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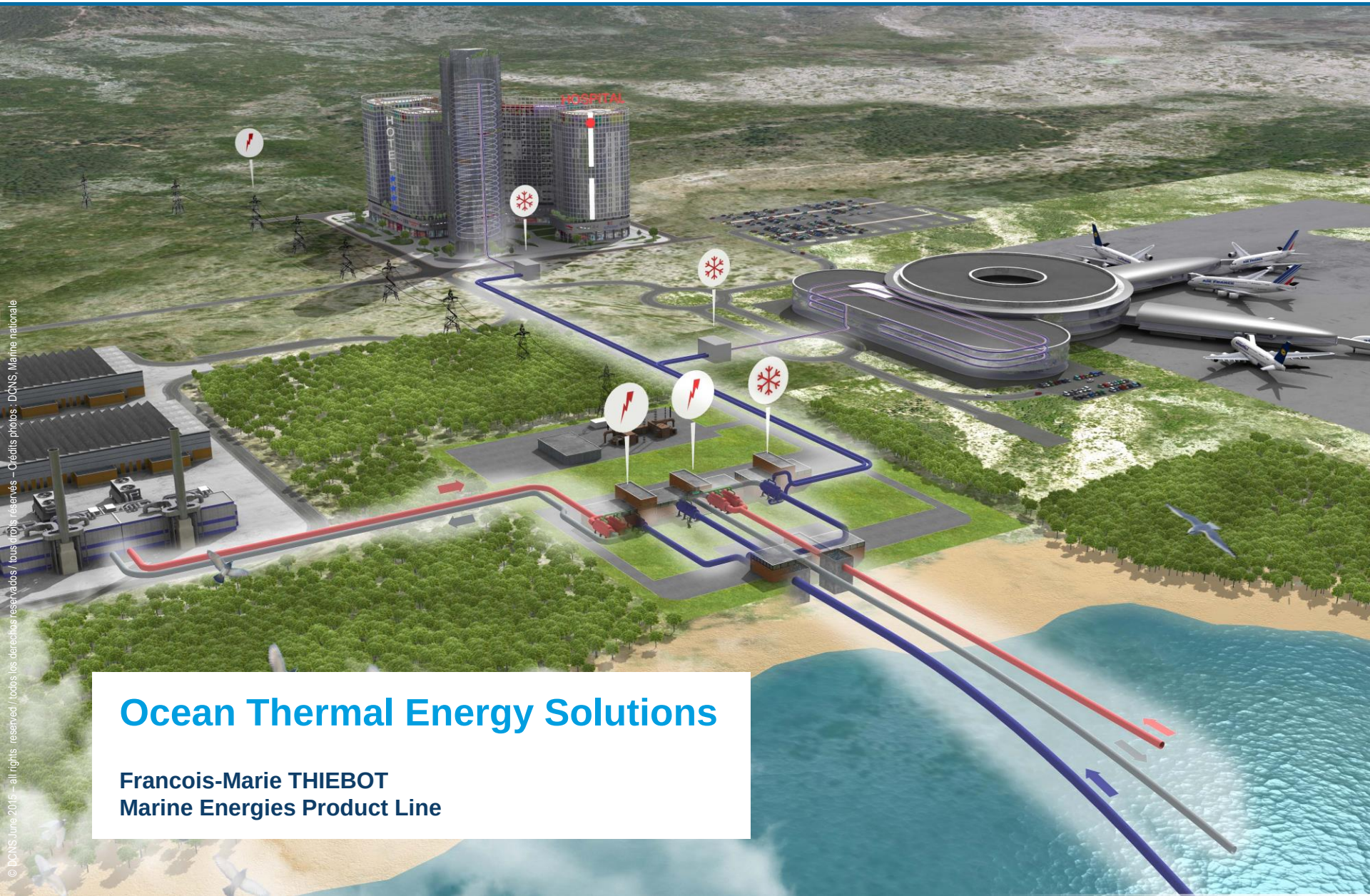


Ocean Thermal Energy Solutions

Francois-Marie THIEBOT
Marine Energies Product Line

DCNS: a world leader in naval defense, an innovative player in energy

3.1
billion euros
in revenue

13.2
bn. euros orderbook
(€3,6bn 2014)

13 130
employees

≈ 100
millions R&D
≈ 3% of turnover

1/3
of revenue
from int'l sales &
cooperation
programmes

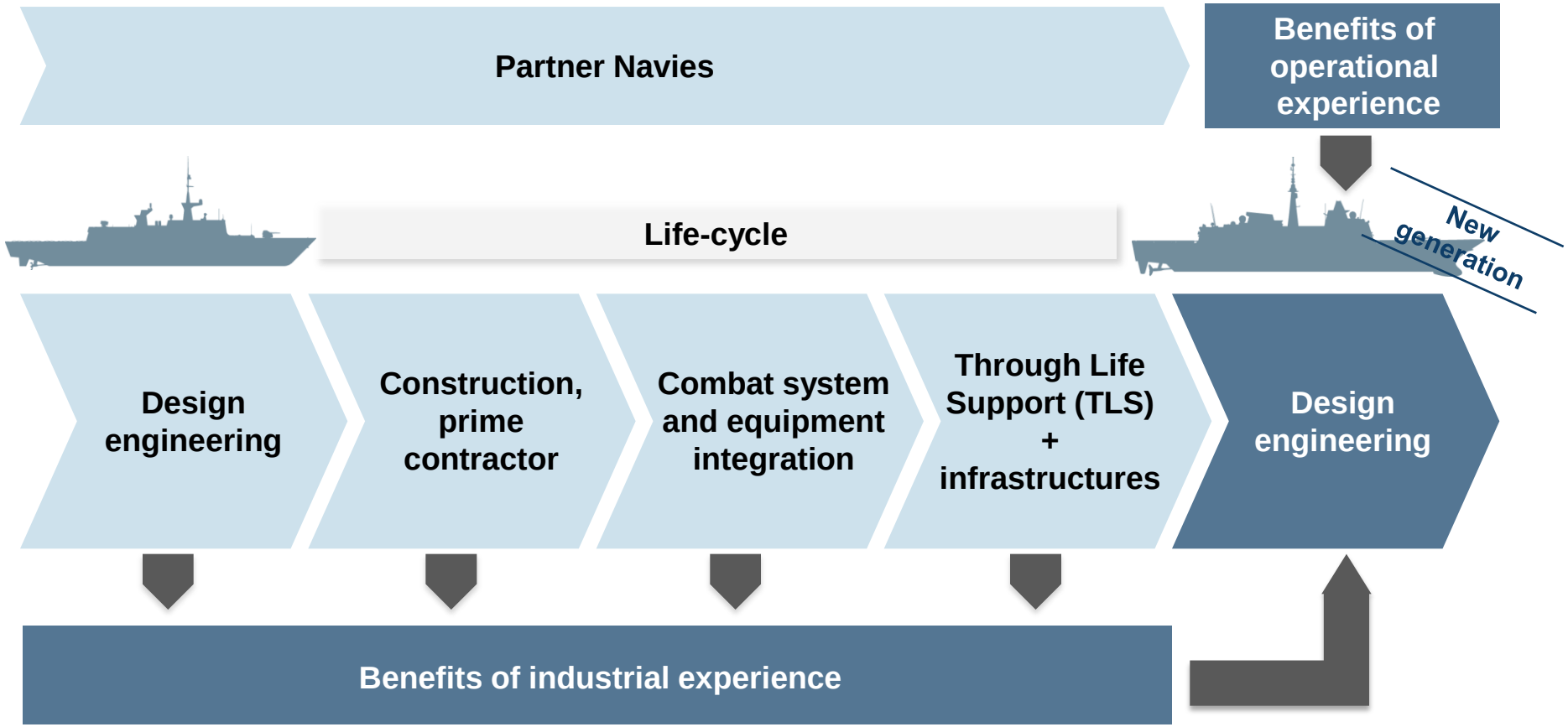
(2014 figures)

A world leader in Naval Defence…

A range covering all client's needs
from nuclear powered submarine to aircraft carriers.

