PECC Hawaï Seminar

SEMINAR MARINE RENEWABLE RESOURCES

HAWAI 26 - 27 March 2012

EMACOP

(Energies MArines, COtières et Portuaires)

A National Research Programme

for Marine Renewable Coastal and Portuary Energy

for

Henri BOYÉ

MEDDTL CGEDD

EMACOP

Liberté • Égalité • Fraternité
RÉPUBLIQUE FRANÇAISE

Ministère
de l'Écologie,
du Développement
durable,
des Transports
et du Logement

What is the EMACOP Project?

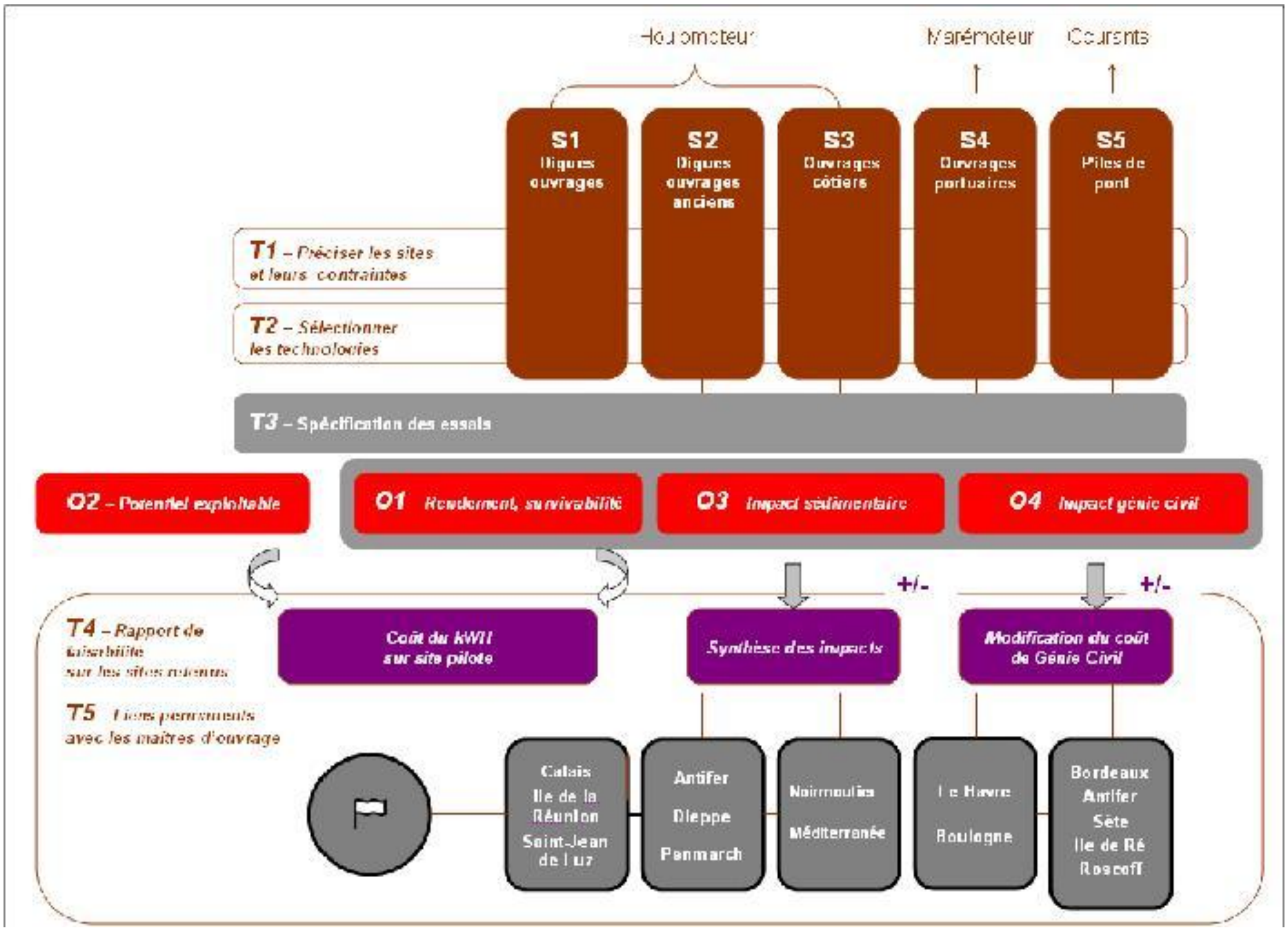
- EMACOP is a French national research project on renewable marine energies in costal and portuary areas
- EMACOP is an acronym for « Energies Marines Cotières et Portuaires » (Marine Coastal and Portuary Energy)
- Many French partners, (technical, engineering, research, ports, companies, local municipalities…)
- Cooperative financing, the Budget is around 7 million USD
- Duration of the project 4 years
- (Henri Boyé nominated chairman of the Emacop Project since February 2012, after one year of preparation for authorization and government funding of the project)

Objectives of EMACOP

- The objectives of this program of research are multiple :
- **Technological progress** in harbors and coastal defenses of coastline and seashore.
- **Feasibility survey and assessment of potential** in MRE, Marine Renewables Energies, especially in wave energy.
- **Awareness of decision makers and contracting owners** (most often the local province or municipality)
- **Sea and ocean is no longer an opponent one needs to be protected from, but an energy resource which can be harvested in a friendly and realistic way.**

Emacop general organisation

a matricial organization, with many tasks and partners



Seashore areas   Coastal and port works

- Marine littoral and coastal zone are by nature a dynamic and sensitive area, exposed to natural phenomena of erosion and marine submersion, and also human development. Seashore structures play a double role : long term protection of littoral area, and allow economic development under a growing anthropic pressure.

