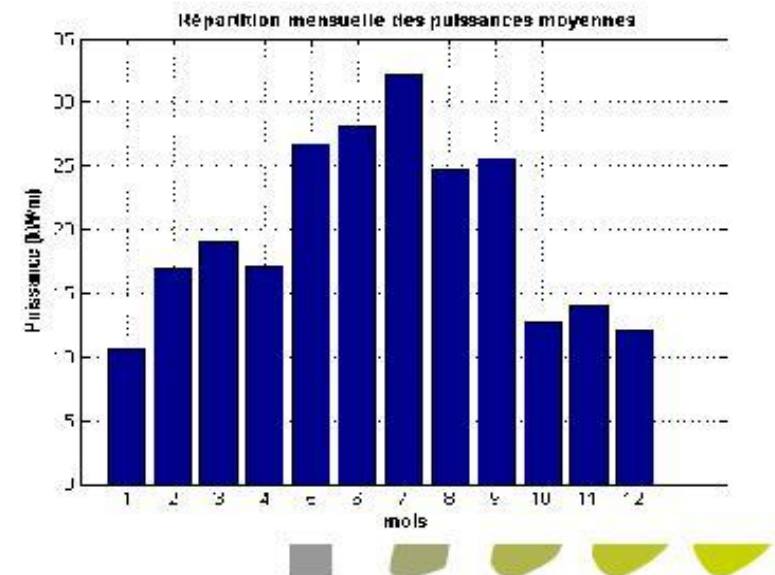
Wave Energy onshore Project Saint-Philippe

Energetic potential of the site

Power of the waves:

$$P = 20.7 \text{ kW/m}$$

- Average waves:
 - $H = 1.9 \text{ m}$
 - $T = 11.9 \text{ s}$
- Bathymétrie : going deep quickly
 - Little friction
 - Few energy losses/



Onshore Wave energy Saint-Philippe

Projet de réaménagement de la cale
de mise à l'eau à Saint-Philippe :



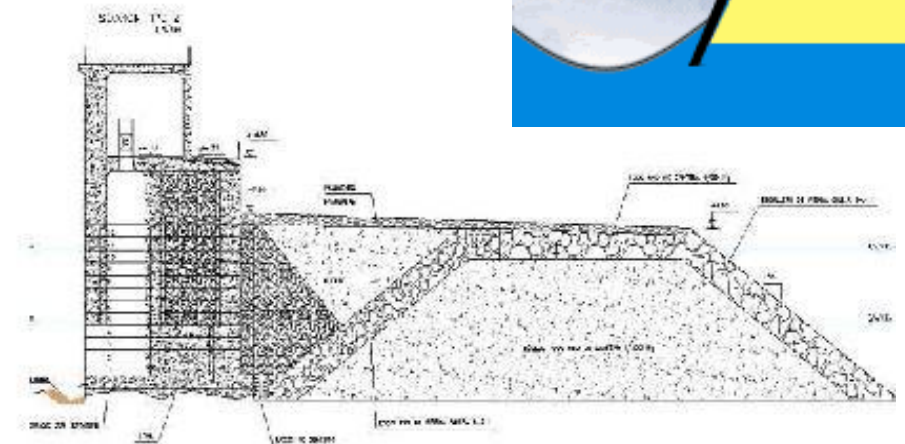
Photos EGIS

Onshore Wave energy

Saint-Philippe

LIMPET Technology (VOITH) :

