Renewable Energy 88 (2016) 494–516

Contents lists available at ScienceDirect

Renewable Energy

journal homepage: www.elsevier.com/locate/renene

The nearshore wind and wave energy potential of Ireland: A high resolution assessment of availability and accessibility

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ARTICLE INFO

Article history:
Received 15 September 2014
Received in revised form
14 September 2015
Accepted 2 November 2015
Available online xxx

Keywords:
Wave energy resource
Wind energy resource
High-resolution regional model
Complementarity
Weather windows
Ireland

ABSTRACT

A 14-year high resolution wave and wind hindcast was carried out for Ireland. The wind was dynamically downscaled from the ERA-Interim reanalysis to a 2.5 km horizontal resolution and 65 vertical levels, using the HARMONIE meso-scale model. The wave hindcast was derived using WAVEWATCH III on an unstructured grid with resolution ranging between 10 km offshore and 225 m in the nearshore, forced by the downscaled HARMONIE 10 m winds and ERA-Interim wave spectra. The wind and wave hindcasts were thoroughly validated against available buoy data, including wave buoys in nearshore locations and coastal synoptic stations. In addition, the significant wave heights and winds from the hindcasts were compared against all available altimeter data from the CERSAT database at Ifremer. The quality of both the wind and wave hindcasts was found to be good.

The wave and wind energy resource in coastal areas was assessed, and discussed in terms of water depth, distance to shore, and seasonal and inter-annual variability. In addition, the current study investigates the nearshore wind and wave climate in conjunction with each other, and highlights two issues with relevance to the ocean renewable energy industry: (i) the complementarity between the wind and wave energy resource, and (ii) the accessibility for marine operations. Our study highlights sites around the Irish coast that might have been overlooked in terms of the potential for wind, wave or combined wind/wave energy installations.

1. Introduction

From an offshore renewable energy perspective, a country like Ireland in the Atlantic Ocean is uniquely placed in Europe in terms of its wind and wave energy resource. As part of the Irish government's overall target of achieving 40% of electricity generated from renewables by 2020, a 500 MW target for installed ocean wave capacity by 2020 [1] has been set. The *Offshore Renewable Energy Development Plan* for Ireland [2], which was launched in February 2014, aims to encourage developments for Ocean Energy (OE) at a national level.

The ESB's WestWave [3] project has also secured funding under the EU's New Entrant Reserve (NER300) scheme and plans are underway to install a 5 MW demonstrative Wave Energy Converter (WEC) farm off the west coast. In addition, the development of ocean energy test sites off the west coast of Ireland (a quarter-scale test site in Galway Bay, a full-scale test site in Belmullet – the Atlantic Marine Energy Test Site AMETS) and of the new Marine Renewable Energy Ireland SFI Research Centre (MaREI) [4] ensures that Ireland continues to develop its position as a potential global leader in marine renewable energy into the future.

At a European level, 4.9 GW of offshore wind power capacity is under construction [5]. In Ireland, there are currently seven turbines (with 25 MW power capacity) installed in a wind farm on the Arklow Bank, off the east coast of Ireland in the Irish Sea. Additional foreshore leases have been granted for the Arklow Bank and another site on the Codling Bank (also off the east coast, see Fig. 1) with a combined power capacity of 1620 MW. Another tranche of offshore wind projects are currently seeking foreshore leases for projects around the coast, such as the Oriel Windfarm and the

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http://dx.doi.org/10.1016/j.renene.2015.11.010
0960-1481/