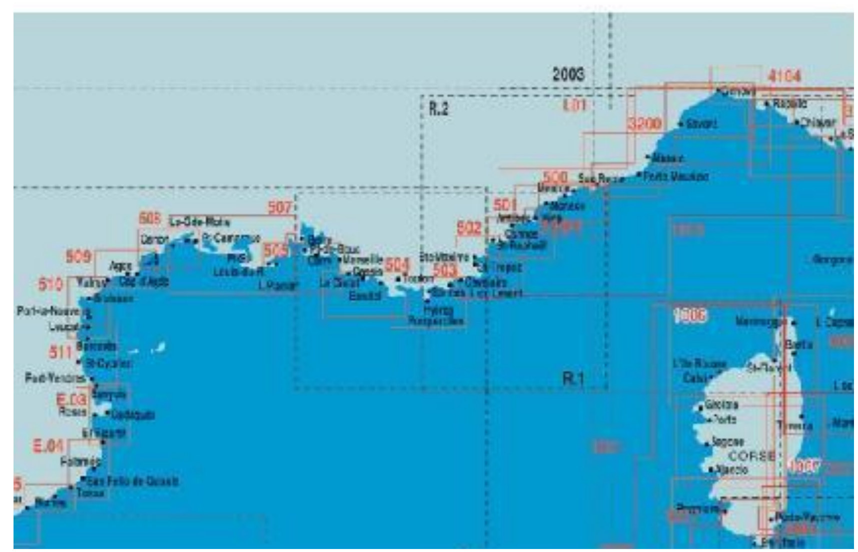
- France owns one of the longer littoral coastline in the world. (Maps)

- Today, the marine park of coastal and port works is composed of very diverse structures, many are aging and confronted to several classical problems at seashore, (stability, durability, sedimental dynamics..) and also to the possible threats of climate change.

- As the costal defences, our ports and harbor structures (an asset and heritage) are aging. They must be developed and modernized, adapted to the growth of traffic and the size of ships. This necessary adaptation will require investments, but provides an opportunity for renewable energies and reduction of green house gas emissions.

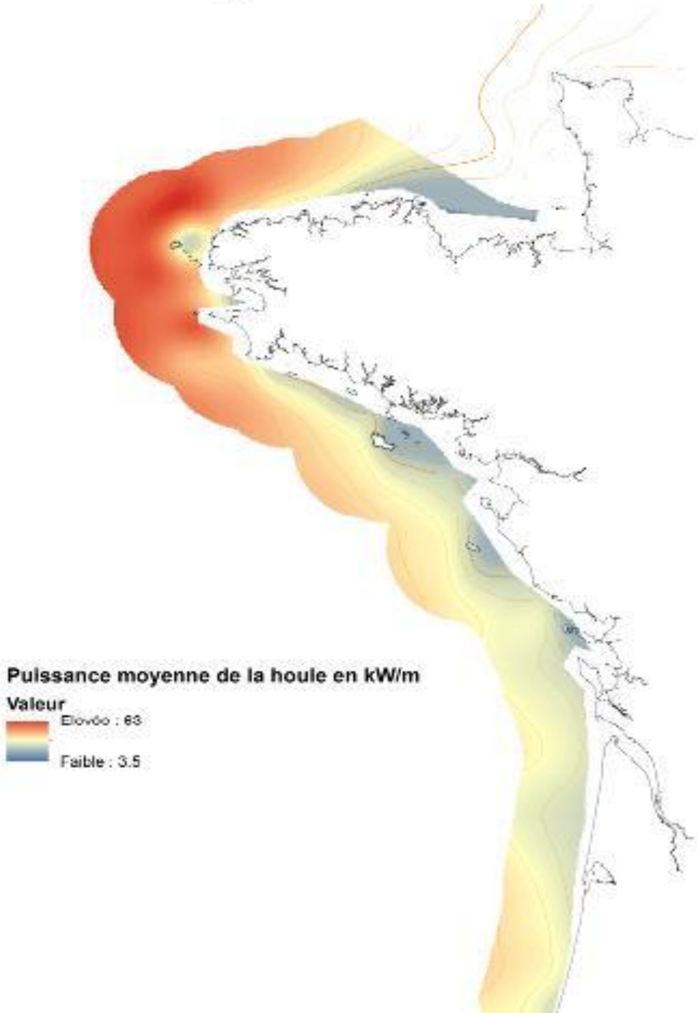
France marine energy
Coasline and harbors

