Portuguese initiatives in a European framework for Ocean Energy

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Abstract

Ocean Energy is facing difficult times as it is being perceived as an energy source that may not contribute significantly to the EU 2020 renewable energy targets and so is not included in the SET Plan with the result that it will not be significantly funded in the forthcoming years. There is then a need for European MS to work closer and to jointly show their interest in this energy source and to develop the means to develop the technology and the market. This paper presents the past and future actions and perspectives of Portugal in this area in view of contributing to a joint European effort.

Keywords: Ocean Energy, Portugal, Support Measures, Projects.

1. Introduction

Ocean Energy is facing difficult times as it is being perceived as an energy source that may not contribute significantly to the EU 2020 renewable energy targets and so is not included in the SET Plan with the result that it will not be significantly funded in the forthcoming years. This situation is a bit unfair, as it does not recognizes the significant progress in technology development over the last five years, in spite of the relatively small amount of money invested when comparing to other more advanced forms of renewable energy. Also, it does not takes into account the increasing interest of large European companies in this energy source and its contribution to the supply of energy in Europe in the longer term. The situation is also dangerous, as it coincides with the announcement of large public funding in the US and the possibility that a significant part of the technology development effort (and outcomes) move away from Europe. There is then a need for European MS to work closer and to jointly show their interest in this energy source and to develop the means to develop the technology and the market. This paper presents the past and future actions and perspectives of Portugal in this area in view of contributing to a joint European effort.

The paper starts by presenting the current understanding of the role of the oceans for Portugal's economic development, it continues by reviewing the offshore renewable energy resources and the comparative advantages of Portugal in developing wave and offshore wind energy and proceeds with the existing support measures, the past and ongoing projects and the recent initiatives by the industry in the offshore renewable sector.

2. The Portuguese perspective

2.1 Oceans of opportunities for Portugal

Since its foundation in the 12th century, the oceans have played a major role in Portugal´s history, in particular in the 15th and 16th centuries, during the Portuguese discoveries around the world. However, much later, with the independency of the former Portuguese colonies in the mid seventies of the 20th century, the oceans lost their relevance, in particular in what concerns maritime transport. The decrease of the fishing effort also contributed to this situation, which, opposite to what happened in many European maritime countries, was not reversed by the exploitation of offshore oil and gas. Nevertheless, due to the archipelagos of Madeira and Azores, Portugal has the biggest Economic Exclusive Maritime Zone (EEZ), which represents more than half of the total EEZ of the European Union.

Over the last ten years and across all Portuguese society and political parties, there has been a recognition that we need to face the oceans again as they are a last frontier for mankind with important opportunities for scientific, technologic and economic

development. This has been the outcome of several ministerial and economic working groups and lead to the following bodies at present:

- Estrutura de Missão para os Assuntos do Mar (EMAM) – a public body depending from the ministry of defense with the mission to advise the government on horizontal aspects;
- Forum Empresarial para a Economia do Mar (AFEM) – a working group formed under the Associação Comercial de Lisboa (the Lisboa Trade Assotiation);
- Forum Permanente para os Assuntos do Mar (FPEM) – a private body of citizens with scientific, technologic and economic interest in the oceans;
- Oceano XXI – a recently created and public funded cluster of companies and R&D bodies aiming at developing new opportunities related to the oceans.

The economic opportunities that have been identified related to the oceans cover the traditional activities, like fishing, maritime transport, leisure (sailing, surfing, etc.) or sand extraction and more recent ones as offshore aquaculture and renewable energy. Economic relevant oil and gas reserves have not yet been founded in the Portuguese shelf, but new efforts are being undertaken in the deep offshore.

The coordination of these activities in the sea is of course important. Following the European maritime legislative initiative, the spatial planning of these activities is now being initiated in Portugal, with the first public consultation expected in September 2010.

We can thus say that Portugal is clearly looking at opportunities to exploit the ocean, offshore renewable energy being one of these. The week points of Portugal are the inexistence of an offshore industry supported by oil and gas exploitation and, to some extent, the lack of financial availability.

