Renewable Energy 78 (2015) 276–287

Contents lists available at ScienceDirect

Renewable Energy

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

Wave energy assessment in Sicily (Italy)

M. Monteforte, C. Lo Re*, G.B. Ferreri

Department of Civil, Environmental, Aerospace, Material Engineering, University of Palermo, Viale delle Scienze ed. 8, IT-90128, Palermo, Italy

ARTICLE INFO

Article history:
Received 23 May 2014
Accepted 4 January 2015
Available online

Keywords:
Wave energy
SWAN
Sicily
Wave energy propagation
Spectral models
Mediterranean Sea

ABSTRACT

This research presents an estimation of wave energy potential in Sicily (Italy) carried out using both buoy wave measurements from *Rete Ondametrica Nazionale* (RON), the Italian Government wave buoy network, and wave parameter data by ERA-INTERIM, a recent meteorological reanalysis project of the European Centre for Medium-Range Weather Forecasts (ECMWF). Starting from these offshore data, we first identified the western part of Sicily as the area with a higher availability of offshore wave energy; subsequently, we selected a study area in the western part of the south coast and assessed the nearshore potential energy by performing propagation using a spectral model (SWAN). The nearshore analysis highlights the presence of a "hot spot" relatively close to the coast where energy concentration produces even higher energy availability than offshore. Based on this result, the site may be a possible location for a wave energy farm, provisional on a technical–economic feasibility analysis.

© 2015 Elsevier Ltd. All rights reserved.

1. Introduction

Oceans and seas represent an enormous and virtually infinite energy resource carried in waves, tidal streams, salinity differences, and temperature differences, with theoretical global estimates of, respectively, 8000–80000, 800, 2000, and 10000 TWh year^{-1} [1].

In recent years, wave energy has been considered the most promising marine energy source due to its properties such as easy predictability and availability around the world. The potential is enormous compared to global electricity production, which, for instance, in 2007 was 19,855 TWh [2].

There have been two boom periods for development of sea wave energy: the first in the 1970s and the second beginning in the mid-1990s, which is still ongoing. The 1970s boom was due to the oil crisis, which attracted worldwide attention. Although there was a multitude of ideas at that time, none emerged as a commercial reality because the technology was not mature. The drivers for the second boom started with carbon-reduction targets but have evolved and matured in recent years to include aspects such as energy diversity and security of supply. A new energy crisis may be looming, and the planning is more difficult for onshore wind and tidal stream; thus, interest in wave energy has been reignited as an alternative resource. Although the global economic downturn has slightly slowed progress in recent years, it has also consolidated the sector and directed the focus on economic energy returns [3].

Substantial work has been conducted concerning wave energy estimation for many areas of the world. Isaacs and Seymour [4] estimated the global wave power potential to be on the order of 1–10 TW, which is the same order of magnitude of world consumption. Recently, work by Mørk et al. [5] assessed the global gross theoretical wave power resource to be about 3.7 TW, 381 GW of which is from Europe and 37 GW from the Mediterranean Sea. These values are in agreement with the estimates given by Clément et al. [6].

Several works focused on the Atlantic coastline of Spain showed a large amount of offshore wave energy; in particular, the average wave power and the annual wave energy exceeded, respectively, 40 kW m^{-1} and 400 MWh m^{-1} in the northwest part and 30 kW m^{-1} and 250 MWh m^{-1} in the north part [7–10].

Gonçalves et al. [11] conducted a similar study on the western French coast, the area of the Cantabrian Sea, finding a mean energy resource of 20–25 kW m^{-1} throughout the year. For this area, Clément et al. [6] found annual power levels up to 40 kW m^{-1} and a total resource of approximately 28 GW, whereas on the Mediterranean French side the annual power level is 4–5 kW m^{-1}. Several studies addressed wave energy assessment around the Canary, Azores, and Madeira Islands, showing average energy values in the range of 20–25 kW m^{-1} [12–15].

Several studies have been conducted on the Mediterranean Sea, one of the most recent performed in the framework of the WW-Medatlas project [16]. In this project, sponsored by the Italian,

* Corresponding author.
E-mail addresses: massimiliano.monteforte@unipa.it (M. Monteforte), carlo.lore@unipa.it (C. Lo Re), giovannibattista.ferreri@unipa.it (G.B. Ferreri).

http://dx.doi.org/10.1016/j.renene.2015.01.006
0960-1481/© 2015 Elsevier Ltd. All rights reserved.

French, and Greek Navies, an extensive atlas of wind and wave conditions in the Mediterranean Sea was mapped based on data derived from the archive of the European Centre for Medium-Range Weather Forecasts (ECMWF), which were then calibrated using satellite data. Based on the mild and steady wave climate, Bozzi et al. [17] proposed wave energy converter (WEC) installations in only two sites of the Mediterranean Sea.

One of the first assessments of the Italian offshore wave energy resource was conducted by Filianoti [18], recently updated by Vicinanza et al. [19], which led to publication of the Italian Wave Energy Atlas (http://www.italywavenergy.it/).

Using wind data provided by ECMWF, Liberti et al. [19] assessed the wave energy resource in the Mediterranean Sea by using a generation III wave model (WAM Cycle 4.5.3). They validated the model results against satellite and buoy measurements and showed that the most productive area is located in the western Mediterranean Sea between the Balearic Islands and the western coast of Sardinia, having average power values >15 kW m^{-1}. Furthermore, they assessed an average wave power reaching 9 kW m^{-1} for the north-western and southern Sicilian coasts.