France owns one of the longer in the world coastline

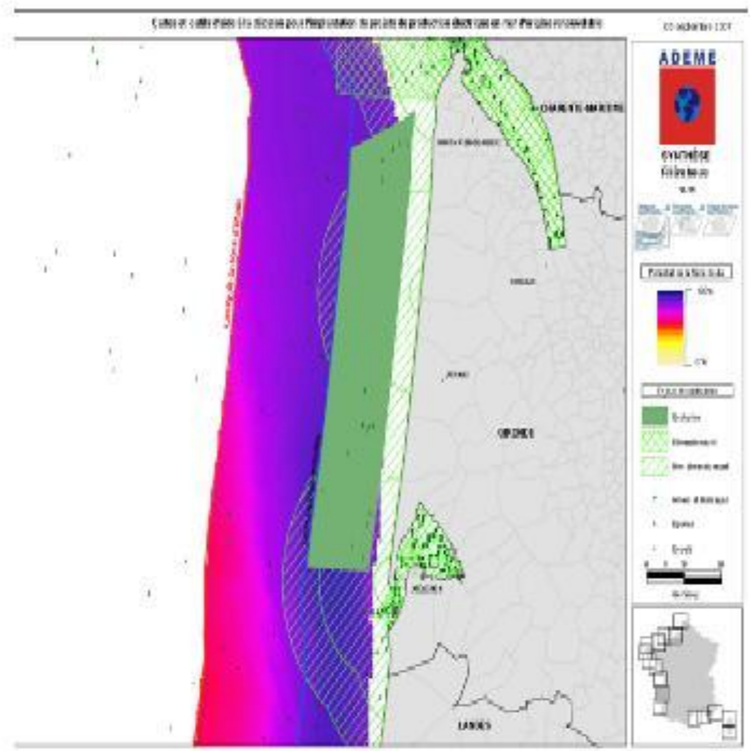


Example of the wave energy potential
a domain with local constraints

Potential by linear meter in coast length

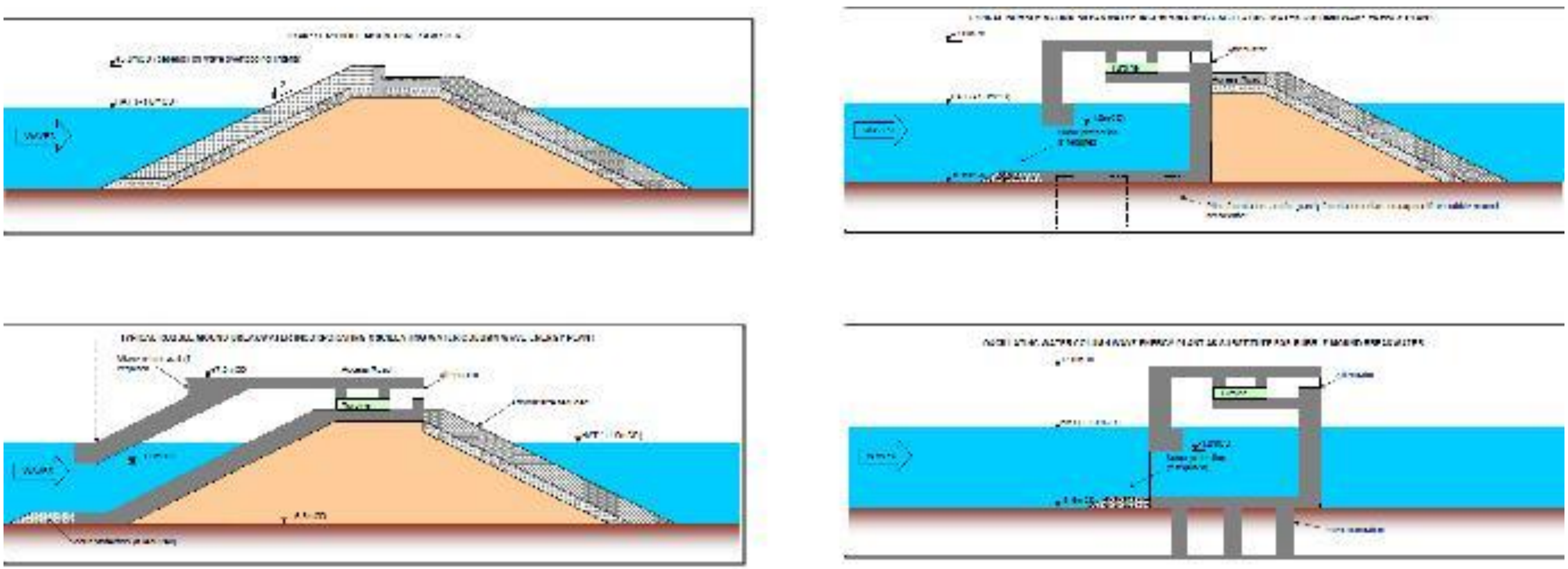


Example of potential locally available



Wave energy systems

- For new and old constructions
- Analysis of the state of the art



Credit : Voith Hydro

Wave energy systems

- Existing maritime structures

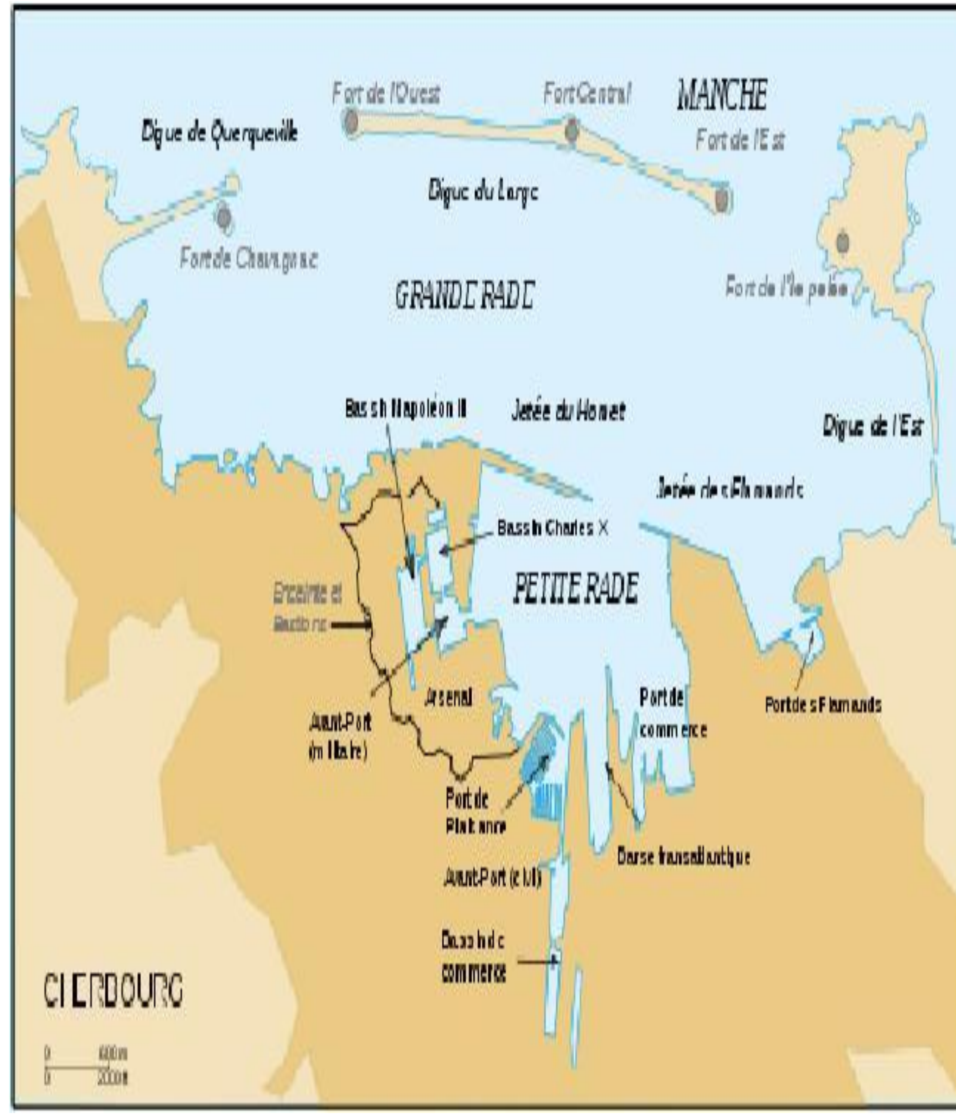
  Dykes made of natural riprap and artificial concrete