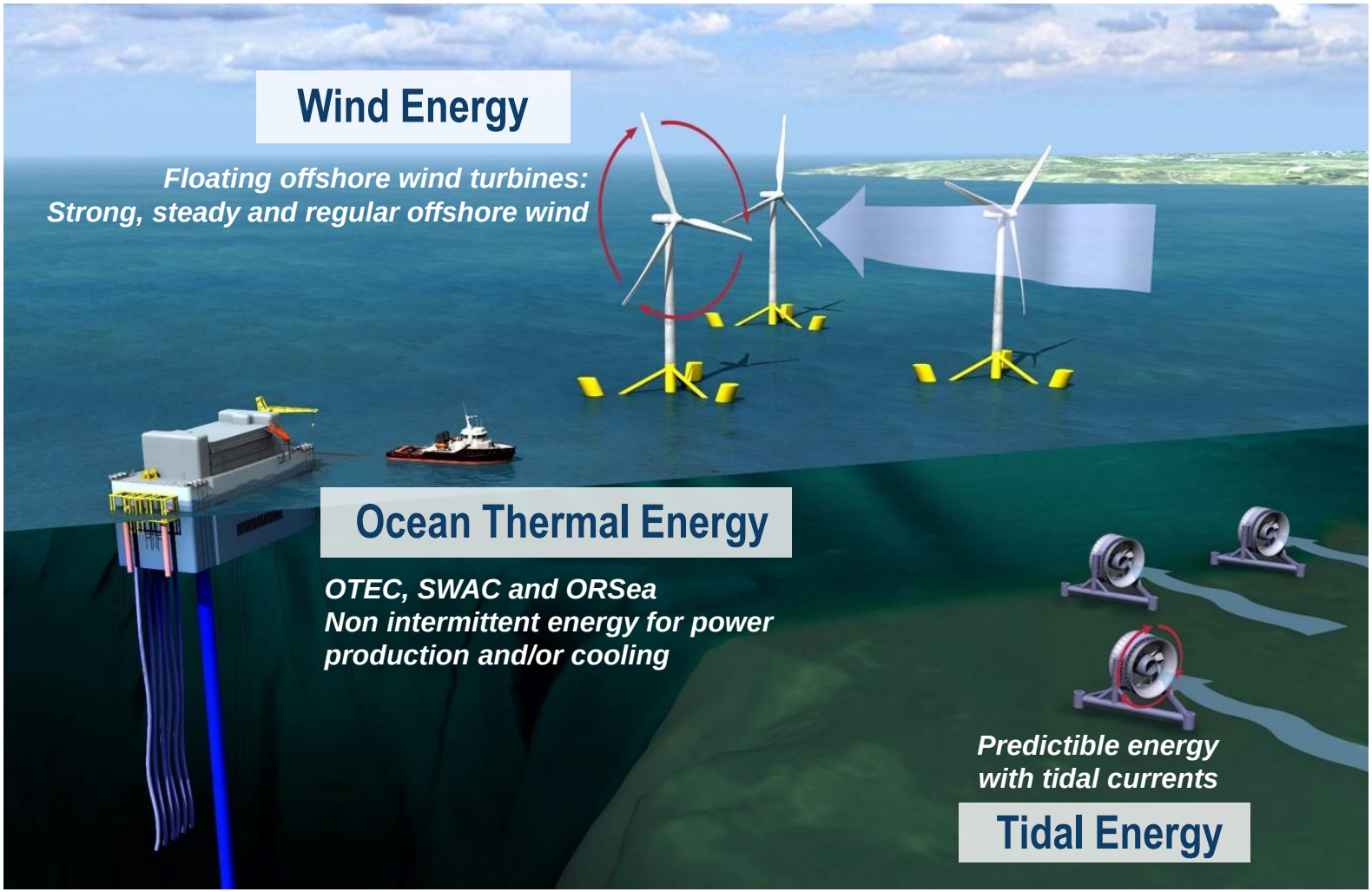
Totally in command of ships' entire life-cycles
Full guarantees on lifetime performance & availability

EPC contractor bringing guarantees on all the value chain



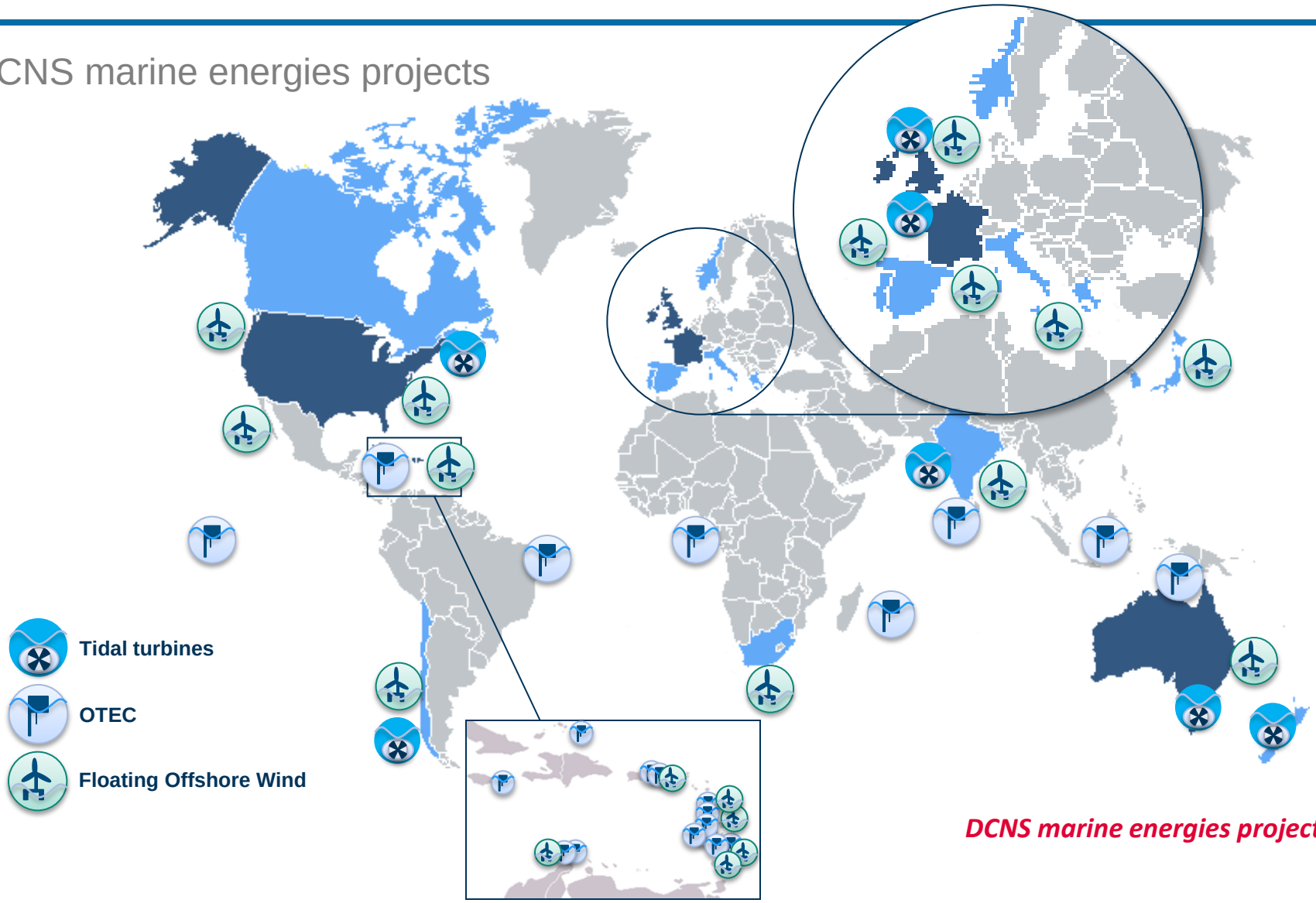
…an innovative player in Energy

DCNS invests in 3 MRE: tidal turbines, OTEC, floating offshore wind



Ocean energies : a mushrooming market

DCNS marine energies projects



DCNS marine energies projects

DCNS positionning on Ocean Energies : know-how & competencies on energies and marine infrastructures

