



Investigating the potential and feasibility of an offshore wind farm in the Northern Adriatic Sea



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HIGHLIGHTS

- First feasibility study for an offshore wind farm in the Northern Adriatic Sea.
- Field wind and wave data collected at the site.
- Site-specific design of transition piece and foundation.
- Economical and technical feasibility applied to four different scenarios.

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ABSTRACT

The use of offshore wind power is becoming increasingly important towards a sustainable growth worldwide. In Italy, as well as in other countries where wind energy is provided only by onshore plants, the interest in the deployment of offshore wind resources is rapidly growing, despite relatively modest average wind speeds, compared to typical wind conditions in the North Sea. Research efforts have, so far, addressed the exploration of the most promising locations, based on wind characteristics; however, more extended evidence of technical and economic feasibility is now needed to raise awareness in the decision makers and secure to this source of renewable energy a proper role in the future energy policies. Within such a context, the paper presents the first feasibility study for the development of an offshore wind farm off the coast of Rimini, in the Northern Adriatic Sea. The study is based on an anemometric campaign started at the site in 2008 to provide a statistical assessment of the wind characteristics and the related wind energy potential, and on a 10-year wave measurement record next to the area, together with a thorough analysis of the site geological and environmental characteristics. Environmental data are interpreted with a proper consideration of the extreme events distribution and relevant results are used to select the most appropriate commercially available wind turbine and to design the site-specific support structure. A comprehensive evaluation of the investment costs and revenues is then carried out with reference to two wind farm layouts (a first smaller, constituted of 15 elements, and another one, featuring up to 60 elements) and in relation to two different scenarios, conservative and comparatively more realistic. Results of the study clearly show that the Northern Adriatic Sea is potentially suitable for the development of a large wind farm and should encourage investments on more advanced experimental campaigns and related studies in order to prove the feasibility of innovative technological solutions that would substantially increase the profitability of such installation.

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0. Introduction

The ocean energy sector has undoubtedly got a great potential of making an important contribution to the supply of renewable

energy and the percentage of electricity that could be produced from offshore wind farms (OWFs), worldwide, has been estimated to be around 7% by 2050 [1]. According to [2], Korea, Spain, Norway, Portugal as well as the US are emerging countries in the deployment of offshore wind resources, as also documented by several research works carried out in the last years. Established practice in those countries is consistent with the trend, where

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several pending projects are still awaiting for their approval and only few demonstration prototypes have been actually installed, as it happens for instance in the US [3], where the production of wind energy is primarily onshore while the harvesting of offshore energy is mainly related to oil and gas extraction.

The situation in Italy is alike: the wind energy is entirely provided by onshore plants, for a total rated capacity of 8.66 GW at the end of 2014 [4], and the experience in the offshore field is well consolidated only in the oil and gas sector (Italy currently has about 100 productive platforms in activity [5]). In the country interest is now growing towards the deployment of OWFs, as it is also documented by Tradable Green Certificates made available since 2009, and towards the support of the high investment costs required by wind power in the marine environment [6].

In the last few years, a significant research activity has been devoted to map wind speeds and wind energies over the Mediterranean basin, in order to identify suitable areas for offshore wind deployment [7–9]. Relevant results would locate the most promising spots in Southern Italy. The already published feasibility studies are consistent with these findings, addressing the deployment of offshore wind farms along the southern coasts, off Puglia [10] and Sicily [11] regions. In such studies, the offshore wind turbines (OWTs) are located a few kilometers from the shoreline, where a reasonably shallow water (less than 35 m deep) is still found and no special technology for the foundation systems is required.

The widespread presence of deep water near shore would provide a natural constraint for the diffusion of wind plants, as related environmental impact becomes critical to obtain construction permits in high-density touristic areas [12,13]. The use of floating wind turbines is recognised as a possible solution, as they can be installed in deep waters [14]. However, the development of such structures is still subjected to serious technical challenges, notably for the design of mooring and anchoring systems under complex non-linear and dynamic loading conditions [15,16]. Furthermore, economic feasibility has been assessed for water depths greater than 60 m [17], where other issues related to the distant wind farm location can arise, as discussed in [18].