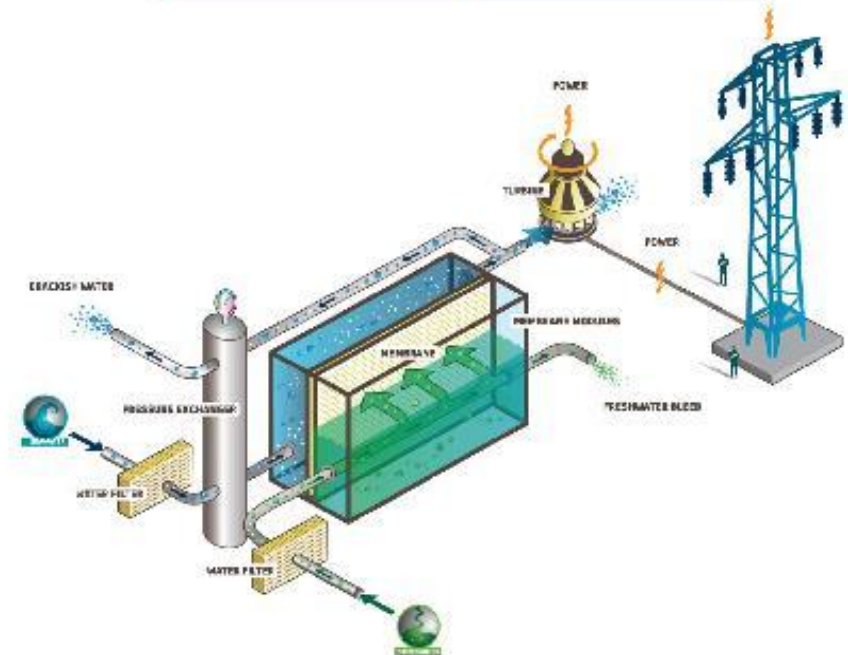
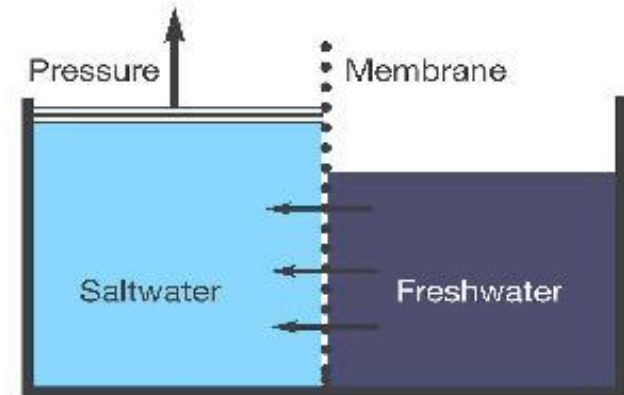
- Experimented since 2000 in Scotland
- Similar Project at Mutriku (Spain) :
 - Wave power: 5 kW/m
 - Power for 60m: ≈ 300 kW
- For St Philippe :
 - Power for 160m: ≈ 800 kW



Osmotic Energy Project Sainte-Rose

Osmotic Energy :

- Uses the natural pressure between freshwater and saltwater
- A Baseload energy
- Research and development level
- Progress from desalination
- Still an expensive technology (cost of membrane))



Osmotic Energy Project Sainte-Rose

Potential of Sainte-Rose :

- Operation de la centrale hydroélectrique, 5 to 7 m³/s in average (up to 10 m³/s)
- A power de 4 MW ($\approx$ 28 GWh)

Industriels du secteur :

- STATKRAFT (leader mondial)
 - Prototype en cours à Oslo
- Spécialiste de l'osmose inverse : VEOLIA EAU, ...