Vicinanza et al. [21] investigated in detail seven sites north-west of Sardinia by analysing wave buoy measurements from Rete Ondametrica Nazionale (RON), the Italian Government wave buoy network [22], and reanalysing wave data from ECMWF propagated from offshore to nearshore by means of a spectral numerical model. Their results highlighted the presence of two “hot spots” with wave power of about 10 kW m^{-1}.

Hot spot is a term introduced by Iglesias and Carballo [23] to indicate a site with concentrated wave energy. Nearshore hot spots are more likely candidate sites for wave energy conversion facilities than offshore hot spots because the length of underwater transmission cables plays a critical role in determining the economic feasibility of a wave energy conversion project [24]. Further, nearshore hot spots are often coastal areas that require coastal defence structures; therefore, the installation of wave farms in these areas can also be used to protect the coasts from erosion caused by wave energy concentration, as numerous studies have demonstrated [25–29].

In general, the wave energy in the Mediterranean Sea is low compared to oceanic coastal areas; however, any hot spots relatively close to the coast may prove promising for installing wave energy converters (WEC). Bozzi et al. [17] showed that the scale reduction of a device allows an optimal energy conversion to be gained in sites having a low energy, such as in the Mediterranean Sea; however, detection of hot spots through the analysis of wave energy propagation from offshore to nearshore assumes a main role, especially for the devices designed to operate in intermediate and shallow water.

The present research focused on estimation of wave energy potential off the three Sicilian coastal sides, starting with offshore wave data from ECMWF and RON. Then, by propagating energy in the most energetic areas, the existence of possible hot spots was investigated.

2. Offshore analysis

2.1. The data used

Two types of wave data were used: buoy measurements and reanalysis data. The wave buoy measurements were collected by RON, managed by the Italian Institute for Environmental Protection and Research (ISPRA). The 15 RON buoys are located along the Italian coast in approximately 100 m deep waters. The data used in this study are from the three buoys along the Sicily coast near Capo Gallo (in front of Palermo), Mazara del Vallo, and Catania, respectively, on the north, east, and south coasts (Fig. 1). The geographical coordinates of the buoys are, respectively, 38.26°N–13.33°E, 37.52°N–12.53°E, and 37.43°N–15.15°E. Data availability periods for each buoy are from January 2004 to June 2012 for Capo Gallo and from July 1989 to June 2012 for Mazara del Vallo and Catania, with the exception of short malfunction periods. RON data consist of significant wave height (H_s), peak wave period (T_p), and mean wave direction (θ). Until 2002, RON collected data for 30 min within each 3-h interval, but collection was continuous when H_s exceeded 3.0 m or 4.5 m, respectively, for Catania and Mazara del Vallo. Since 2002, the RON measurements are continuous for every buoy.

In addition to the RON data, reanalysis data by ECMWF were also used. ECMWF has supported the creation and development of the ERA-INTERIM project, which replaced the old reanalysis project ERA-40 and performs a reanalysis of the global atmosphere and

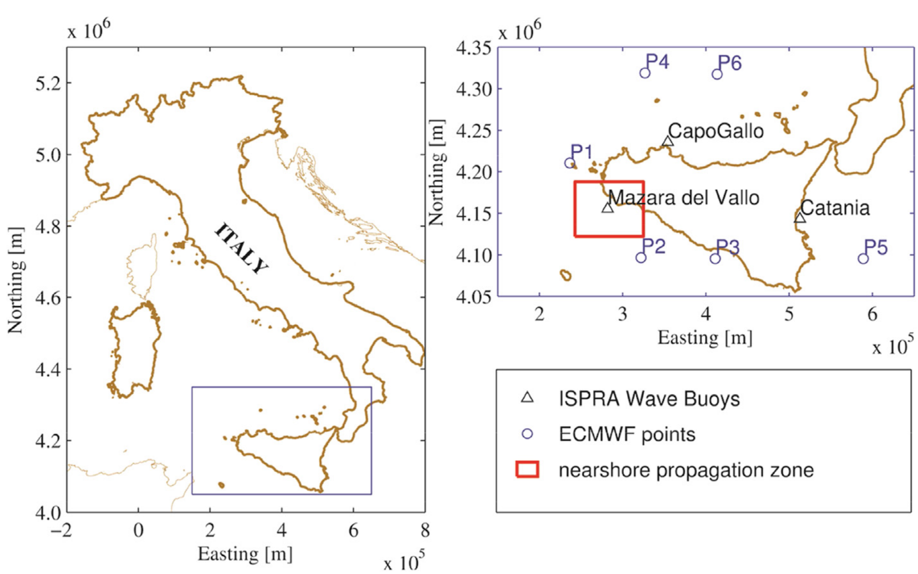

Fig. 1. Map of Italy and Sicily showing: 1) the location of the ISPRA (RON) wave buoys and the ECMWF nodes considered and 2) the area examined for nearshore propagation (ED50-UTM33N).

Download English Version:

https://daneshyari.com/en/article/6767338

Download Persian Version:

https://daneshyari.com/article/6767338

Daneshyari.com