  Vertical Dykes

  Breakwater, Pier, jetty, with perforation

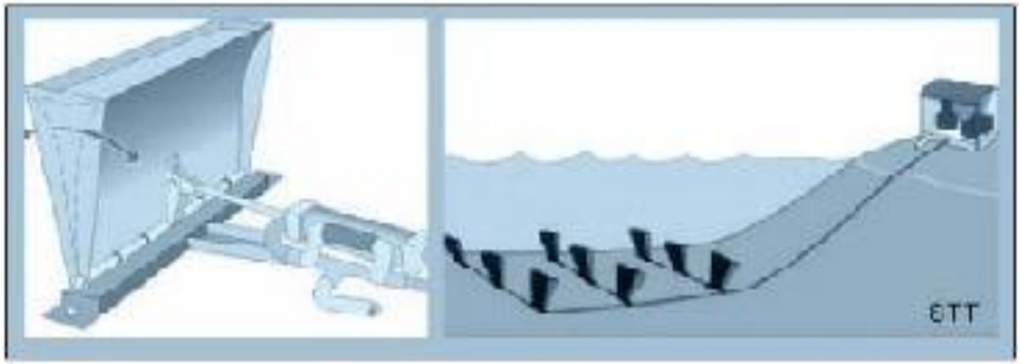
- Existing piers and jetties Lengthwise 180 km

  A Picture of the Harbor of Cherbourg



Wave energy systems

- Coastal protection methods against the waves
- Gabions, seawalls, revetments, groynes pratections
- Exemples in Mediterranean Sea - Valras
- Pure Wave energy works (Waveroller)



Current energy systems in River site –
Bordeaux bridges in river environment under tidal influenc

Ouvrage : pont en environnement fluvial

Pont de Pierre à Bordeaux
soumis au régime des marées

Projet SEENEOH® Bordeaux
(Site Expérimental Estuarien National pour l'Essais et l'Optimisation d'Hydroliennes)
www.energiedelalune.fr

Projet Hydroomel www.ecocinetic.fr

Projet Harvest

www.grenoble-inp.fr/recherche/

Tidal current energy systems St-Nazaire and Normandy Bridges in estuary environment

Tidal current energy systems
Bridges of the Noirmoutier and Ré Islands

Tidal current energy systems
an example : The pier of Roscoff

Ouvrage : jetée

Exemple de la jetée de Roscoff

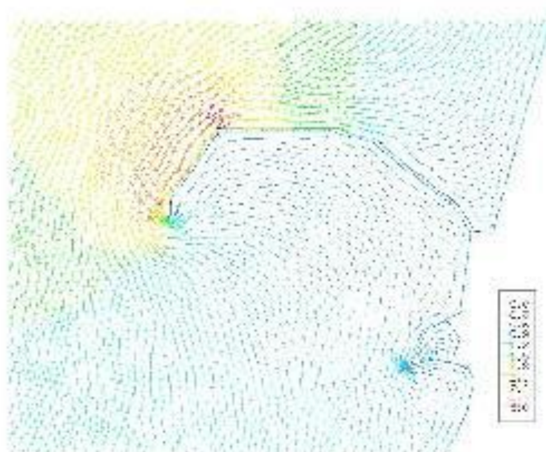
portées sur plateau rocheux sans navigation sauf à l'extrémité
site probablement exploitable au-dessus de la mi-marée
potentiel à évaluer

Accostage à marée basse
des navires de transport de passagers
pour l'île de Batz.

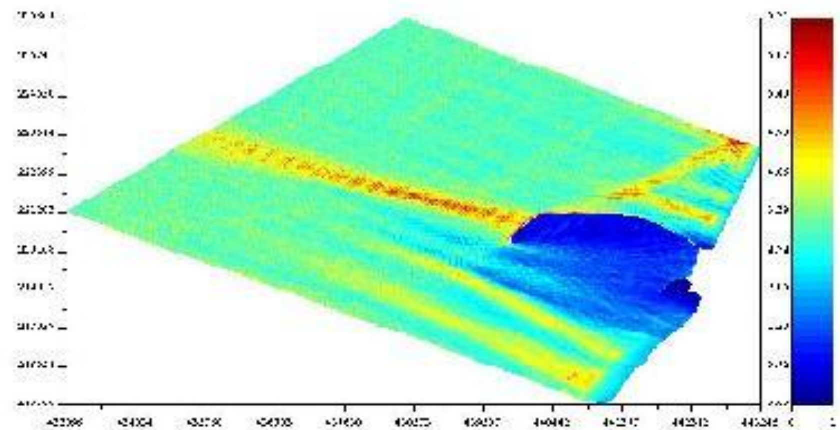
Tidal Current the Antifer oil terminal

- Antifer oil terminal Harbor
- a long protection dyke,
- offshore, 3,5 km long
- 6,75 m tidal rage downstream
- Fast current (more than 3 m/s)