2.2 The Portuguese economic

After a 10 year period in the nineties, where Portugal converged to its European Union partners in economic terms, in the first decade of the 21 century Portuguese economy has been growing less than the average in the European Union, from what results that Portugal had 78.3% of the average EU GDP per Capita in 2009. Part of the economic problems of Portuguese economy results from a significant percentage of low qualified man-power whose work force was used to produce low added value goods in factories that mean while where transferred to eastern European countries and to Asia. The situation, as everywhere, has become worth with the recent financial and economic crises.

As a reaction to this situation the Portuguese government defined and implemented over the last decades a policy to enhance innovation, man-power qualification and the setting up knowledge and know-how based industrial clusters in relevant areas. To support the creation of one of these clusters in wind energy, the Portuguese legislation qualifies the proposals for wind connection power based, among other factors, on their contribution for setting up an industrial cluster in this area. Similar procedures are expected to occur for offshore renewable power in Portugal.

2.3 The energy sector in Portugal

Portugal has no significant endogenous source of energy other than renewable energy. As a result traditionally Portuguese dependency on fossil fuels is on the range of 80% with no contribution from nuclear energy and about 30% of its electricity being produced by large hydropower plants. However in the last decade a significant effort to use other renewable energy sources has been developed, with onshore wind becoming significant in the last few years and the total renewable energy sources duplicating the installed power from 2000 to 2008. Table 1 shows the contribution of renewable energy in 2005 and 2010 and the expected contribution in 2020, as presented in the renewable energy plan for Portugal after public consultation. According to this plan the RES will contribute to 31% of the total energy consumption, through the contribution of 60% to the electrical energy production, 30.5% to heating and cooling and 10.4% in transports. The rational for this significant increase in RES is multiple: to improve the environment, to increase energy security supply, to improve the Portuguese balance of payment, to increase the number of jobs and, last but not the least, to develop a renewable energy cluster.

	2005		2010		2020	
RES	MW	GWH	MW	GWH	MW	GWH
Hydro	4816	5118	4934	9742	9548	14074
Geothermic	18	71	30	195	75	488
Solar	3	3	156	230	1500	2475
Oceans	0	0	5	1	250	437
Onshore Wind	1063	1775	4256	10214	6800	14416
Biomass	476	1976	647	2400	952	3516
Total	6376	8941	10028	22783	19200	35584

Table 1: RES contribution to electricity in Portugal

Table 1 shows that there will be a significant additional contribution from large hydro plants, onshore wind and solar (mainly photovoltaic's, but also concentrated thermal power). Ocean and offshore wind are expected to attain technology maturity and the commercial scale, but are expected to contribute significantly only after 2020.

The opportunity that the energy sector as a whole may represent to Portugal's economy is considered to be very significant, not only by the government, but also by the industry itself. The four leading companies in the energy sector (EDP, GALP, MARTIFER and EFACEC), together with a consortium of universities, created by the end of 2009 a Pole for Energy Competiveness and Technology, the ENERGYIN,

supported by national public funds. The ENERGYIN, as will be explained latter in this paper aims at promoting innovation in the energy sector through collaboration between its members (now much more than the four founders), the R&D sector and the public administration. The ENERGYIN identified five priority areas, one of which is Offshore Energy. This includes offshore wind and waves at present, but may include other forms of energy that share the same space and require similar technologies, such as oil and gas or the production of macroalgae for biocombustibles.

3. The offshore renewable energy in Portugal

3.1 The offshore renewable energy resource

As mentioned above, offshore renewable energy includes, in the Portuguese case, wave energy and offshore wind, in particular floating offshore wind. The reason for associating these two forms of maritime renewable energy is manifold: they share the same space, stakeholders, licensing and permitting procedures, to a great extent the same or similar technologies and offshore operations and possibly, at least in some cases, the same offshore structure.