Industrial EPCI / prime contractor, including BOP

- Commited on performance, availability, cost, quality and security of turnkey arrays and power plants
- Arrays/farms engineering and BOP (Balance Of Plant)

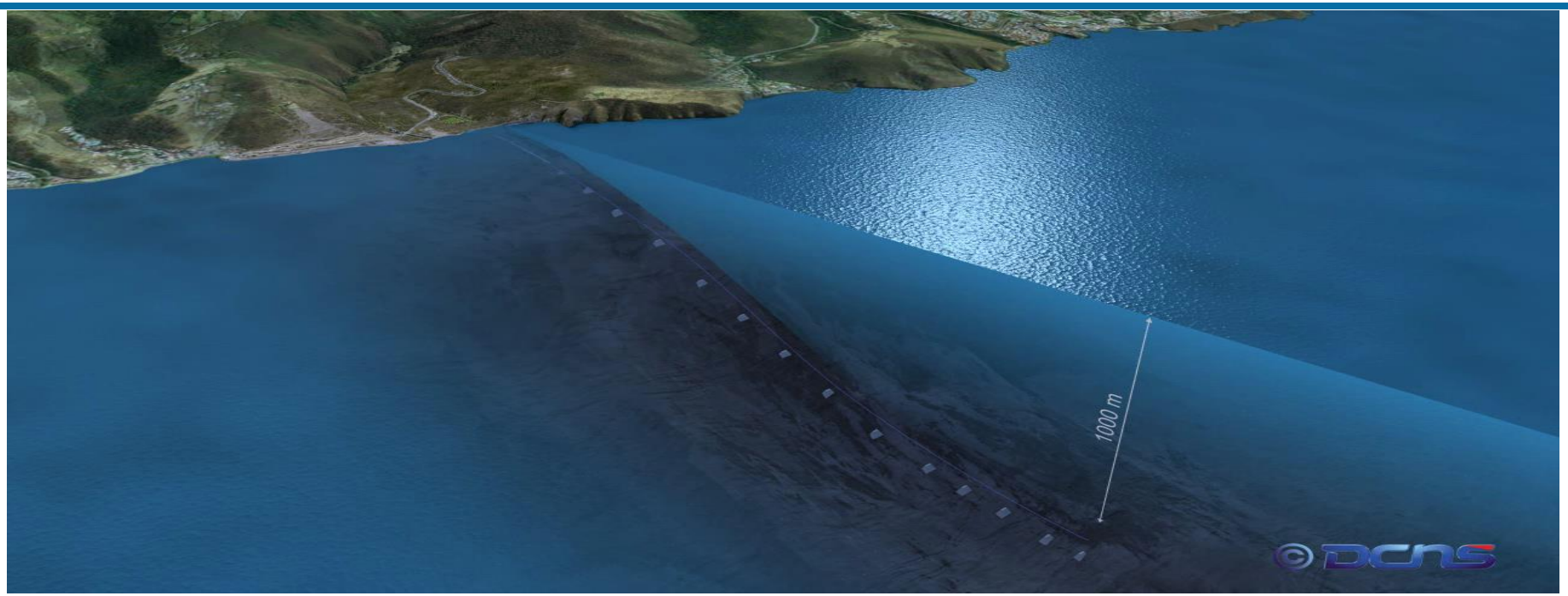
Renewable energy equipments provider

- OpenHydro tidal turbine
- OTEC energy module
- Floating offshore wind turbine, partnership with ALSTOM

Energy services provider

- Installation
- Maintenance

Dedicated and commited to renewable energy stakeholders : utilities, territories, developers, banks, …

