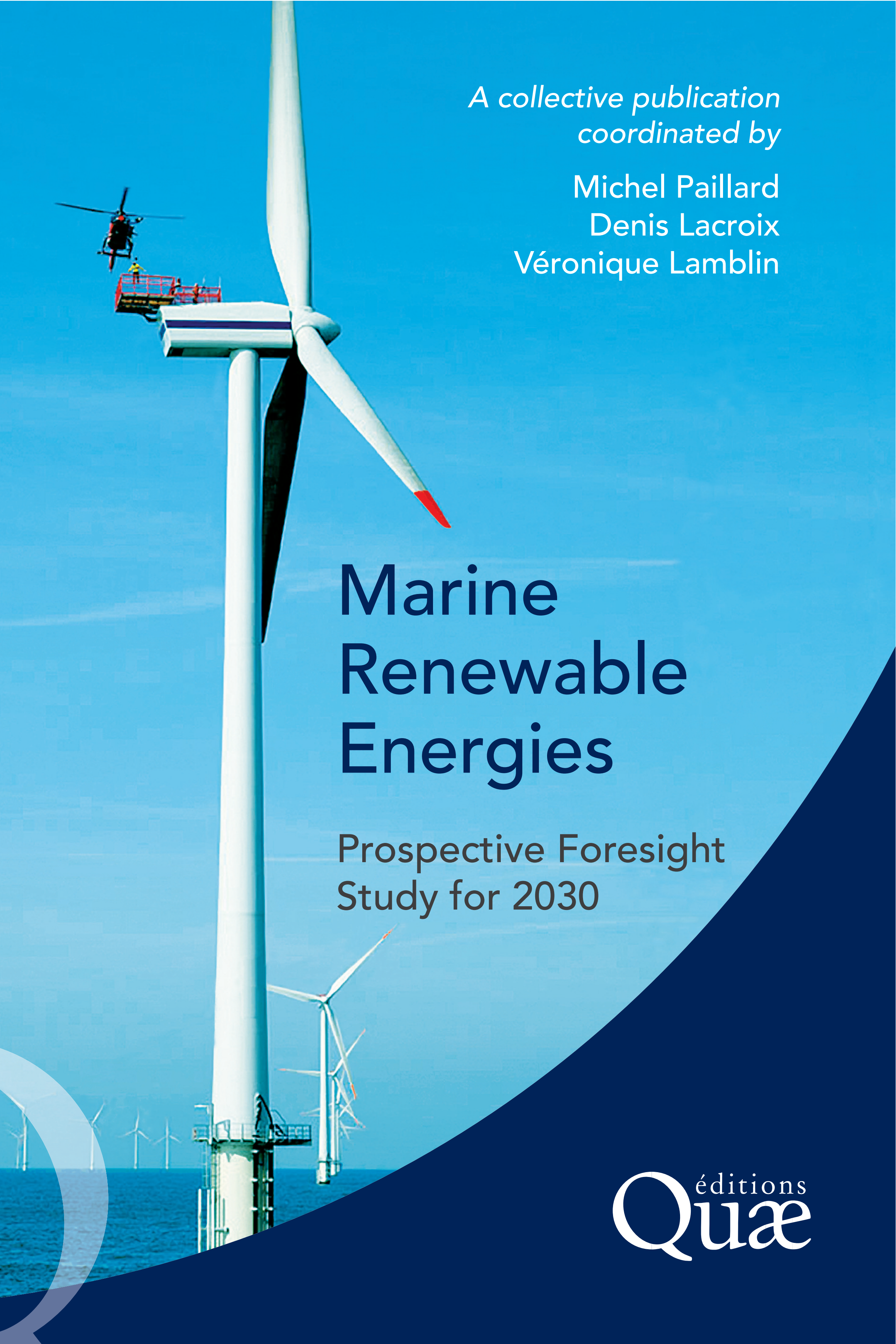

*A collective publication coordinated by*

Michel Paillard
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# Marine Renewable Energies

## Prospective Foresight Study for 2030

éditions Quæ

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String of wind turbines in Denmark (© Dong Energy, DK)

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# Preface

More than ever before, the conjunction of France's energy commitments to Europe within the domestic framework of the Grenelle environmental summit meetings, and the context created by the new oil crisis, should lead us to actively consider renewable energies.