courants



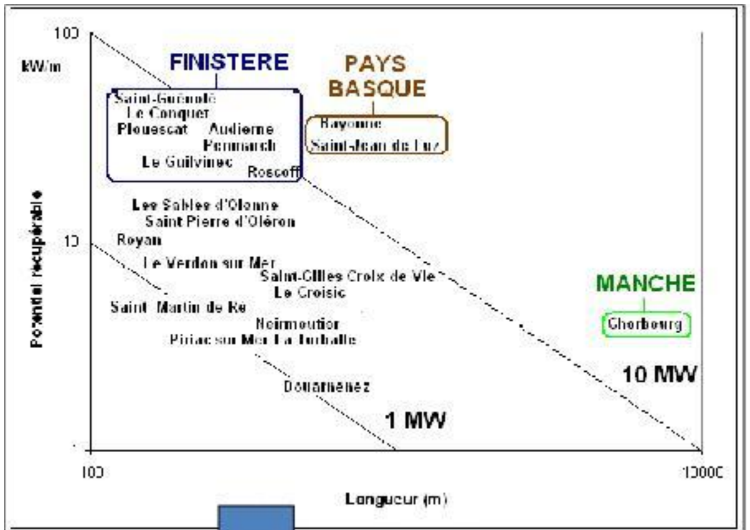
houle

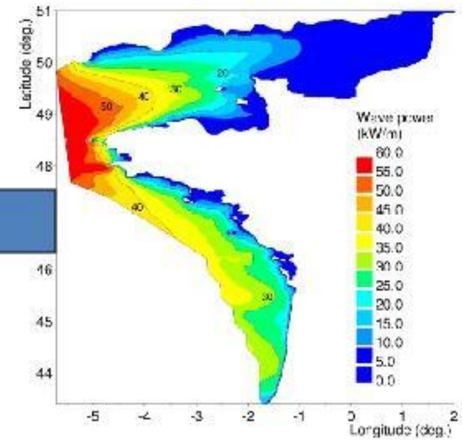


The sites and their constraints

- Geographical and technical data and constraints ;
- Wave and Tidal current ;
- Technical data and characteristics af the existing works
- Sizing requirement, building hypotheses (if known) ;
- Expected duration and length of life, and capacity to support additional mechanical stress ;
- Which length of dyke could receive equipment ?
- Local needs in energy ;   Connection to electric grid ;
- Environmental and societal constraints ;
- A summary **estimation of the potential ?**

The sites and their constraints





French Brittany

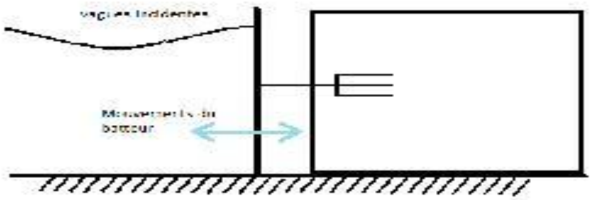
The sites and their constraints

- Technology feasibility of MRE projects;
- Adaptability to each specific site data (wave action, currents, tidal range ;
- Survivability in extreme condition, resilience / robustness ;
- Number of mobile parts, maintenance, access and operability
- Environment impacts (noise, visual, hydrosediment, navigation, fauna/flora) ;
- Impacts on the functions of the marine works and structure
- Estimated energy produced ;
- Total cost of the project (system alone, or additional cost on a civil work project) ;
- Conclusion : the cost of installed kWh

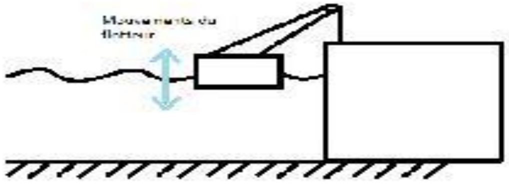
Selection of Technologies

Four systems

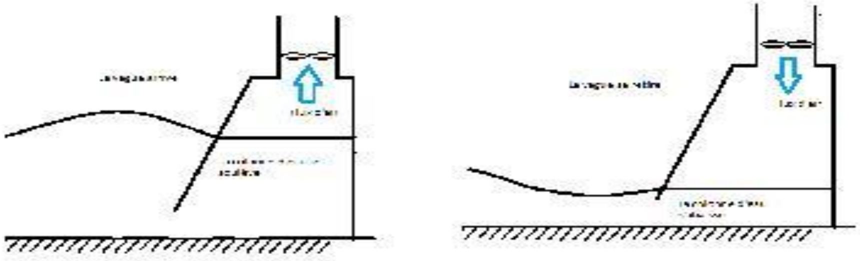
D1 : overtopping systems



D2 : reversed paddle systems'



D3 : Oscillating Systems

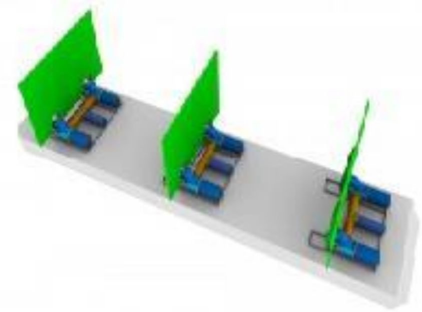


D4 : Oscillating Column water

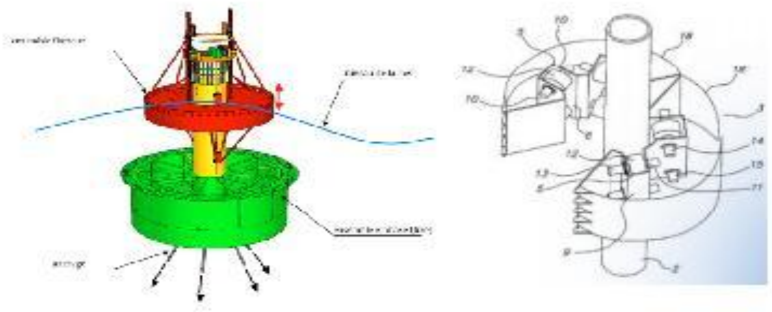
Select the best adequate technologies

The detached systems (nearshore)