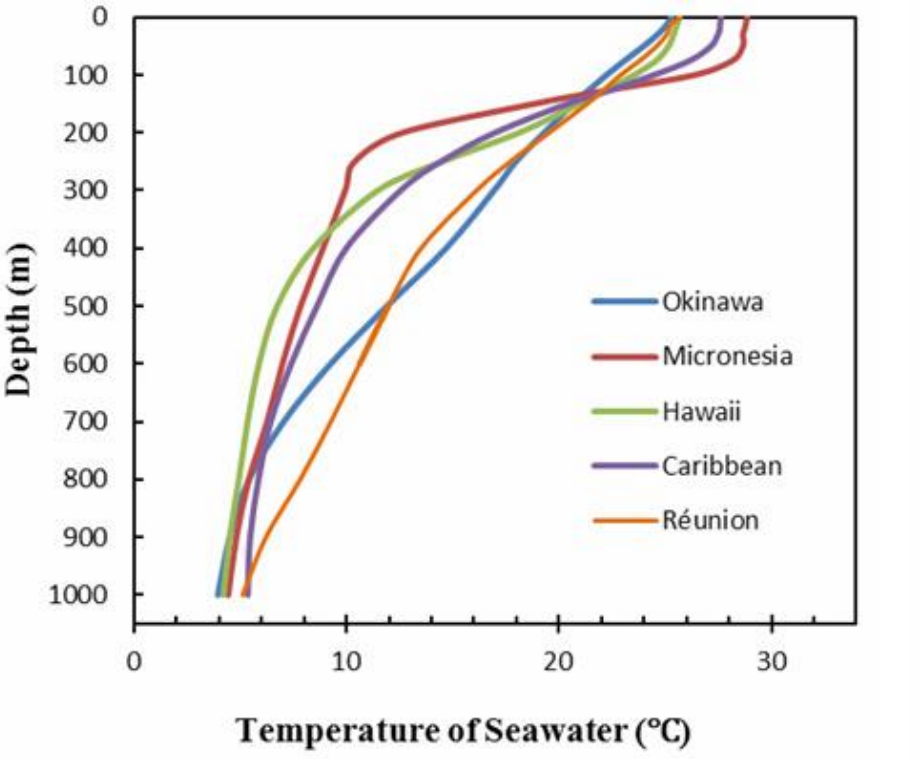


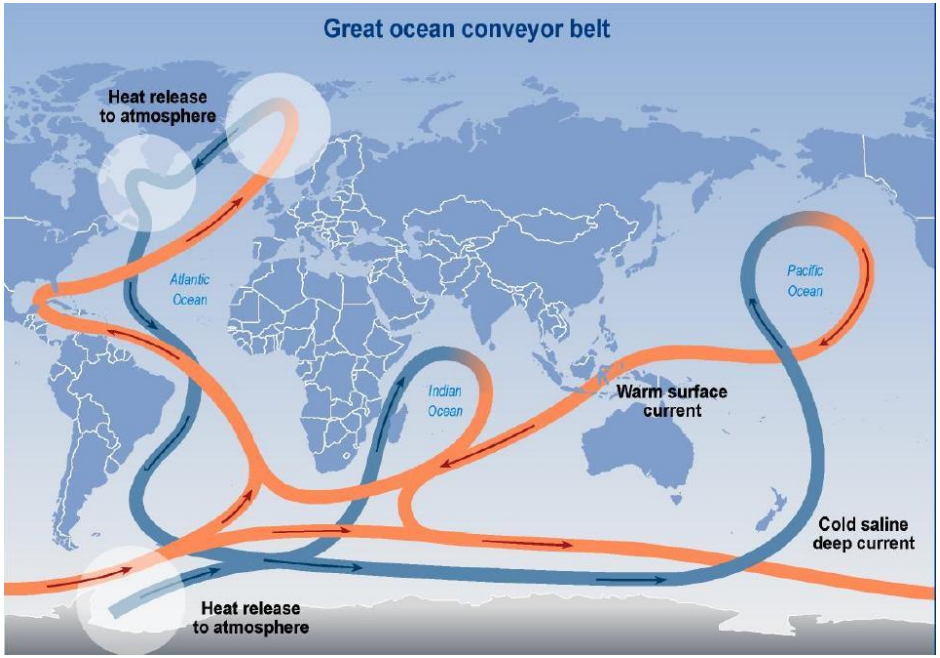
Ocean Thermal Energy

Huge renewable resource for islands and coastal areas

Ocean thermal energy resource

- **A global current called thermohaline circulation brings the cold potential**
  - Almost unlimited
  - Fully constant and predictible
  - In the ocean depths
- **5°C is reach at 1000m deep**

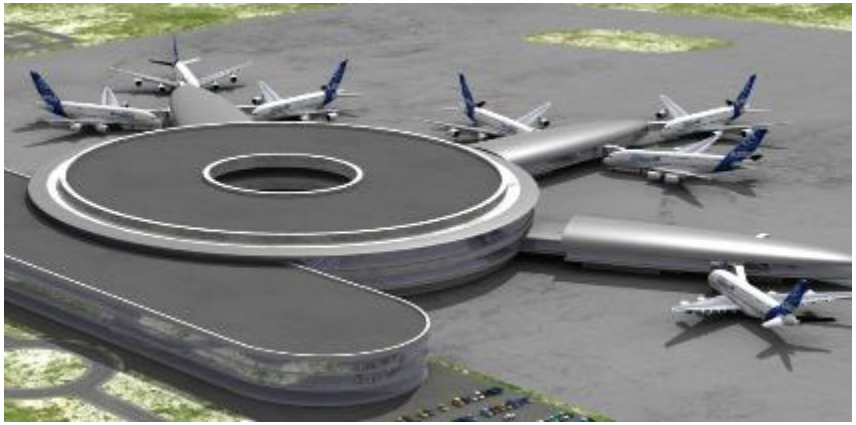




- **The sun warms up the surface water to 25-30 °C**

SWAC: Direct use of ocean thermal energy

- **Conventional cooling:**
  - Uses electricity mainly from fossil fuel (Global warming impact)
  - High cost of energy : (average up to 250 to 300€ / MWh)
  - Creates the 7°C cooling from a 30°C hot source
  - Distributed cold production (per building when not per room)



- **SWAC idea:**
  - Why not using locally existing huge 5°C cool renewable resource?

SWAC: Direct use of ocean thermal energy

SWAC system:

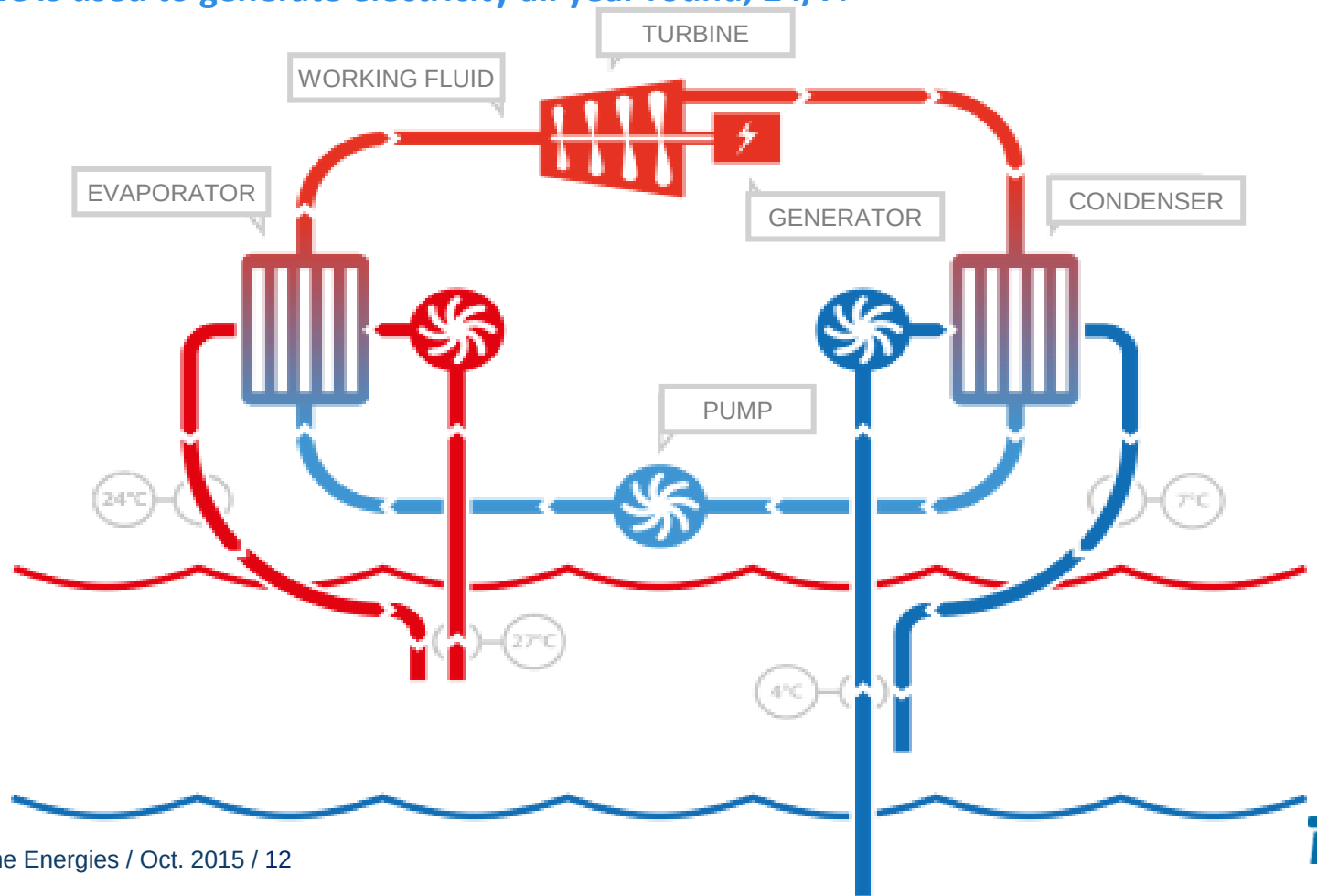
- Reduces electricity consumption by 10
- More independence from fossil fuel
- Does not create but transports the cool
- Centralizes the cold production (SDC)