Well aware of these considerations, in March 2007, I decided to launch a prospective foresight study on marine renewable energy sources (RES) for 2030. The ocean is a huge reservoir with wind, currents, waves, tides, biomass, thermal power, etc. France enjoys significant potential for the development of renewable energy sources having extensive seafronts in metropolitan France and overseas as well as the necessary knowledge and expertise.

Twenty French partners representing the main actors in the sector took part in this work. I would like to express my warm thanks to them for their participation. This study describes a range of possibilities for the future (depending on the world context, energy demand trends, the role played by stakeholders, etc.), the consequences of developing various known technologies, and the research and development they will require.

The work is also part of a European foresight perspective, in that it highlights the advantages of the numerous types of synergy and co-operation that can be developed between EU countries in the next twenty years.

Ifremer has thus, true to its calling, contributed to the collective think-tank, aiming to enlighten public decision-making in the field of energy and more especially, marine renewables.

It is now up to each of us to take these reflections on board and put them into action. Ifremer will draw concrete results from them in the framework of its strategic plan.

*Jean-Yves Perrot*
Chairman and Chief Executive Officer of Ifremer

# Acknowledgements

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# Foreword

In March 2007, the Chairman and Chief Executive Officer of Ifremer launched a foresight study by a think-tank on marine renewable energies for 2030, with some 20 French partners representing the main stakeholders in the sector: ministries, industrial leaders, research institutes and specialized agencies. The think-tank's multidisciplinary nature is largely justified by a subject, which involves not only the diversification of energy sources, Europe's commitment to fighting the greenhouse gas effect and the environmental impacts of installations and facilities at sea, but also the development of coastal zones where a wide range of uses interact and compete. The study aimed to contribute to an executive summary covering various aspects, such as identifying the stakes, the conditions for emergence and major technologies in the medium term in order to reassess Ifremer's position, beyond offering expert opinions. It also aimed to identify the partnerships and strategic programmes which fall within Ifremer's realm of competence. The issue of marine renewable energies is part of the renewable energy issue overall. The latter is vital, particularly as the Western world comes under pressure from energy needs and rising oil costs, as well as global warming. Given the efforts required to develop renewable energies, the relative scope for developing marine renewable sources must be defined in terms of their estimated cost, technological and planning constraints, both on land and at sea, and their potential environmental impacts. The study collected and summarized a large number of studies data. It has reduced the uncertainty and provides an objective capability to assess numerous opportunities for partnerships. It mobilized some fifteen experts over a one-year period. The study received the support of the Futuribles consultant's group in implementing the 'scenario' method[1]. After 30 factors called 'variables' were studied, four contrasting 'scenarios' were selected. Their main driving forces or 'drivers' are: the market in a crisis context; world energy policy and sustainability; national interests and energy security; and local developments with risk-taking.

Developing every technology studied here could be of interest. Their advantages vary greatly, depending on:

– **the energy and socio-economic context**, which will lead either to developing only the most mature technologies, such as wind, as an emergency response, or to seeking synergies between technologies, such as thermal marine energy and biomass;
– **the possibility of manufacturing hydrogen** to store intermittent energy and move production systems away from the coast (giving access to additional resources): of interest for floating wind and wave turbines, for example;
– **the geographical scope**: marine thermal energy has great potential in the tropical islands of France's overseas departments (counties) and regional authorities;

1 A glossary for the scenario method is provided in Appendix 4.

Photo 1 : the Pelamis system to recover wave energy being tested under rough conditions at the European Marine Energy Centre in Scotland (© Pelamis Wave Power Ltd, UK).

– **the specificity of energy needs**: marine biomass is the only one of seven resources which can be used to produce directly a 'renewable' liquid fuel oil-substitute for transport.

Their features also differ in terms of how they fit into coastal areas, depending on the size of developments and the physical-chemical properties of the marine environment they utilize.

Since France ranks second in Europe for potential wave and wind energy at sea, along with an excellent tidal energy resource and large tropical marine areas, it can play an important role in both research and development, particularly if the risks linked to the choice of technologies are shared between all players, including the State. Indeed, the latter has several forms of leverage in pooling skills and expertise and co-financing the risk-taking. Finally, the earlier the consultation is performed, the more people will find the project socially acceptable.

