Preface

In the context of rapidly emerging technologies for exploiting marine renewable energy, we have gathered input from France's top specialists in order to establish an overview of the technological aspects without neglecting the environmental and societal aspects of this relatively new domain.

The ensemble of renewable energy (RE) resources offers immense potential which, through mistrust or denigration, was long considered insufficient, but which today is at last widely recognized and accepted. Across the whole of the terrestrial biosphere, it represents around 8,000 times the current global primary energy consumption [MUL 11]. Given that oceans cover roughly two thirds of the surface of the planet, we can say that they alone constitute a resource equivalent to 5,000 times our consumption. Thus, it is a question of considerable potential in less confined spaces but in places which are far more hostile.

In 1999, when he received the Alternative Nobel Prize, Hermann Scheer [SCH 06] (a member of the German parliament and major proponent of Germany's laws on the development of REs) made the following comments, which perfectly sum up what renewable energy resources (terrestrial and marine) represent for the future: "Renewable energies are inexhaustible. They do not destroy the environment. They are available everywhere. […] Their use facilitates solidarity with future generations. […] They secure the future of mankind."

With regard to electricity, even though it represents only 17% of the final energy consumption worldwide, it is beyond a doubt one of the most potent symbols of human progress. Indeed, more than any other, it helps to serve Man's basic needs, such as sustenance, care and cultivation. Of all the forms of final (commercialized) energy, this is the one which is growing the fastest, and it is likely that it will continue to take pride of place in the global energy market during the 21st Century.

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However, while the use of electricity as a form of energy may be very benign (producing little or no local emissions), it has a profound impact on the environment because at present, over 80% of it is produced using non-renewable and extremely polluting resources (67% from fossil fuels and 13% from nuclear technology). Concerns over the depletion of non-renewable resources and their environmental impact have led to massive-scale development of technologies to convert renewable resources into electricity. It is highly likely that by 2030, electricity production from renewable resources will account for between one third and half of global production. Also, some extremely serious scenarios envisage 100% renewable electricity production at a "local" level (on the scale of large regions) by 2050.

In this context, one of the major problems is the intermittence of electricity production from the most widely available resources – the sun and the wind. The storage of energy, the exploitation of weather forecasts and intelligent management (particularly of consumption) are the main channels to circumvent this problem. However, there is another factor, which is particularly important for reducing costs – complementarity of production. Studies have already shown, on a European scale [PEL 10], for example, that wind/solar complementarity was high and that it helped to significantly reduce storage requirements. It has also been proven, on a smaller scale, that wave power increased the smoothing effect and helped reduce the energy storage capacities needed [BAB 06]. Besides the fact that exploiting this complementarity would enable us to reduce global costs, the fact that a large portion of the world population lives in coastal areas constitutes one of the principal motivations for looking to the sea to exploit resources, in conditions which are, however, rather more difficult than on land.

Marine energy resources encompass a great diversity of forms. Besides geothermic resources and marine (particularly algal) biomass, the majority of resources come from sunlight and its "decomposition residues", which are wind, waves and thermohaline circulation currents. Only the effects of the tides have a different origin, since they result from the gravitational interaction between the earth, moon and sun.

The following table, taken from [MUL 09], gives a global overview of the oceans' resources. The figures given are merely representative. The orders of magnitude of exploitable and recoverable portions, as well as the yields considered in order to calculate the exploitable electrical energy may be subject to criticism. The precise source of this data, and the associated explanations, can be found in [MUL 09]. For reference purposes, world production of electricity in 2008 was around 20,000 TWh.

Energy for the year 1000 TWh	Solar, oceans	Continuous ocean currents	Marine biomass	Hydrological cycles			Tides	
				Offshore wind farm	Waves	Osmotic power	Dams	Currents
Global estimation	400,000	?	450	>> 500	80	30	22	
Primary exploitable part	4,000 (1/100th ?)	1?	4 (1/100th?)	100	2	0.3 ?	0.6	1.8
Recoverable electrical energy	80 (η 2%)	0.3? (η 30%)	1 (η 25%)	37 (η 37%)	0.75 (η 35%)	0.1? (η 30%)	0.6	0.9

Table 1. *Orders of magnitude of renewable energy resources and of the portion of them that is recoverable in primary and electrical energy, with means of production, for which the efficiency (η) is specified*

While the economic and societal factors are also included, this book mainly covers the technological and, in particular, electrical, aspects of marine energy converters. The environmental dimension could have been developed further, in particular the lifecycle assessment, which is absolutely fundamental, on such subjects. We encourage all the actors in the field of renewable energy production to begin taking account, where information is available, of the environmental impact across the entire lifecycle of the concepts in question.

Finally, we wish to mention that Brittany, which has great potential for marine energy (apart from ocean thermal energy conversion!), in 2009 produced a reference document [JOU 09], which is less technologically specific than this book, but which complements it very well, and which we recommend to the reader.

In conclusion, we hope that this volume will contribute to accelerating the emergence of renewable marine energy, with new technologies and new concepts which will play a part in creating the sustainable development of which mankind is currently very much in need.

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