Revolution in business models requested

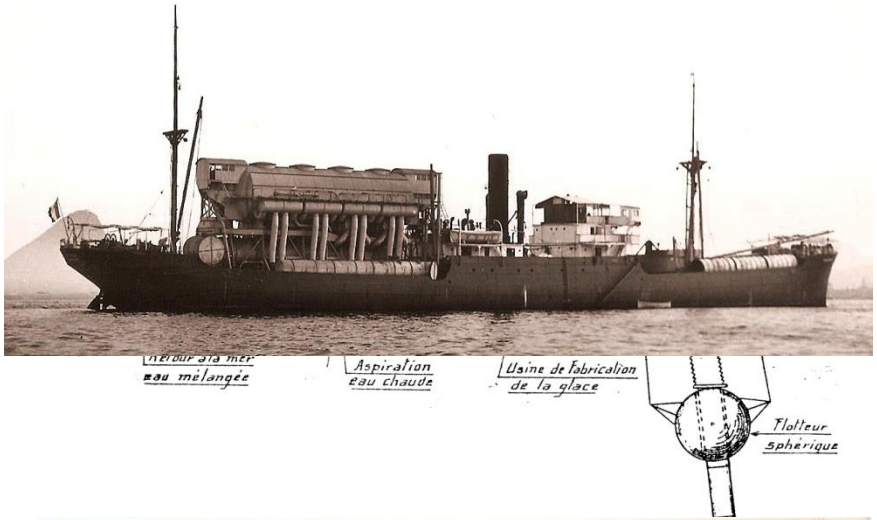
- Low OPEX but financing needed for CAPEX
- Long term contract with consumers

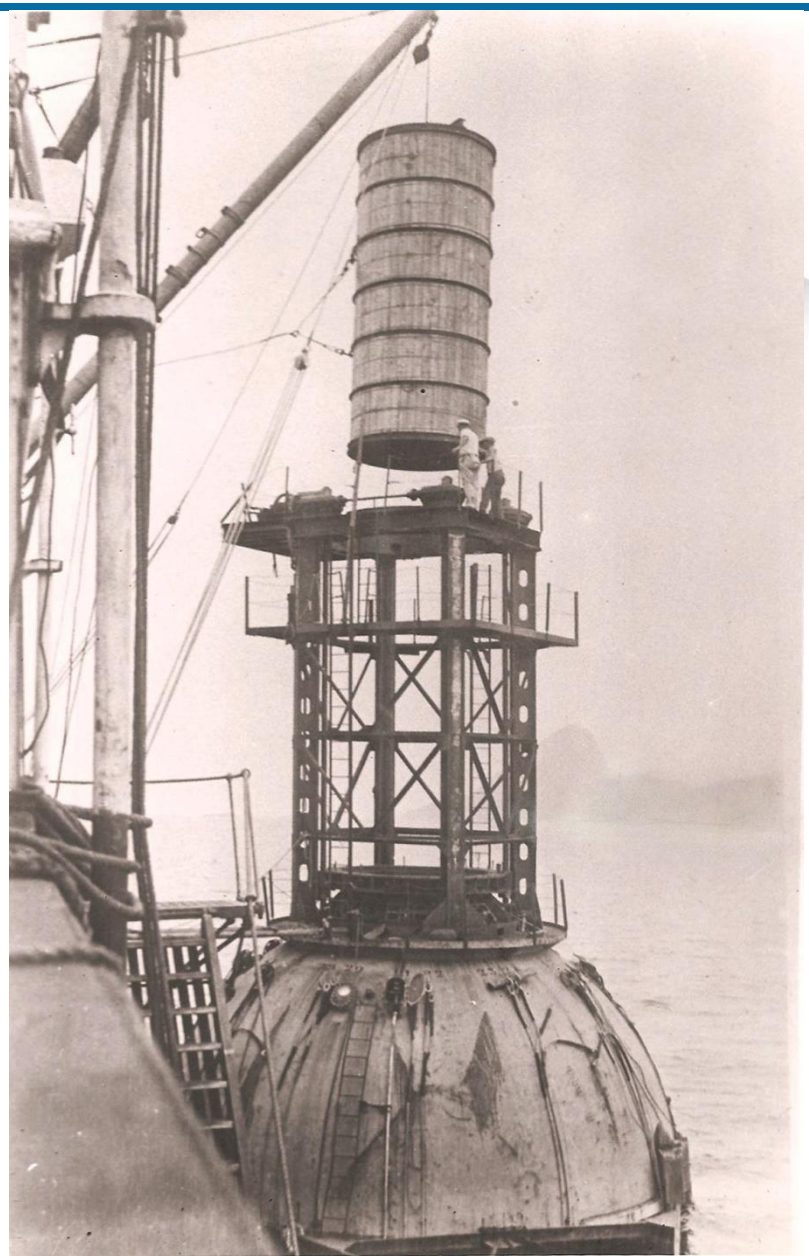
OTEC: indirect use of Ocean Thermal Energy

- **OTEC uses Organic Rankine Cycle (ORC) technology exploiting:**
  - Warm source: surface seawater (at around 25 °C)
  - Cold source: deepwater (around 5 °C at depths of 1,000m)
- **OTEC is used to generate electricity all year round, 24/7.**



OTEC: Georges CLAUDE experimentations - Cuba 1930





Technical aspects

LCOE is key:
Two major innovations requested in order to lower costs

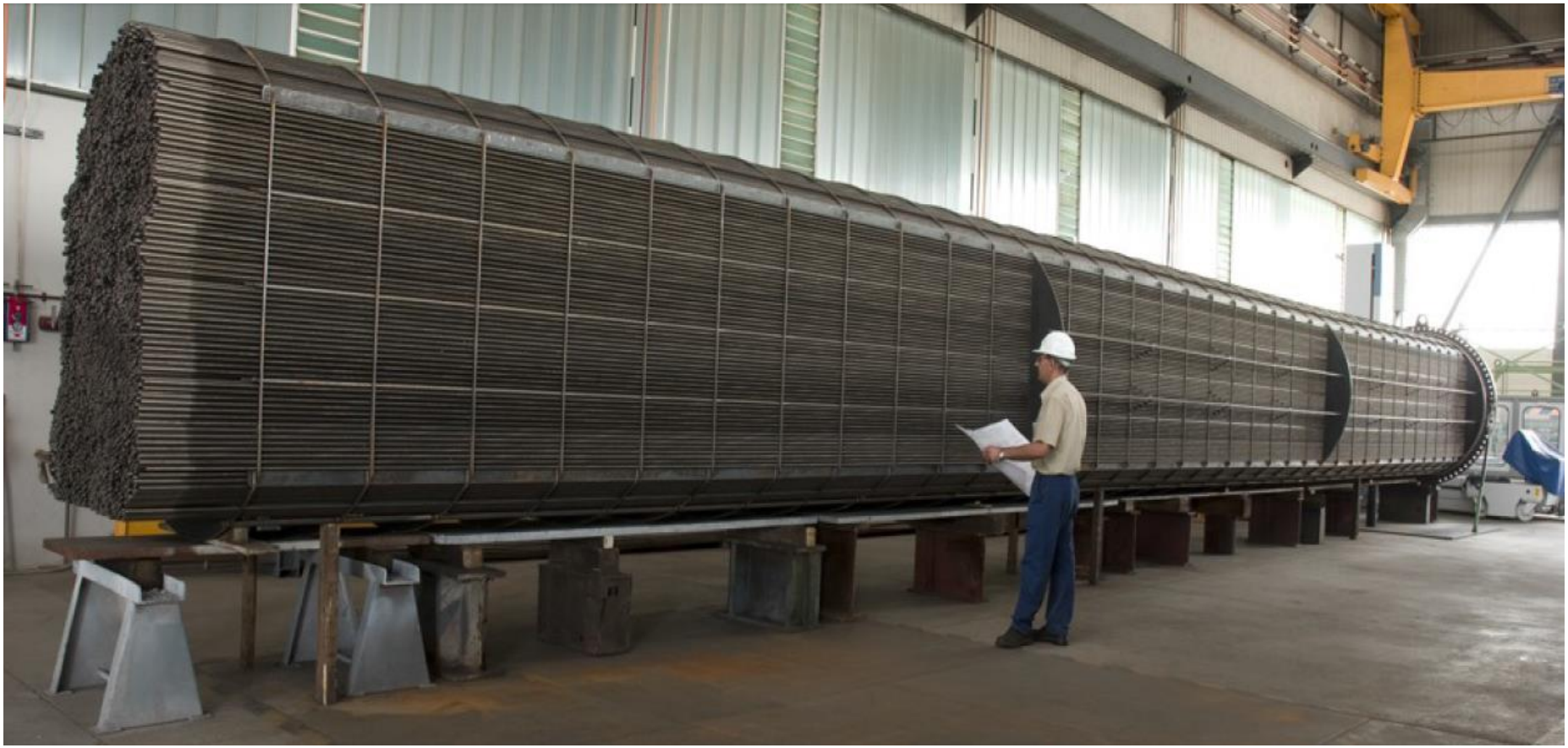
- **Innovative deep seawater pipe (1km deep, 30 years or more reliability)**
  - We cannot afford available oil&gas technologies
    - SPAR platform is too expensive: offshore OTEC uses simple barge (not as stable)
    - Offshore installation means have to be reduced to a minimum