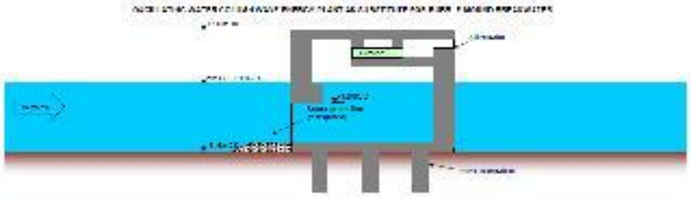
D1 : overtopping systems



D2 : reversed paddle systems



D3 : Oscillating Systems

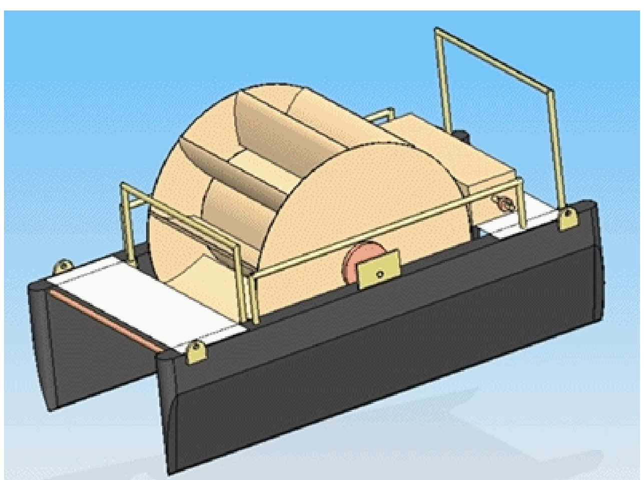


D4 : Oscillating Column water

Select the technologies

The ocean current energy designs and concepts

Hydroomel www.ecocinetic.fr
Harvest www.grenoble-inp.fr/recherche/
Tocardo www.tocardo.com
Ecofys Wave Rotor www.c-Energy.nl
Hydro-Gen www.hydro-gen.fr
Blue Energy www.bluenergy.com
Blustream www.gazintegral.com/blustream



Select the technologies

- State of the art

  A wide ange of experience, for keeping the more mature and the most promissing technologies

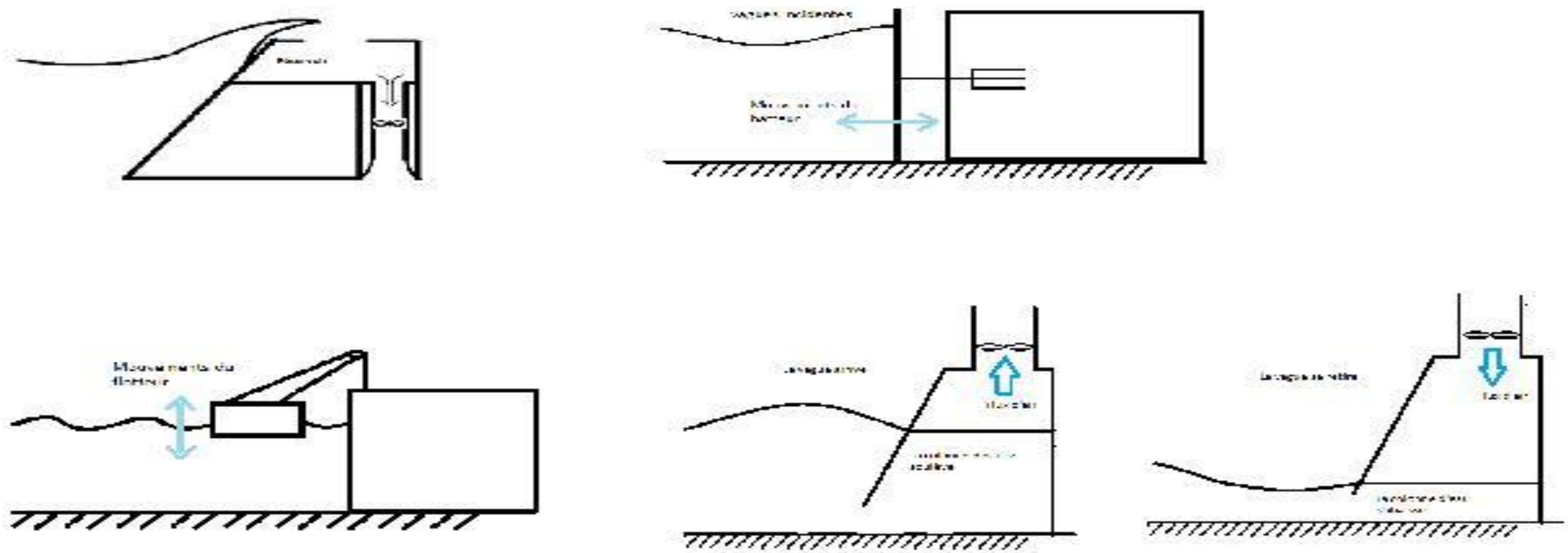
  Assessment of performance

  Ranking by family

  Ranking : by performance in energy absorption

- Development of Tools

Performance assesment



Estimated yearly energy produced on site - **Income**

Estimation of generated energy to system mass ratio

Estimation of generated energy to system wetted surface ratio

Manufacturing and construction costs ;