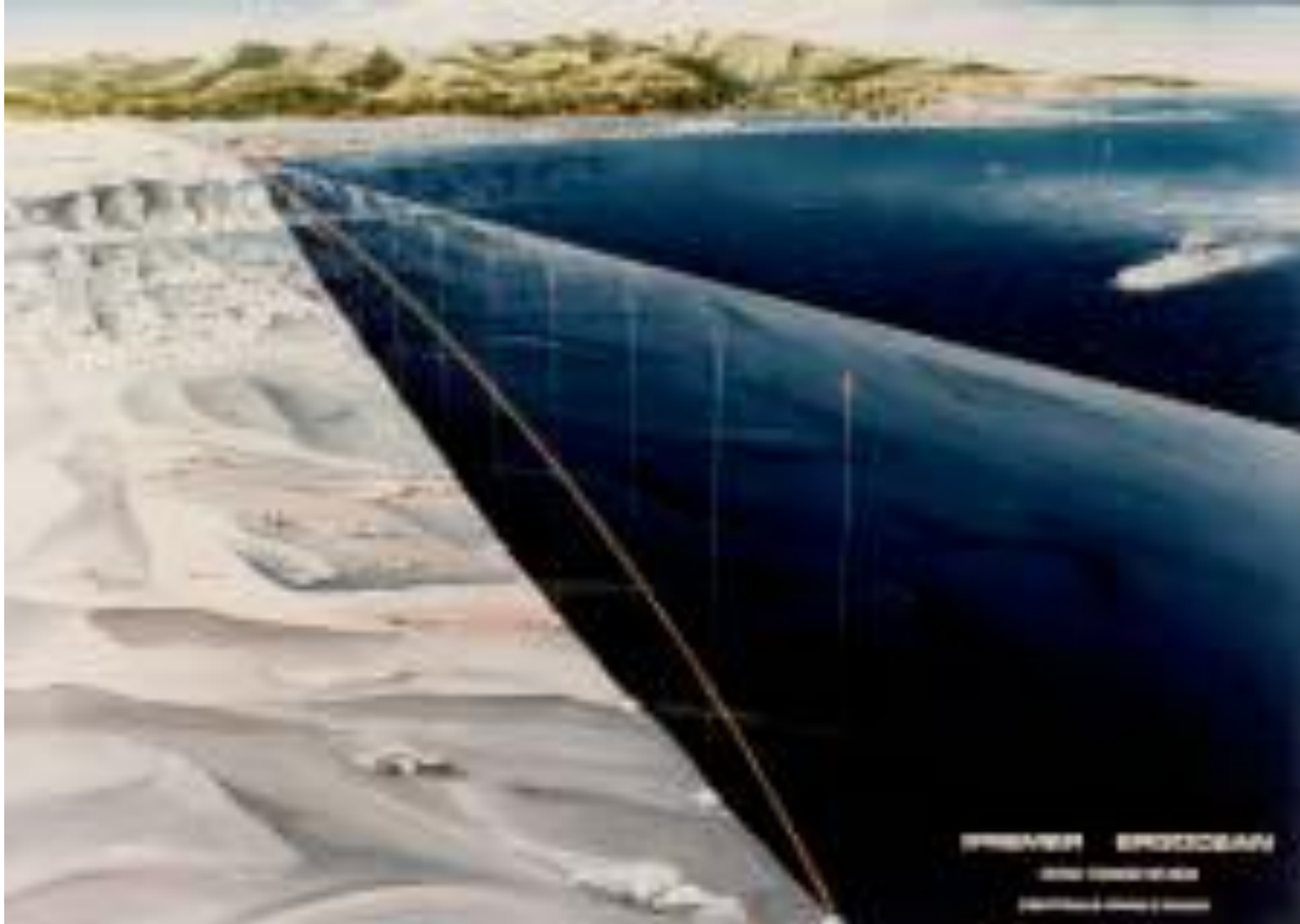
Ocean Thermal Energy Conversion

Sea thermal energy

Volcanic Tropical islands are quite appropriate to OTEC.

OTEC uses the temperature difference that exists between deep and shallow waters to run a heat engine. While the surface water is heated by the sun in the tropics, the global ocean circulation drive deep sea currents around 1000 m with cold dense water from the Polar Regions, with a substantial vertical temperature gradient.

OTEC Plant Project at Tahiti



Power: 5Mw neat (7Mw brut)

Tube Diameter : 2,5 m

Cold Water flow : 20 m³/s

The SWAC project

- **SWAC Sea water Air cooling**
- Project for huge Urban air-conditioning network
40 MW cold
- Saint Denis-Sainte Marie SIDE0
- At Procurement level