  ⇒ DCNS has developed its own technology of pipe
    - Withstanding instability of the platform
    - Easily installable from the platform without offshore means or any diver
    - Innovative material: no HDPE, no steel…
- **Low temperature gradient Organic Rankine Cycle (ORC)**
  - 25°C gradient never been exploited commercialy by ORC technology
    - Heat exchange pinch has to be very low, reaching unknown areas of available modelization
    - Any pressure drop has to be hunted

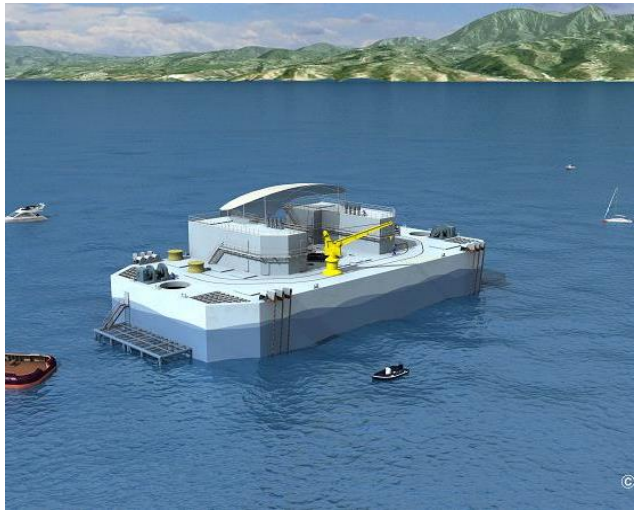
  ⇒ DCNS has developed and tested several titanium exchanger
  and a fine tuned numerical model providing reliable performance estimation

Land based prototype for low temperature gradient ORC at StPierre university, La Réunion island

Titanium tubes for OTEC heat exchangers



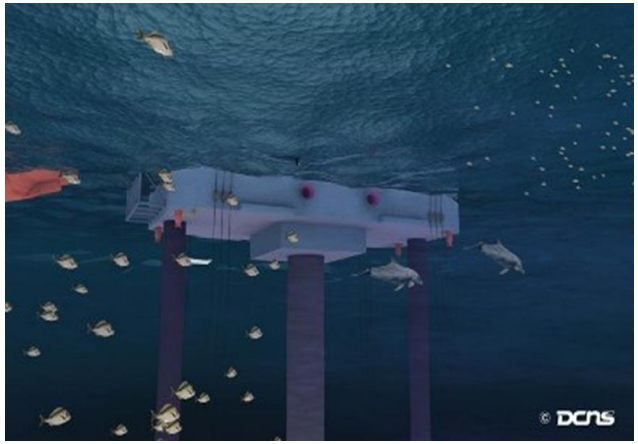
Ocean Thermal Energy Conversion (OTEC) : Roadmap



Key points

- Renewable baseload energy with zero uncertainty on the resource
- A new source of renewable energy for island communities
- Bringing green added value to Caribbean territories (Academic programs, O&M know-how and competencies)

- High-power floating plants of up to 30 MW+
- Onshore plants of 5 to 10 MW, with the possibility of adding SWAC and Waste heat recovery (ORSea)

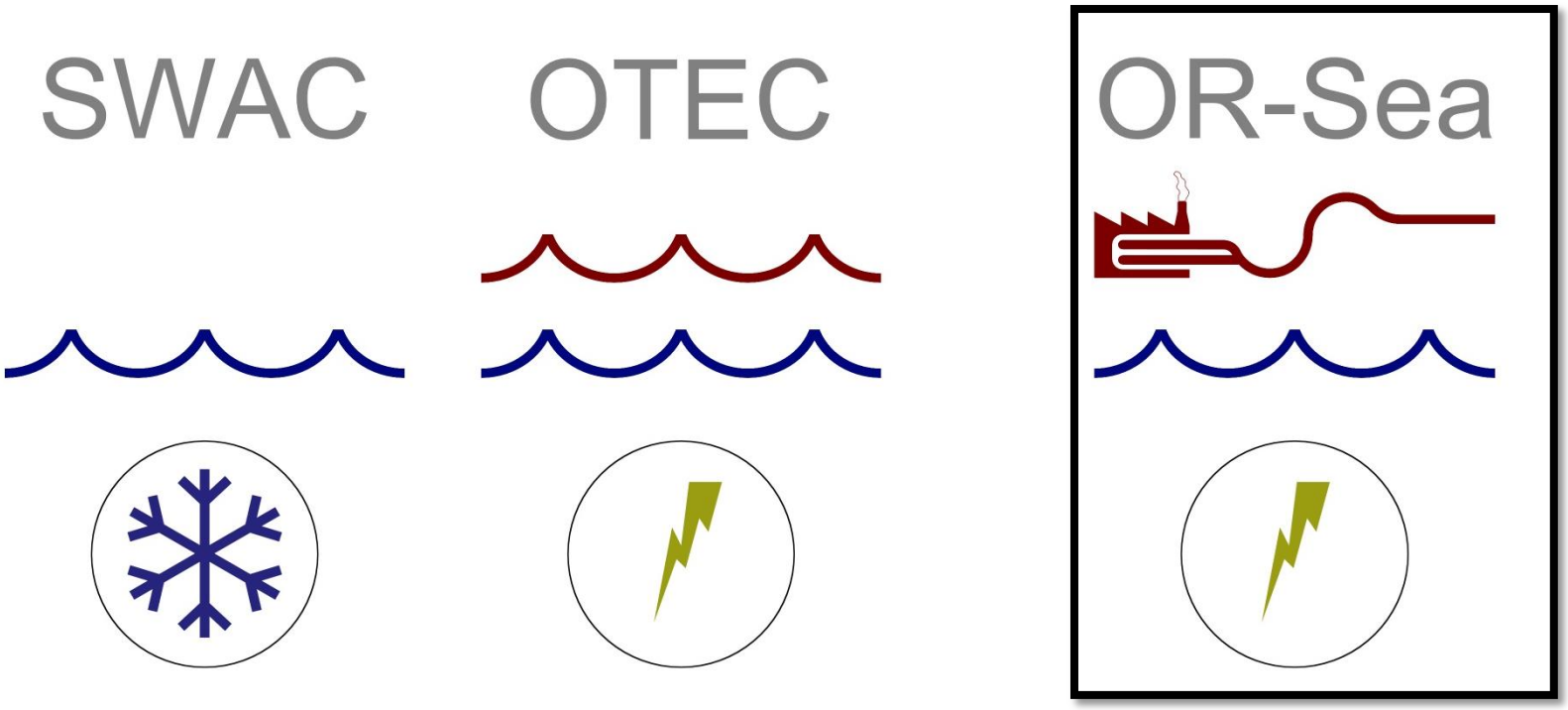


Calendar

- 2009-2012 : feasibility studies La Réunion, Tahiti, Martinique
- 2010 : land based OTEC prototype Réunion island
- 2013: basic design of a pilot offshore plant of 16 MW
- 2013: basic design for combined OTEC/SWAC systems
- 2014: NEMO project awarded €72M subsidy by NER300 European funding program : 16MW offshore OTEC plant in Martinique in 2019
- 2019: NEMO project in operation