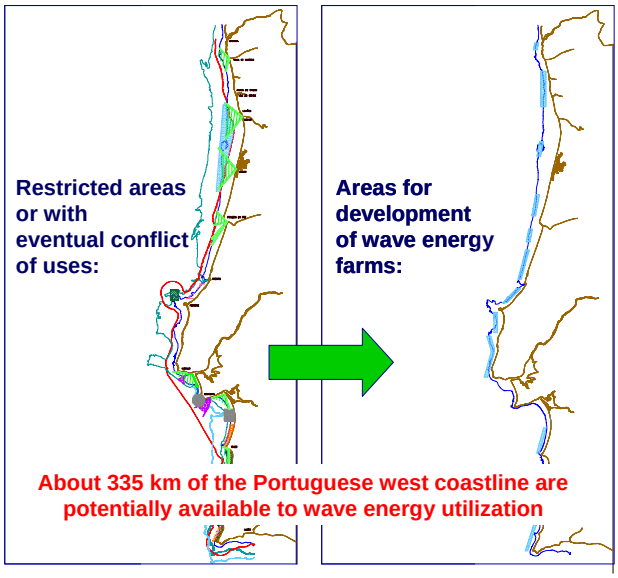

Figure 1: Potential areas of development for wave energy. On the right figure, the red line is the 6 miles contour, the green line the 100 m bathymetric line and the blue line the 50 m bathymetric line.

Portugal has a very long west coast in the continent to which we need to sum the coasts of the Portuguese archipelagos of Madeira and Azores. The continental west coast is very well supplied with an electrical grid thus facilitating the availability of electrical connection points. This coast is also well supplied with ports and shipyards and, in many areas, has sandy bottoms. Other advantages of the Portuguese west coast is the proximity of deep waters (this being of course much better in the archipelagos' coasts) and the relatively mild climate, with good weather windows for offshore operations (required to deploy the offshore energy devices and undertake their O&M).

Fig. 1 presents the areas along 50 m bathymetric line on the Portuguese west coast identified by the Wave Energy centre (WavEC) as possible areas for deploying wave energy devices [1]. These areas are being considered as representative for wave energy deployment under the national maritime space utilization plan (Plano de Ordenamento do Espaço maritime, POEM). POEM is being developed under the EU maritime legislation and is expected to be under public consultation in September 2010. The WavEC expects that these areas will also be recognized as of interest for offshore wind and that they will span between the 30 m and the 150 m water depth. From Fig. 1 it we can see that possibly only floating offshore wind energy may provide a significant contribution to the energy scenario in Portugal as the 50 m bathymetric line is in most parts very close to the coast. Based on Fig. 1 the Wave Energy Centre (WavEC) estimates that up to 5 GW could be deployed off the Portuguese west coast allowing to produce about 10 TWh of electrical energy. There are only initial estimations of the offshore wind resource [2] and no estimation on the potential for power deployment or energy production, but these are expected to be higher than for wave energy.

Not much information is available with respect to ocean currents along the Portuguese coast; however they are small and not interesting for energy purposes. This has a positive factor in developing offshore renewable energy farms as it results in less demanding mooring design. Tidal amplitudes in Portugal are in the range of 3 m to 4 m.

3.2 Past, present and future offshore renewable projects in Portugal

The offshore renewable energy activity in Portugal was initiated in 1978 with R&D in wave energy, this being the renewable offshore energy area where most activity has been developed. The R&D activity started first at IST and a few years later at INETI and more recently at the Wave Energy Centre (WavEC). Until mid nineties the R&D activity was focused in the resource assessment, at INETI, and in the Oscillating Water Column (OWC) technology mainly at IST. This lead to the construction of the 400 MW European Pilot plant at Pico in the Azores in 1999 under the responsibility of IST. The plant cost about 4 M€, half of which supported by Electricidade de Portugal (EDP) and Electricidade dos Açores (EDA) and the other half by the European Commission under a Joule project and the Portuguese government under a "Energia" project. The first years of the plant were very problematic due to technical difficulties, mainly in the mechanical equipment. In 2005 under the umbrella of the WavEC and its associates the plant was refurbished and operation was resumed in 2007. This action cost about 1 M€, half of which was supported by PRIME (Portuguese public funding scheme). Since then the

number of hours and energy production have being duplicating every year. Between January and March 2010 about 7 MWh of electricity have been delivered to the grid in about 300 hours of operation. At present the plant is operating autonomously with reasonable reliability and efficiency.