Reunion Island OTEC

Study of the best ORC cycle Prefeasability study

On shore Pilot project 2,5 Mw and 10 MW power plant

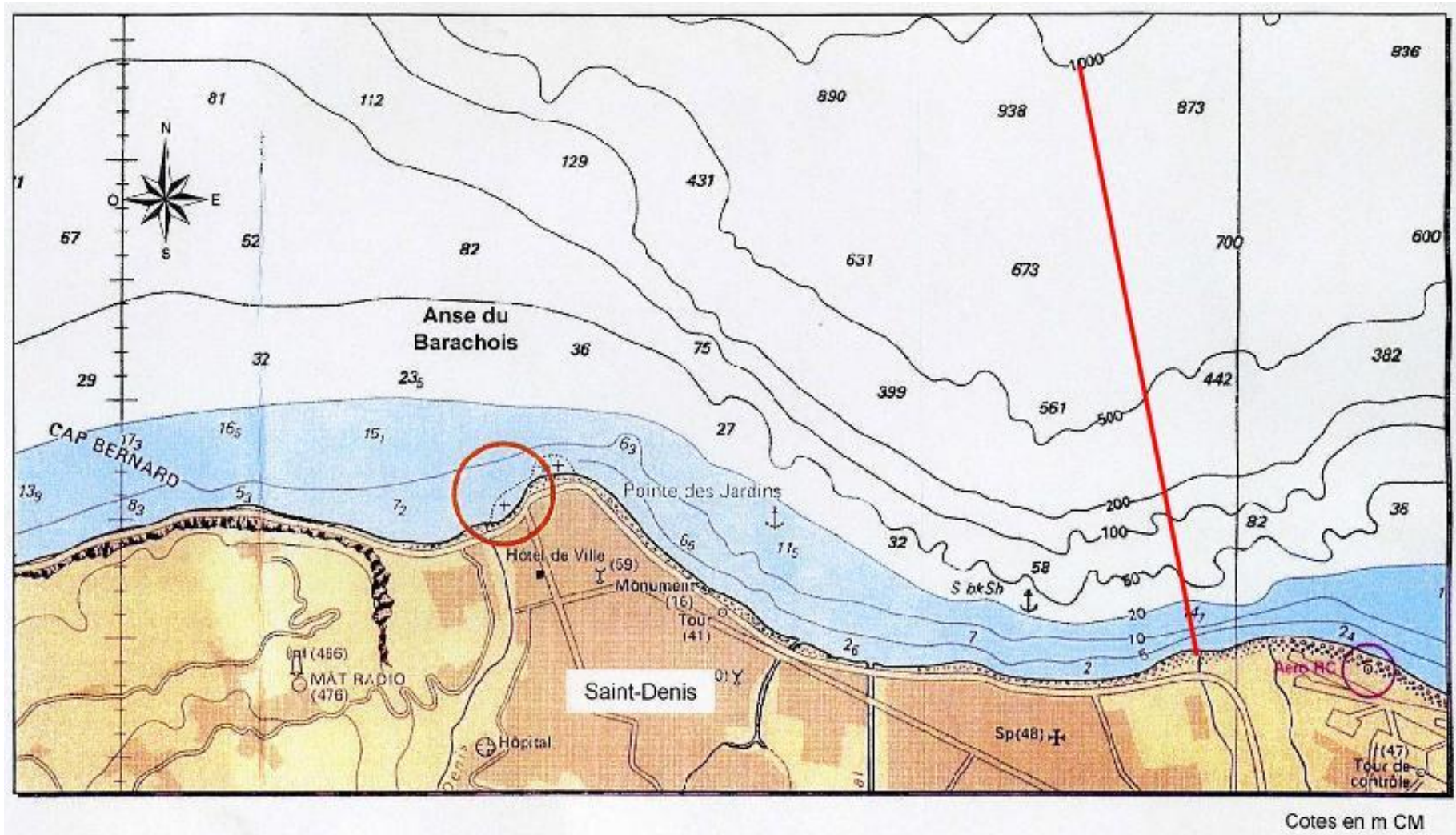
Project with DCNS at Le Port. 2015

Baseload - System typically generates electric output around the clock with an annual capacity factor greater than 75%.