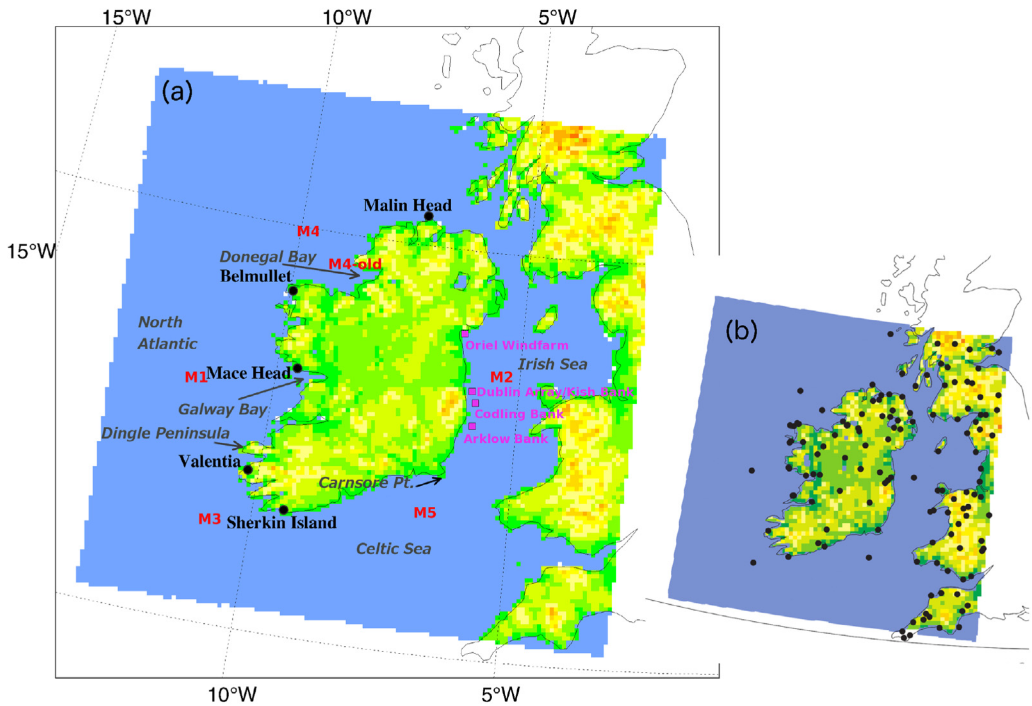

Fig. 1. (a) The horizontal grid of the HARMONIE model with the location of the coastal land synoptic stations (Malin Head, Belmullet, Mace Head, Valentia and Sherkin Island denoted with black circle markers) maintained by Met Éireann, and used for validation of the 10 m HARMONIE downscaled winds. Wind data from the M-buoys (denoted in red) from the Irish Marine Weather Buoy Network were also used for validation (also see Fig. 2 for their locations). Windfarm locations in the Irish Sea are denoted with magenta square markers. Geographical locations of interest are labelled in grey. (b) The locations of the full network of surface stations used in the HARMONIE model 10 m wind validation (>120 stations). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Dublin Array (Kish Bank) on the east coast and Fuinneamh Sceirde Teoranta on the west coast, near Mace Head [6,7].

In this context, it is paramount to have an accurate picture of the available wave and wind energy resource, and thus, of the potential energy yields from these developments. Furthermore, this knowledge is necessary for the selection of additional OE sites in Ireland. Data from a small number of buoy or coastal weather stations provide detailed information at specific sites, but over large areas there is a general lack of detailed information. In addition to the few wave buoys and weather stations, most of our wave climate knowledge is currently based on deep water, coarse resolution models or limited area models (targeting potential wave energy testing and deployment sites) which are not appropriate sources in this context. Apart from the high-resolution, long-term wave hindcast, driven by ERA-Interim wave spectra and winds, carried out by Ref. [8] for Ireland (both the Atlantic and the Irish Sea coast), there are several other studies limited to small nearshore sites [9–11], or offshore locations on the Irish west coast, [12–14]. The wind energy potential of Ireland has been previously assessed (for example, the SEAI wind atlas for Ireland [15], now updated to a 4 km horizontal resolution [70].). Furthermore, a 40-year downscaling of ERA-40 atmospheric dataset [16] for Ireland has been performed in Ref. [17] resulting in a 13 km horizontal grid spacing with 40 vertical levels.

It should be noted that the wind and wave studies for Ireland mentioned above do not always cover concurrent periods and have disparate resolutions. Additionally, some nearshore/coastal areas of interest around Ireland have not yet been modelled to a high-resolution. At the same time, targeting areas in the nearshore/coastal regions can enhance OE viability for at least two reasons: (i) device survivability and (ii) reduced cost in transporting this energy to the shore. In fact, accessibility for deployment and maintenance is proving to be a key factor in the successful development of OE devices. Apart from an accurate assessment of the energy resource, building a joint picture of met-ocean conditions (both wind and wave) is crucial. The complementarity between both wind and wave power also has the potential to reduce transmission requirements [18,19].

The paper is organised as follows. Details of the wind and wave model data and method of implementation are presented in Section 2. (The wind and wave model validation is included in Appendix A.) In Section 3 we discuss the wind and wave energy resource around the Irish coast and the complementarity between the two, whereas in Section 4, we assess the accessibility for marine operations. In Section 5 we discuss the results of the study and finally, in Section 6, we summarise and conclude our findings.

2. Data and methodology

To accurately represent coastal features (quite complex in the case of Ireland) climate hindcasts of high spatial resolution, properly calibrated against available measurements are indispensable. To address these requirements, we have performed a high-resolution, 14-year (2000–2013) wave and wind climate hindcasts for Ireland (both the Atlantic, Celtic Sea and Irish Sea coasts), with a focus on the nearshore areas. We have adopted a dynamical downscaling approach using the ERA-Interim re-analysis dataset [20], from the European Centre for Medium Range Weather Forecasts (ECMWF) as forcing for high-resolution regional-area atmospheric and wave models (HARMONIE and WAVEWATCH III, respectively).

The wind hindcast was derived by using a high-resolution limited-area atmospheric model (LAM) to downscale the ERA-Interim Atmospheric re-analysis. This was carried out using