DCNS: First OTEC commercial offshore plant : NEMO Project

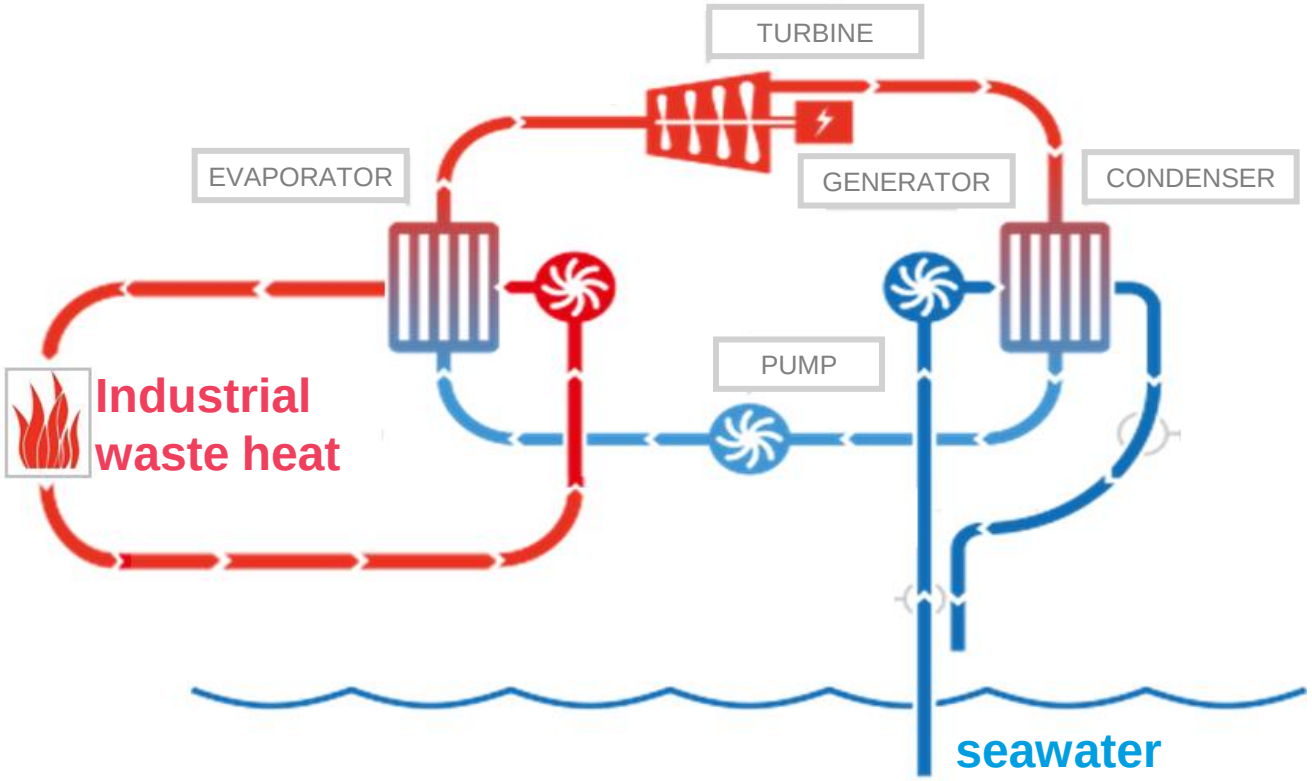
Ocean Thermal Energy



ORSea uses industrial waste heat as warm source to produce electricity thanks to the seawater

As OTEC, ORSea uses Organic Rankine Cycle (ORC) with greater temperature gradient:

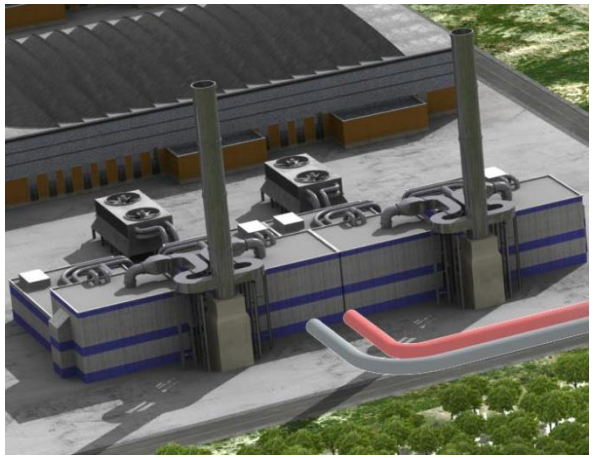
- **Warm source: Industrial waste heat between 50 and 150°C**
- **Cold source: seawater**

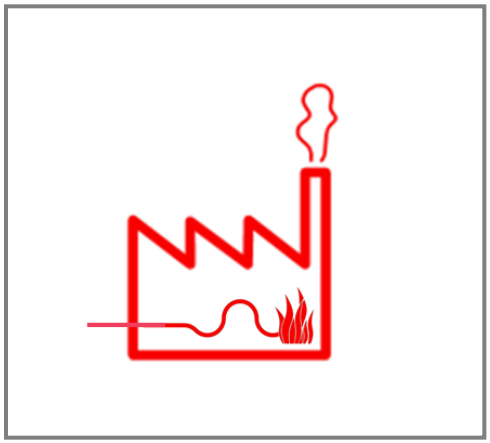


Harnessing waste heat of coastal industry…

Converting waste industrial heat from 50 to 150°C into renewable electricity

- **Using never exploited « low temperature » waste heat**
  - Warm sources < 150°C have always been considered as unexploitable
  - Warm sources need energy-consuming cooling
  - Warms sources are discharged within the atmosphere
- **Exploitation is made possible by strong DCNS know-how on OTEC**
  - First technology provider to harness small temperature gradient at a commercial scale thanks to Ocean Thermal Energy Conversion development