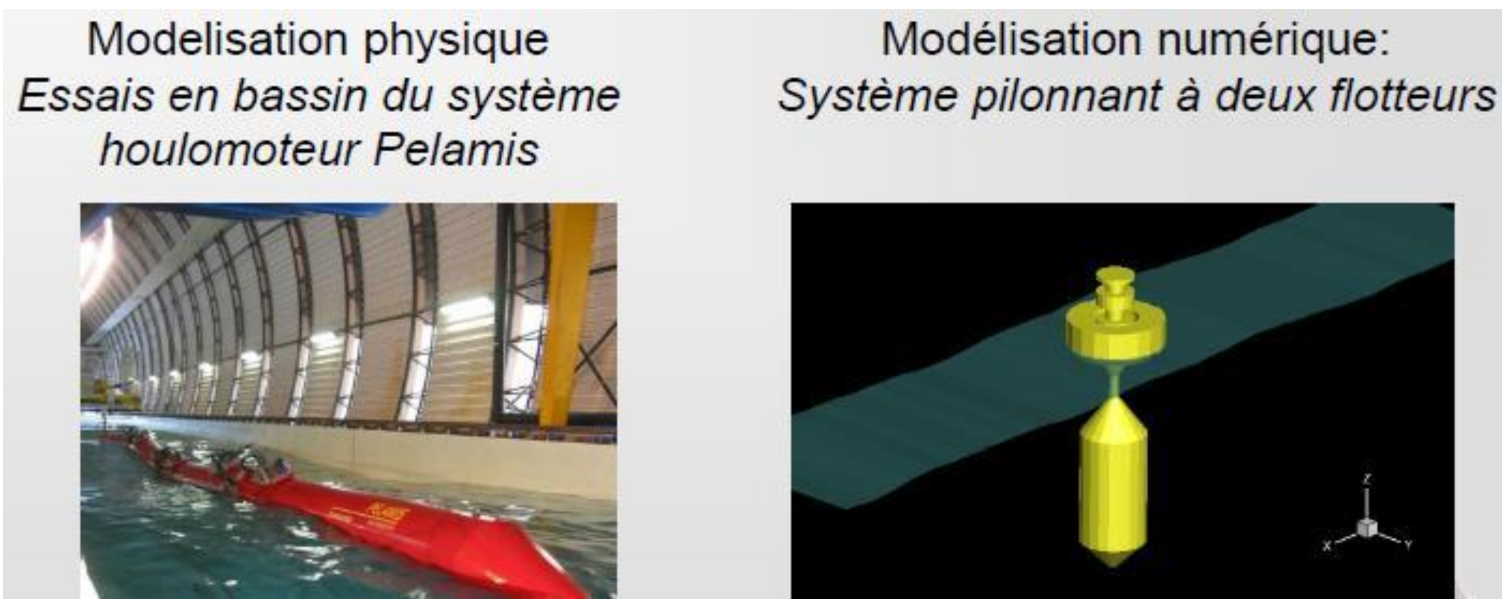
Performance Survey

Analysis through benchmark of data and figures,

Critical data analysis,

Development of computing models if the data searched in scientific litterature are insufficient or unavailable.

Physical and numeric numerization



Survivability survey

Computing models
developed for the study of performance used to extrapolate the maximum forces and the standard deviation of efforts dimensioning
Tank tests on a small scale

Years 2 and 3

Fatigue survey

Rules for implementation of an experimental model to a model structure real size
Estimation of stress cycles experienced during testing
rules for implementation of an experimental model to a model of real size
Extrapolation on lifetime of stress cycles experienced
Fatigue durability tests and possibly corrosion fatigue of structural elements and cable elements
Conclusions about the risk of fatigue cracking and on the estimated lifetime risk in case
Any special recommendations for monitoring, auscultation and maintenance vis-à-vis fatigue

Years 2,3, 4

Assessing the Potential of ressource

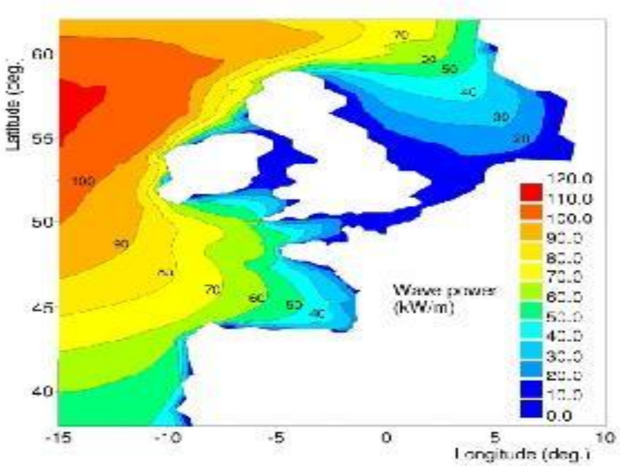
Improvement in knowledge and prediction of resource in wave energy in coastal areas (cartography, temporal variability, etc.).

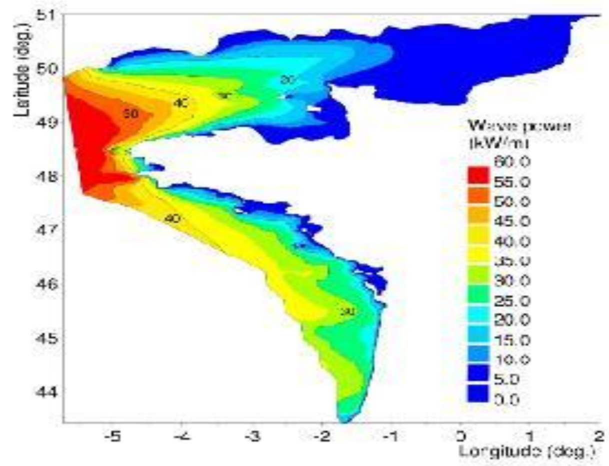
Climatology of the waves, an essential data for the selection and choice of the best sites for wave devices or wave energy farms

Estimating the theoretical maximum power that could be recovered on a site once a system concept of wave energy and its characteristics are known,

Studies of design and survivability of the system (estimated extreme conditions), and studies of fatigue,
Accessibility of a site
Production forecast in operational condition