From the end of the nineties and in particular from 2000 onwards there has been a growing interest in Portugal in other type of wave energy technologies, both from the academy and the industry. Two technologies where tested at the Aguçadoura site, the 2 MW AWS prototype in 2004 and the three 750 kW Pelamis farm in 2008. This last project was supported by Portuguese public funds under PRIME. In the first case there was a significant involvement of IST and WavEC in the scientific support to the development of the technology and prototype testing. In both cases ENERSIS, a Portuguese leader in the renewable energy market at the time, was involved, in particular in the Pelamis case. It is well know that both cases were not very successful for different reasons, but in any case they are representative of the risks and difficulties that the industry is facing to develop wave energy into a commercial energy source.

In spite of the negative impact on the Portuguese society resulting from these cases (and Pico plant in an earlier phase), other companies are proceeding with technology development. This is the case of AW Energy, the Finish company that, in association to the Portuguese Eneólica, is developing a Waveroller 300 kW project in Peniche, Portugal, under the € 3 million funded SURGE FP7 project. Also Martifer, a Portuguese leader in metalwork and renewable energy, is developing their own technology, the FLOW, and has granted public funds under QREN (the present Portuguese funding scheme) to built and test a full-scale prototype. Together with the Portuguese Generg, Wavebob is developing the Standpoint project, which consists in building and testing in the Portuguese coast a Wavebob prototype. This project costs € 8.5 million and is supported by a FP7 grant of € 5.1 million. The Portuguese Kymaner has secured a € 1.2 million from QREN to develop components for oscillating water columns, namely a new air turbine, a control module and a communication module and a floating oscillating water column in cooperation with leading energy companies in Portugal.

The interest for offshore wind is much more recent due to the relatively deep waters and extreme waves in the continental shelf. The development of floating offshore wind turbines technology and the expansion of fixed solutions for deeper water, however, are opening an opportunity for exploiting the offshore wind resource in Portugal. One project in this area is being developed: the 2 MW WindFloat, a floating offshore turbine being developed by Principle Power and EDP and expected to be tested in the Aguçadoura site from 2011 onwards. This € 20 million project is expected to grant € 3 million from FAI (Fundo de Apoio à Inovação, see below).

Other projects in the offshore renewable area include the Wind&Wave@Sea project. This is a € 1.2 million project that is being submitted for funding aiming to characterize the Portuguese continental shelf up to the 12 miles in what concerns the offshore wind and wave resource, the extremes of wind, waves and currents and the temperature and salinity regimes. A combination of historical data, data from new wave and multiparameter buoys and coastal wind stations and numerical ocean-atmospheric circulation models will be used to characterize the continental shelf and select the most interesting areas for offshore renewable energy utilization. These areas will also be studied in what concerns environmental impacts and maritime space use conflicts and their economic value.

3.3 Infrastructure support for sea trials and further development

Three relevant support infrastructures for offshore renewable energy exist or are planned in Portugal: Pico wave energy plant, the Aguçadoura site, and the Pilot Zone.

Pico wave energy plant project was briefly described above. The plant is possibly the only wave energy plant available for research and testing under no commercial constraints. It is owned and managed by the Wave Energy Centre, a private non-for-profit organization. The plant provides an opportunity to validate numerical models, assess the power take-off equipment and concrete structure performance and aging, study control methodologies, develop O&M strategies, etc. Furthermore with the construction of a second turbine test rig, the plant can be used to test and demonstrate new turbines, valves and components. Pico plant will be part of the European network of R&D infrastructures on ocean energy, under the MARINET project, at present in final grant negations with the European Commission. Under this project European researchers may be funded to develop R&D activities at Pico plant.

The Aguçadoura is the open ocean test site where the AWS prototype in 2004 and the Pelamis farm in 2008 were tested. It consists of a land station with electric power equipment to deliver energy to the grid and data acquisition equipment, a 4 MW underwater electrical cable and three grid connected berths at 45 m water depth. A new berth is being developed to deploy the 2 MW Windfloat prototype in 2011. This test infrastructure is owned by EDP, EFACEC and PWP, EDP holding the majority of shares. EDP has shown availability to discuss with interested parties the use of the three previous Pelamis berths at Aguçadoura.

The Pilot Zone is a large area off the west coast (about 400 km^2) devoted to the development of wave energy. Three regimes are identified: demonstration, pre-commercial and commercial.