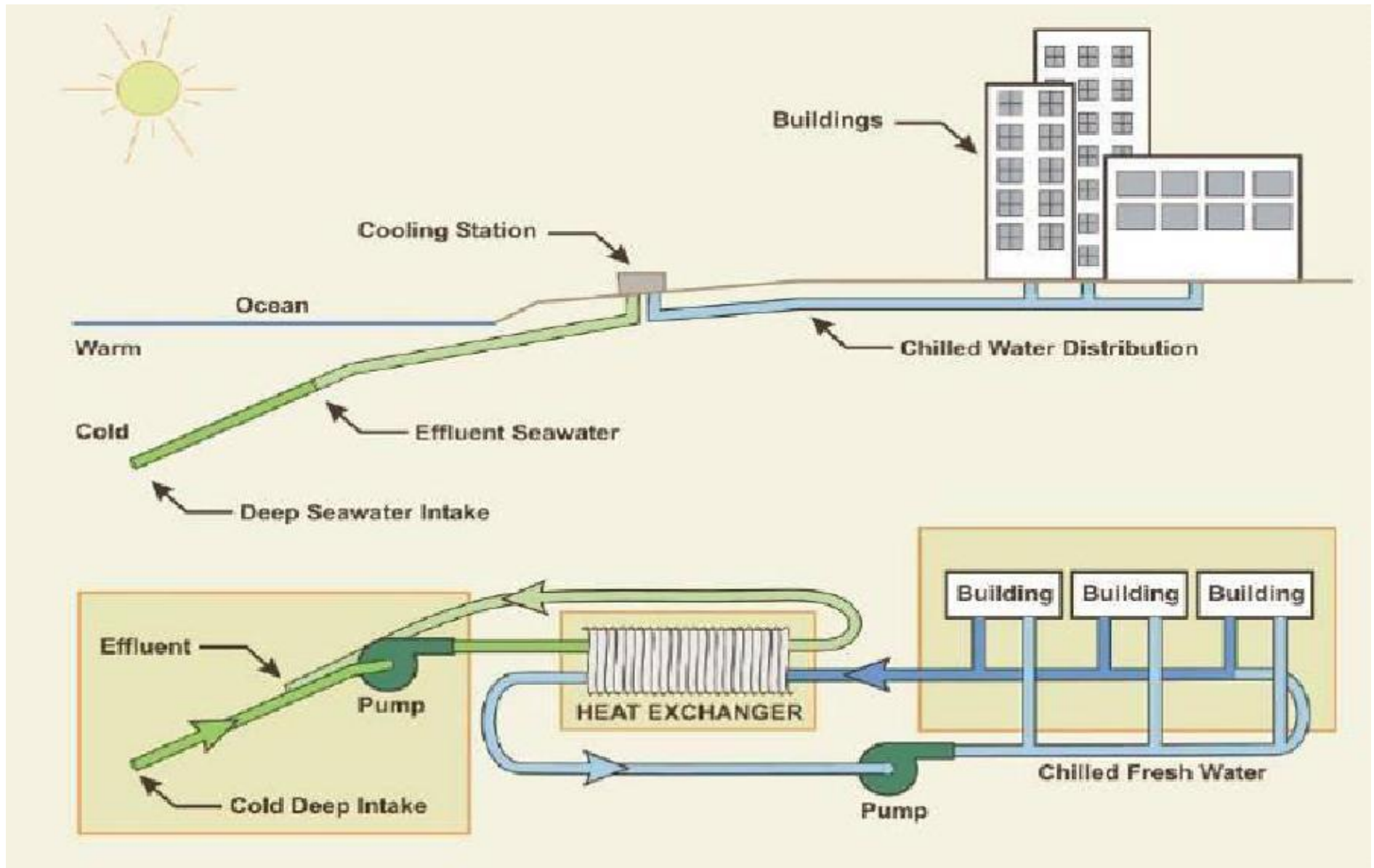


SWAC Implantation

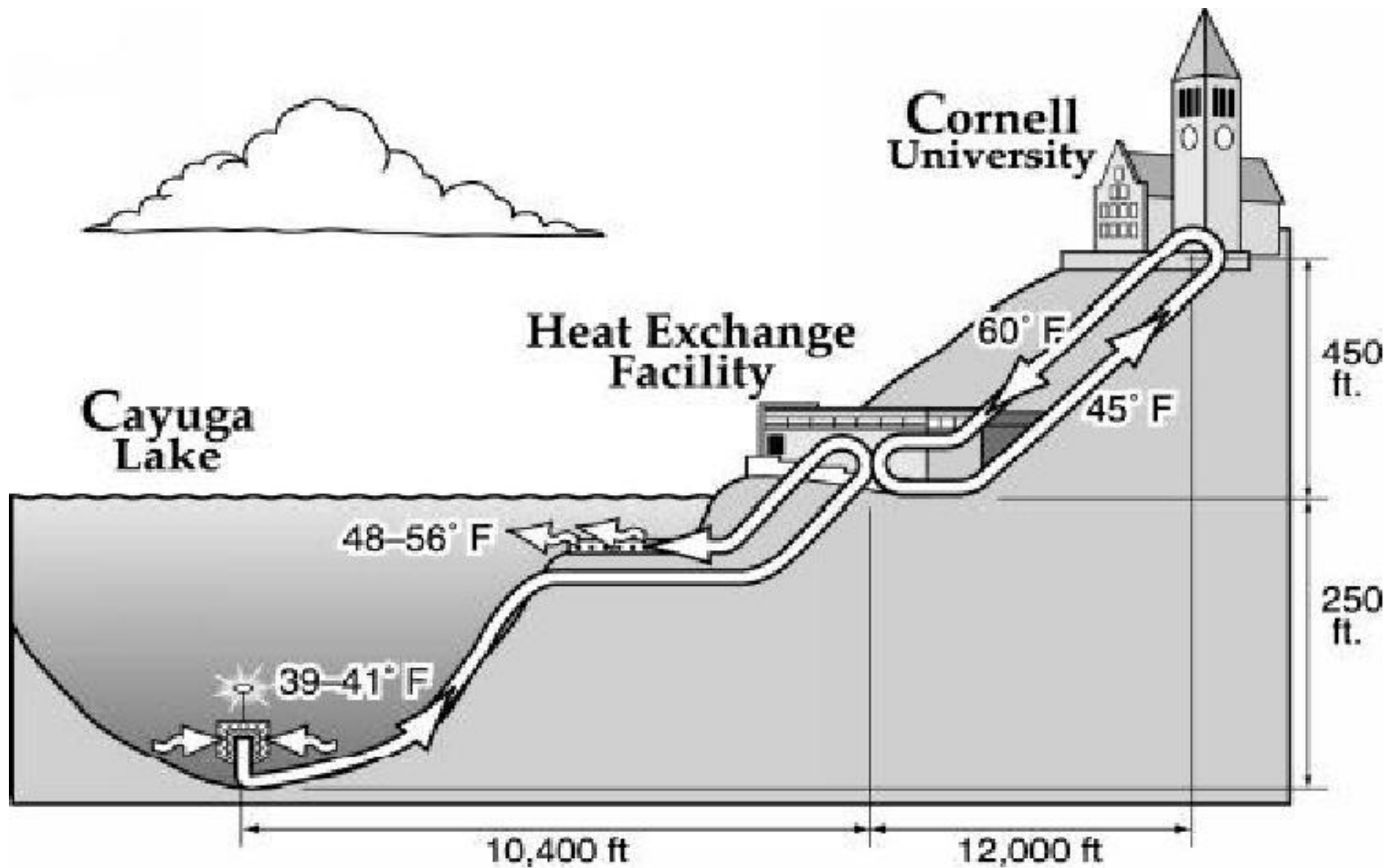
Deep Seawater Intake and heat exchanger