Exploitable potential



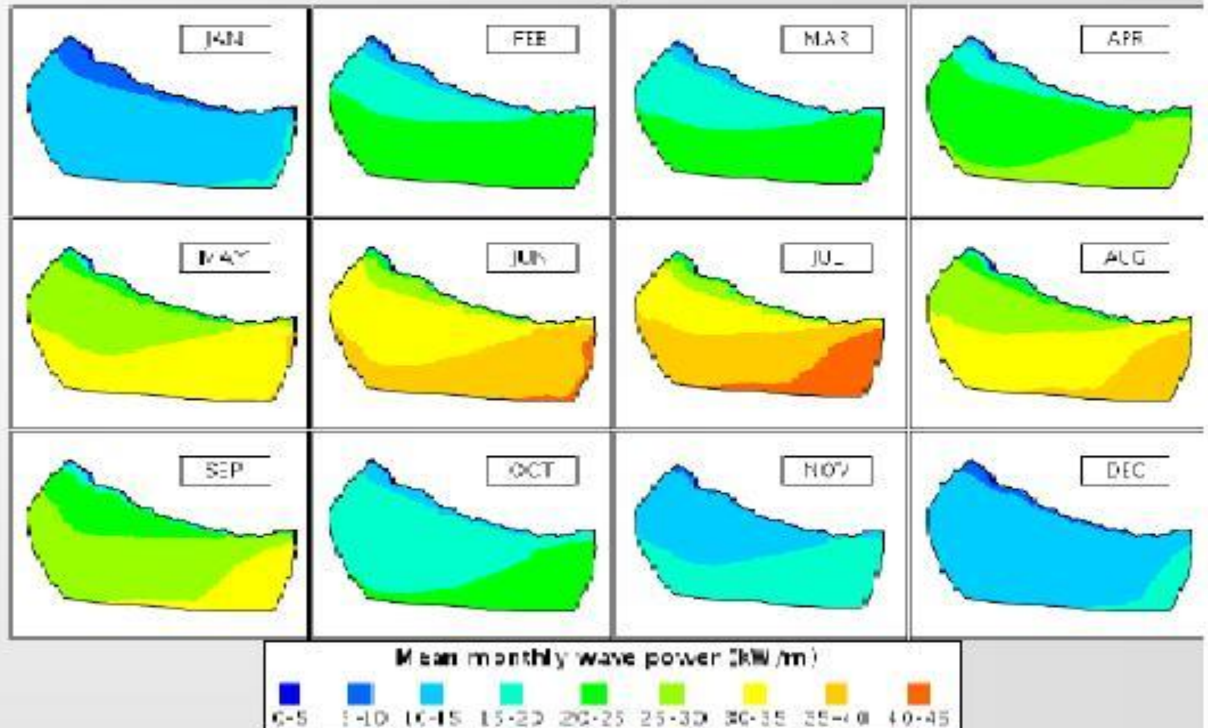


Base d'états de mer ANEMOC (figures extraites de Mattarolo et al., 2009)

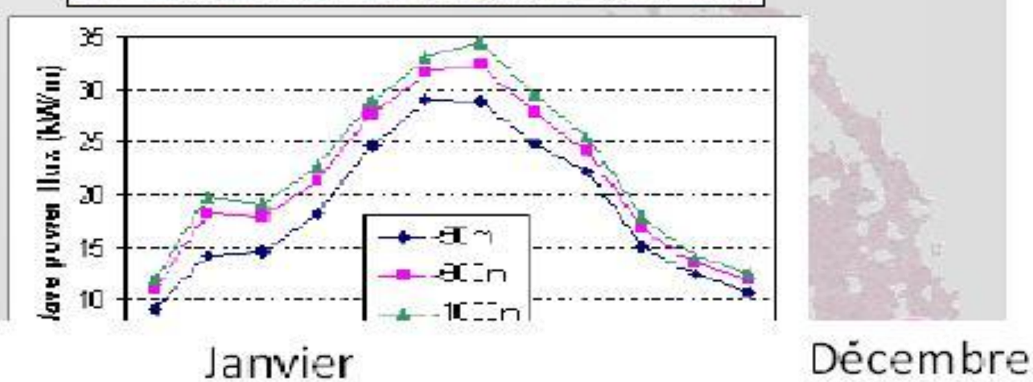
- DATA BASES
- Databases across the ocean (total available power, frequency distribution, directional distribution, ...) Databases at the local level (shallow tide effect, diffraction by the islands, …)

Example of seasonal analysis in Reunion Island

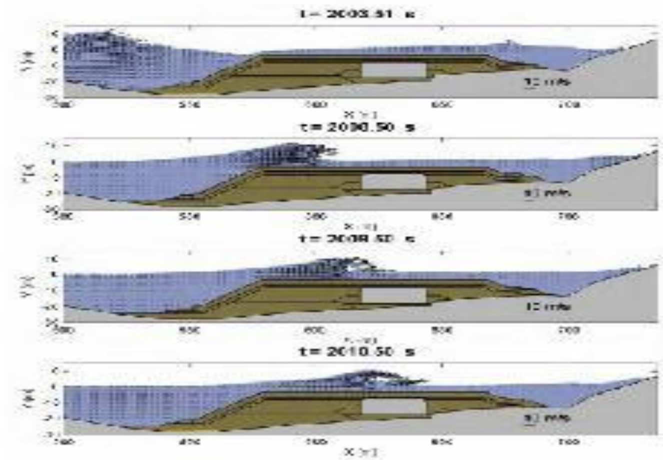
Ressource houlomotrice mensuelle moyenne sur le modèle local de La Réunion



Ressource houlomotrice mensuelle moyenne au large de Saint-Pierre, pour 3 profondeurs d'eau



Sedimentary Impact



Determination of the impact by physical modeling or numerical wave power systems
Impact on wave propagation and the structure (reflection, transmission, interaction water / air, porous media, breaking waves ...)   Impact on current
Impact on the funds (interface modeling small / large scale)

Numerical modeling of the interface small scale - large scale

Feedback from the impact of multi-scale wind farms and tidal stream sites
State of the art of hydro-sedimentary processes multi-scale (excluding structures)
Status of techniques and methodologies of digital multi-scale coupling and structures
Summary and recommendation for consideration of the operational impact of large-scale wave power structures
Year 1

Impact Assessment hydrosedimentary local

Study of a harbor breakwater
Study of a structure detached
Study of a site without work
Years 2 and 3

Impact Assessment of Regional hydrosedimentary

Development of regional models at selected sites **Year 2**

Assessing the impact of technologies adapted to sedimentological Sites **Year 3**

Optimization techniques for taking account of wave power works and methodologies nested multiscale **Year 4**

Evaluation of uncertainties about the impacts of wave power systems and the performance of these technologies **Year 4**

Impact assessment and final recommendations sedimentological **Year 4**

Impact civil engineering and structures

Coexistence of the two functions

1) Protection against marine stimuli
2) Energy Recovery

Develop an inclusive vision

1) Design and construction
2) Economic Implications
3) social acceptability

impact on hydraulic performance and stability of the structure

Impact on the function of bearing structures

Experimental study of the crossing and stability for **old structures**.

Experimental study of the crossing and stability for **new structures.**

New design rules.

Years 3 et 4

Design of the structure and economic study

For existing structures: evaluation and qualification of existing support structures, study of building and financial estimate of the work.

For new structures: a preliminary study with energy recovery devive, first estimate of the work before the project by taking a device for energy recovery and estimate of additional cost.

Years 1, 2 and 3

Societal impact

Spatial optimization
Multipurpose territorial usage
Conflicts of use (navigation, fishing from the shore)
Local consumption of energy
Visibility of devices at low tide
Curiosity and endangering the public (tourism industry)
noise

Years 2, 3 and 4