The demonstration phase applies to the first 4 MW per technology with a total of 20 MW at national level (so at least five technologies are expected to apply under this regime). The access to this phase is expected to be on a first come first go basis. Special feed-in

tariffs will be applied under this regime (see section 3.4). The pre-commercial phase applies between 4 MW and 20 MW per technology with a total of 100 MW at national level. The access to this phase is similar to the demonstration phase. There is also a specific feed-in scheme for this phase. The commercial phase applies after the first 20 MW per technology. The access to the pilot zone in this phase is competitive. Feed-in tariffs are also defined for this phase.

The pilot zone will be managed by the Portuguese TSO – Rede Energética National (REN) who will license the different wave farms to different project developers and end-users. The managing body will be responsible for developing the required infra-structures in particular the electrical connection points. It is expected that these will be developed in three phases (not confirmed by REN): 18 MW, 80 MW and 250 MW (high voltage connection).

There are also plans to develop a prototype test site (possibly in the pilot zone) and a 1:4 scale test in the Algarve under the creation of the Institute of Offshore Energy (see next section). A decision on this is expected to be taken before 2011.

3.4 Relevant R&D institutions

The Wave Energy Centre (WavEC) was formed in 2003 with the aim of supporting the development and marketing of wave energy. It associates 12 companies and 3 R&D institutions, including the leading energy producers and energy industry companies. Since 2008 the WavEC has also being dedicated to offshore wind, in particular in those areas where synergies with wave energy exist: site selection, licensing, dissemination, public policies, supply chain, floating structures, modelling and environment impacts. In part as a result of its success, the wave Energy Centre is expected to evolve to the Institute of Offshore Energy as resulted from a working group formed within ENERGYIN. This is the national pole for energy competitiveness and technology and resulted from a joint action of the four leading energy companies (EDP, GALP, MARTIFER and EFACEC) and the MIT-Portugal consortium of universities. ENERGYIN defined five priority areas, one of which offshore energy and identified the creation of the Institute of Offshore Energy as the key project. Other key project is the Wind&Wave@ Sea project referred back in section 3.2.

The activity at WavEC covers public policies, ocean energy economy, site selection, licensing, environment impacts and legislation, dissemination and training, sea trials and numerical modelling.

IST is the oldest and biggest engineering school of Portugal and is part of Lisbon Technical University. IST covers all main branches of engineering teaching and research. Activity in wave energy started in 1978 and includes the areas of plant design, control and operation, numerical and experimental modelling, site selection, resource assessment and power take-off development, in particular air turbines and electric and power electronic equipment. Whilst initially the activity was developed by staff at the Mechanical Engineering Department it now spreads to the Electrical Engineering Department and the Section of Naval Engineering (now integrated in the Mechanical Engineering Department). Other relevant areas of R&D at IST include ROV design and operation at ISR (Instituto de Sistemas e Robótica).

LNEG is the National Laboratory for Energy and Geology and belongs to the Ministry of Economy. It was created recently as a result of the former INETI reorganization into several smaller but more focused laboratories. Activity in wave and wind energy started there in the early eighties and concentrated mainly in resource assessment, site selection and numerical modelling, in this last case mainly in the wave energy area.

Instituto Hidrográfico (IH) is a national laboratory belonging to the Ministry of Defence and covers all the areas related to the physical processes in the ocean, in particular oceanography and geology. IH is well equipped with research ships, ROVs and state-of-the-art marine instrumentation. IH is able to provide all the physical data required to develop an offshore farm, namely the bathymetry and ocean soil and subsoil characteristics. IH also operates the national network of multiparameter and wave buoys and tidal gages and provides data from these on a regular basis through their web pages.

INEGI is a private laboratory linked to the engineering school of Porto University. INEGI has a wide expertise in onshore wind energy resource and site selection and is now moving also into offshore wind and wave energy and more generally to the ocean environment through its participation in the Ocean XXI cluster, formed by a number of research centres from the universities of Porto and Aveiro and companies from these regions.

3.5 Legislation and public funding schemes

Portugal has developed over the last 10 years very ambitious targets for renewable energy as presented in section 2.3. To be able to attain this targets a set of legislation was introduced in order to reduce the licensing difficulties, reduce risks and increase the economic attractiveness of renewable energy. This includes the obligation of renewable energy acquisition by the electrical grid and a feed-in tariff for the different technologies.