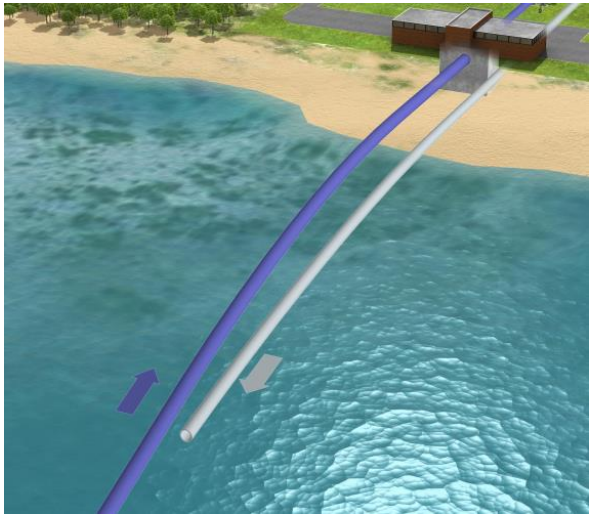


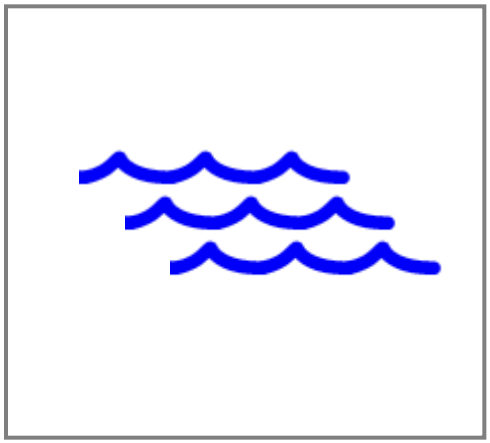
- **No impact on industrial heat provider plant operation**
  - ORSea perfectly fits industrial plant operation cycles
  - Undetectable transfer from conventionnal cooling to ORSea
- **Wathever the industrial plant proving heat**
  - Water cooling systems of electrical thermal plant
  - Waste facilities / incinerators
  - …

…by using ocean thermal potential

Seawater brings unique and high-performing cold source

- **Efficiency**
  - Based on its OTEC expertise, DCNS implements fine tuned heat exchanges (very low pinch of less than 3°C)
- **Small footprint**
  - Sawater cooling is 50 times more compact than air cooling
- **Stability**
  - Seawater temperature is constant and highly predictible





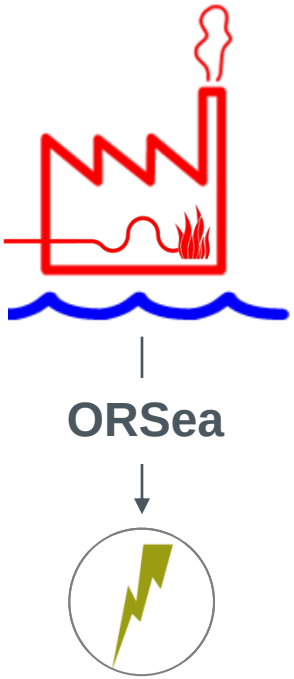
Providing that marine environment is well known

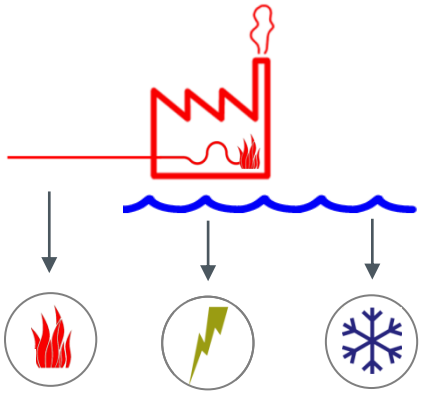
- **Marine environment knowledge and respect**
  - Taking into account local environmental specificities
- **Seawater intake and discharge studies**
  - Current, plume dilution studies
- **Filtration**
  - Filtering systems without sea detritus collection

ORSea benefits and opportunities

Benefits

- **Renewable and non-intermittent electricity production**
  - To increase renewable share in the energy mix
  - Not subject to 30% intermittent energies limitation
- **Industrial plant energy bill reduction**
  - End of cooling systems consumption use
  - Auto-consumption of produced electricity
  - Possible sale of electricity to the grid
- **Environmental impact reduction**
  - Heat exhaust reduction to the environment

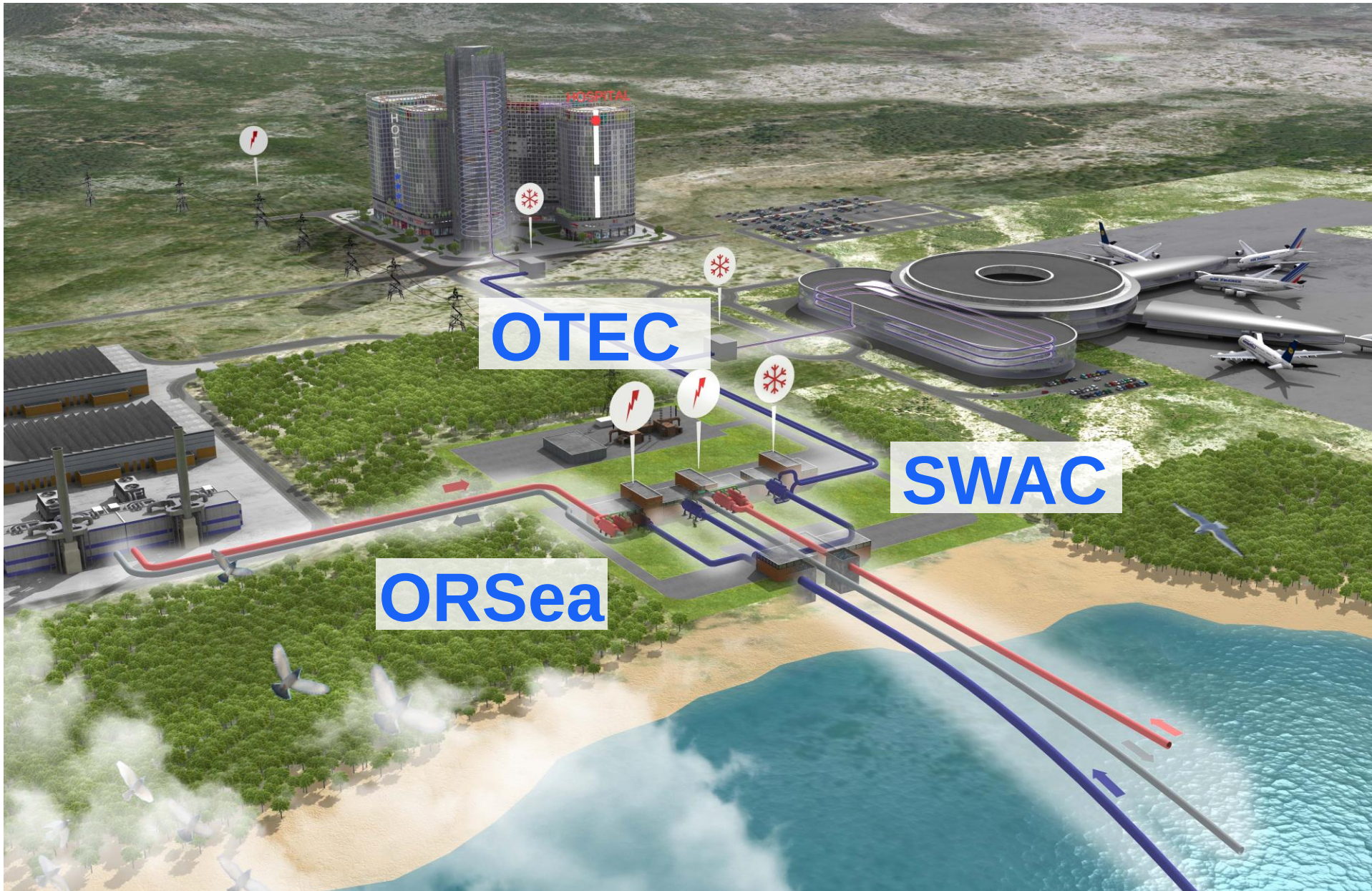




Opportunities

- **ORSea can bring added value to district heating**
  - Bringing renewable and non-intermittent electricity sale contract
  - Associating heat conversion to air conditionning module (absoption technology)
- **ORSea can bring added value to SWAC project**
  - ORSea even more efficient with deepsea water cold source
  - Bringing renewable and non-intermittent electricity sale contract

Perfect hybridization of SWAC, OTEC and ORSea



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