Under these conditions, marine renewable sources can help to meet the objectives set by the EU for renewable energy in 2020 while developing technologies that can be exported. One 'normative' scenario including concrete and balanced hypotheses for developments shows a possible net contribution from marine energies of 1.5 million tonnes of oil equivalent (Mtoe) per year (17.2 TWh/year) by the year 2020, making 7.7% of the 20 Mtoe increase in renewable energy production, which is the target envisaged in the framework of the French environmental summit meeting. Within this scenario, the 7.7% would be divided between 5.2% for wind farms at sea and 2.5% for other marine energy sources.

This scenario clearly indicates the efforts needed to support the industries which would have to be set up in order to reach this objective. This entails creating the conditions to promote building and strengthening French skills in the field, better support for technologies being developed in France and setting up the first demonstration installations at sea. In fact, although these supply chains have undergone sustained development efforts in a few other European countries and elsewhere in the world, no technology, except for wave turbines, has yet been validated by industrial qualification. This means that France still has time to take its place in this just-emerging future market. By the year 2020, based on the results of the first demonstrations validated at sea in France and Europe, farms could develop on an industrial scale and put the target of 7.7% of the 20 Mtoe increase in renewable energy generation within reach.

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## Appendixes

# PART 1

# Summary of studies

Photo 2 : offshore wind farm at Nysted, Denmark
(© Ifremer, G. Véron).

# Scope of the study

Marine renewable energy sources (RES) are listed as one component in Europe's energy mix set out in EU targets for the year 2020 (20% of power consumed will have to be generated from renewable sources). A number of international conferences on the future of the environment have also referred to this issue. In March 2007, seeing the lack of clear direction on this important subject in France, the Chief Executive Officer of Ifremer proposed that the main stakeholders in marine renewable energy research and development (R&D) and the ministries concerned, take part in a collective prospective study.

Four major justifications can be seen for exploring the subject of marine energies:

- the need to reduce greenhouse gas emissions;
- the short- and medium-term risks on oil supplies;
- the need to investigate all avenues for renewable energy production;
- the need to consider the impacts (i.e. environmental and acceptability) of these new plants on coastal areas and their uses.

France pioneered this field in the 1960s with the first tidal generator plant in the world (La Rance). Even more important are the existing developments and growing demand for marine renewables, including the distant overseas territories. A few examples include the air-conditioning for a hotel on Bora Bora, an identical project for a hospital in Tahiti, and issues of energy security and cost in the large French tropical islands.

Thus, the initial scope of the study was set out in the form of three main questions:

- What technologies can serve to produce energy from the ocean?
- What are the social-economic prerequisites to ensure that they are developed and are competitive?
- What are the respective impacts of these technologies on energy sources and the environment?

The main lines of the study were as follows:

- time horizon: 2030;
- scope of study: France – in a global, and more especially European, context;
- technologies: all marine-related technologies, except for fossil fuels;
- method: scenarios method (with support from Futuribles consultants);
- timeframe: 10 months.

Potential RES fall into five categories:

– wind at sea to produce electricity using offshore wind-turbines (neither shipping nor routeing was covered in this study);
– water movements, generating energy from currents, waves or tides;
– water temperature, whether for recovering energy using temperature gradients between the surface and deep sea, or by directly pumping cold water from the deep for cooling purposes;
– marine biomass used to produce energy, especially marine plants like micro-algae;
– osmotic or salinity gradient power, produced by mixing two types of water with different saline concentrations (freshwater/seawater).

Fuels (apart from uranium found in seawater), which could be extracted from the sea, such as methane hydrates, fall outside the range of this study, since strictly speaking they are considered to be non-renewable resources and because using them creates greenhouse gas emissions. The study examined the interest of combining seawater desalination with power generation.

Lastly, the 'potential resources and needs' type of approach was used, calling on inputs from social sciences.


Photo 3 : Rambiz crane-barge installing the Seagen stream turbine on the Strangford Narrows site, Northern Ireland (© Marine Current Turbines, UK).