According to [19], more than twenty projects for OWFs have been presented along the southern Italian coasts in the last years, whose realization was denied or temporarily stopped due to siting issues, which were found critical either by the relevant Municipalities or by the Ministry of the Environment and the Ministry for Cultural Heritage.

As a consequence, interest is now moving to different locations, so far not adequately considered as a possible location for the deployment of an OWF. According to [20], the potential of such areas need to be first comprehensively investigated, taking into account the technical and the economic aspects with a suitable methodology. Direct measurements of environmental conditions are also crucial for such a study; previously published feasibility studies of OWFs on the Italian territory, in fact, made use of extrapolated environmental data [10,11]. However, the importance to collect actual data at the installation site has been highlighted under different circumstances: in order to incorporate local variables [21], to select the most appropriate distribution for the local wind climate description and to minimize possible estimate errors in offshore wind energy [22]. Furthermore, most investors require such information as they would not rely solely on wind data coming from a numerical model extrapolation [23].

Within such context, the study presented herein – with reference to a case assessment in Italy – aims at encouraging the deployment of offshore wind farms, by responding to the current need of detailed, applied and consistent evidence of the actual feasibility of wind farms in countries where the exploitation of offshore wind is still being considered only as a possible but not profitable option.

The study represents the first, field data based, feasibility study of an OWF in the Northern Adriatic Sea, off the coast of Rimini. The area has been selected according to the crucial indications of local public administrations, as it presents very favorable siting conditions and no particular natural constraints. To reliably assess the wind potential, an experimental campaign was launched in the area in 2008 to measure wind speeds and frequencies. Wave conditions were ascertained by a directional wave buoy installed in 2007, few kilometers north of the area. The study aims at taking into account technical and economic aspects using an interdisciplinary approach, as suggested in [24,25].

The paper is organized in three parts. First, a thorough description of the site is given and the experimental data are presented and interpreted with a proper consideration of the extreme events distribution. The second part addresses the technical feasibility, relevant to the selection of the most suitable offshore wind turbine (OWT) and to the preliminary design of the tower and the support structure, based on the interpretation of the field data previously presented. The third part is concerned with the economic aspects, examined on two distinct OWF layouts: a first smaller, constituted of 15 elements, and another one featuring up to 60 elements. Two different scenarios, conservative and comparatively more realistic, are considered for both layouts to complete the evaluation of the investment profitability.

The procedure adopted for a preliminary feasibility study is described in full detail, so that it could be easily repeated and applied on essential data in areas with similar features.

1. Details of the study area

1.1. Site description

The criteria for selecting suitable locations for the deployment of OWFs should not only include technical-engineering terms but also ecological–environmental considerations and socio-economic aspects [26]. The area of study is located in the Northern Adriatic Sea, off the coast of Rimini (Italy) as depicted in Fig. 1, on a schematic map of the current sea uses [27]. Within the boundaries of territorial waters, 12 km far from the coast, the area is approximately 8 km wide and 20 km long and overlaps a wide district for gas extraction, already provided with several productive platforms. Military zones are also present in the proximity, though located distant enough, as well as sand deposits for beaches nourishment. Aquaculture is practiced sufficiently far away, along the boundary of the nursery area, next to the coast. The directional wave buoy named “Nausicaa” and the methane platform “Azalea B”, hosting the anemometer for wind speed measurements, are highlighted on the map. The industrial port of Ravenna is located north of the area, approximately 60 km from Rimini. As observed, five productive gas platform are found in the area. After their construction, an environmental impact assessment study was carried out for platform “Regina”, following a 3-years period data collection [28]. The analyses were focused on the effects of the structure on the hydro-biological conditions, on the chemical and physical properties of the silty sediments and on the metal concentration in local organisms, benthos and fishes. The study showed no significant effects on relevant water and soil properties, but a biodiversity enrichment was detected, as typically expected next to offshore steel structures. As for the effect on birds, no local data are available at present and specific studies should be carried out. However, according to [29], marine birds behavior, collision mortality, habitat displacements are difficult to monitor offshore; fortunately, the Mediterranean has a limited diversity of marine birds and they are listed as “least concern” on the IUCN red list.

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