Table 2 presents the main relevant legislation in support of renewable energy in Portugal. The two last documents in the table concern funding schemes. QREN is the generic funding program from the Ministry of Economy to promote innovation and technological development in Portugal. It is relatively complex and presents support measures of very different kind. Renewable energy and in particular renewable offshore energy is one of the priority areas for QREN. QREN has a generic non-refundable limit of € 1 million and no limit for the refundable part. However some calls allow converting part of this refundable funding into non-refundable, depending on the success of the project, etc. Therefore non-

refundable funds can be of the order of € 1 to 5 million. QREN contribution can range from 45% to 75% depending on several factors. FAI is a public fund to support innovation in renewable energy. In general FAI support is non-refundable, cannot exceed 50% of the eligible costs and has a cap of € 3 million. Exceptions to these are possible but require special authorization from the Minister of Economy. Both QREN and FAI only support projects with a clear innovation and R&D content. The Portuguese Science and Technology Foundation (Fundação de Ciência e Tecnologia – FCT), which depends from the Minister of Science, Technology and Higher Education, supports small projects of R&D nature. Typical funds per project are of the order of € 200.000 and cover all the eligible costs. Interesting for companies is the support of QREN, FAI and FCT to hire young scientists.

Documents	Purpose and/or content
RCM 169/2005	To attain 39% of renewable energy production by 2010 and simplify the licensing processes
DL 51/2010	Allows the over rating power in wind energy to enhance the economy of wind farms
RCM 1/2008	Increases the pumping capacity in some large hydro-schemes for energy storage
DL 225/2007	Defines the feedin tariff for different renewable energy sources
	Creates the National Observatory for Renewable Energy
DL 5/2008	Creation of the pilot zone for wave energy
RCM 29/2010	Approves the pilot zone management contract to be signed with REN
	Development of an industrial cluster devote to offshore renewable energy
RCM 86/2007	QREN - Funding of renewable energy innovative pilot inniciatives
Despacho 32276-A/2008	Creation of the FAI (Innovation Support Fund - R&D and innovation in renewable energy)

Table 2: Relevant legislation to support offshore renewable energy in Portugal (RCM – Resolution of the Council of Ministers; DL – Act; Despacho – Ministerial Dispatch)

So far the pilot zone is devoted only to wave energy, but it is expected that it will be expanded also to floating and deep offshore wind. The same applies to the feed-in tariff for offshore wind, since at present it is the same as for onshore wind. WavEC expects that the feed-in tariff for wave energy presented in Table 3 will be assumed also for floating and deep offshore wind.

Initial FIT (€/kWh)	Min	Max
Demostration	0,258	0,258
Pre-comercial	0,163	0,209
Commercial1	0,102	0,163
Commercial2	0,086	0,117
Commercial3	0,076	0,076

Table 3: Feed-in tariff for wave energy

4. Conclusions

Over the last 10 years Portugal has had an enormous increase in renewable energy penetration. This success resulted to a great extent in the introduction of legislation that reduced the licensing costs and risks and increase the economic outcome of the projects. This legislation (already in place) will also be of great relevance for the development of offshore renewable energy.

Portugal has very good conditions to participate actively in the initial phase of floating offshore wind and wave energy due to its resources, continental shelf characteristics, electrical grid availability and experience in renewable energy. These two forms of energy are foreseen to contribute significantly to the energy supply of the country from 2020 onwards, when the technology is expected to be mature and the more traditional forms of renewable energy (hydro and onshore wind) are expected to attain most of their potential contribution. To the success of Portugal in offshore renewable energy also matters the experience gained with previous wave energy projects, even if their success was limited and, as well, the expertise to be gathered with the ongoing wave and floating offshore wind projects. Relevant is also the expertise in leading R&D institutions and companies and the specific legislation developed to support offshore renewable energy, namely the one related to the pilot zone.

Last but not the least the political support given to wave energy (in Portugal and also in the European dimension) is particularly important when the European SET Plan is missing ocean energy. If this is not corrected the funds required to develop the technology will not be available and Europe will lose its leadership to the USA, where bigger and bigger attention and resources are being given to this energy source.

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