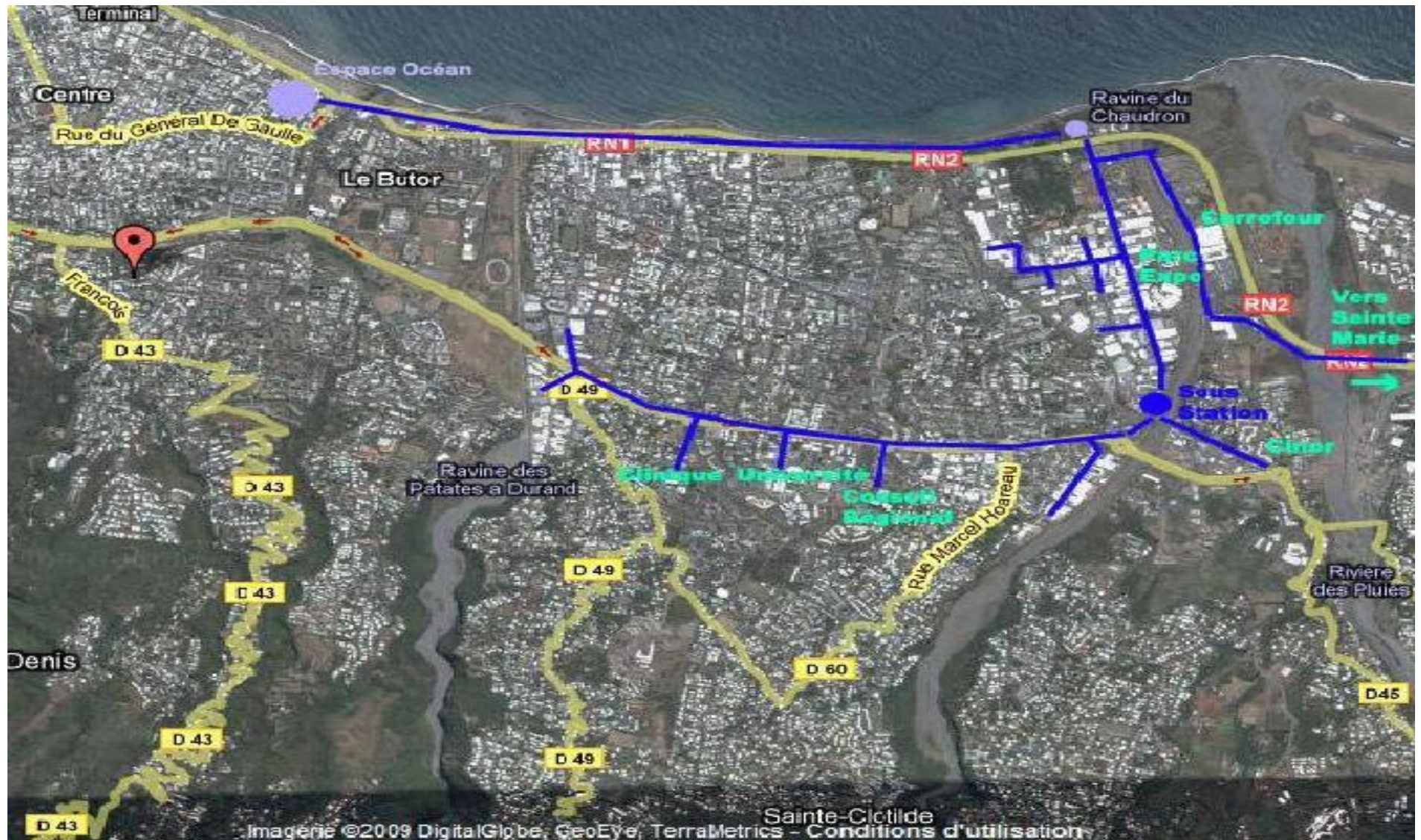
SWAC principle scheme



Example of SWAC



St Denis SWAC distribution network (20 Km)



MICRO-ALGAE and 3rd generation biofuels

Project to grow Micro algae under PV solar green houses St Denis or Ste Rose. BIOALGOSTRAL

Culture in totally controlled area (photobioreactor) or open space

