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A wave energy resource assessment case study: Review, analysis and lessons learnt

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ABSTRACT

A case study of the development of an overall resource assessment for the Wave Hub site in the southwest UK is presented. Wave Hub is one of the earliest large-scale wave farms planned. Several resource assessment studies have been performed for the site, but the published results are high-level and predicted power availability varies significantly. This paper provides a detailed overview and re-analysis of the multiple datasets used in the original studies, which consisted of a combination of physical measurement and numerical modelling. The quality of the datasets is assessed, and reasons for the discrepancies between predicted resource levels investigated. Results from a SWAN model for the region illustrate significant levels of spatial variability in the resource due to the complexity of the local bathymetry, and examination of long-term global model datasets shows notable inter-annual variability. It is thus concluded that a resource assessment methodology utilising datasets from multiple locations and of short duration significantly reduces the accuracy of the predicted levels of resource. From these results, key learnings for future developments are discussed.

1. Introduction

Resource assessment plays a key role throughout a wave energy project development, from initial site selection to farm operation. At its most basic level, it aims to identify the level of wave energy resource available for the extraction of energy. However, the level of detail required will vary with the *stage* of the project development, as described for example in the EquiMar protocol for resource assessment [1]. This breaks the resource assessment stages for a wave energy project down into three stages, illustrated in Fig. 1, with the following requirements:

- Early stage: requires resource assessment over a wide geographical area to identify the optimal location for a development and assess the seasonal and inter-annual variability. At least ten years of data are preferred, and model output will often be used due to a lack of long-term measured datasets, and to provide wider spatial results. Output in the form of parameters (e.g. H_{m0}, T_e, mean direction) is sufficient at this stage.
- Project planning: establishes characteristics for a specific site, including spectral data and extreme conditions. Modelled data should be supported by *in situ* measurements.
- Operation: requirements are dependent on the specific details of the deployment, but as a minimum, an ongoing measurement programme should be operated to allow device output to be benchmarked against the wave conditions. A prediction model will be required for the planning of marine operations, e.g. maintenance and recovery of devices.

Although straightforward in theory, the reality of a full resource assessment is more complex. Global wave model data are readily available from a range of sources and are useful for early stage assessments, but once a site has been selected and detailed project planning commences, an in-depth knowledge of the sea state at the site, its spectral composition, seasonal and inter-annual variation, and potential spatial variation over the site are all required to predict power production with any degree of accuracy and provide confidence for project financers.

A large number of wave resource assessment studies have been published for regions around the globe, e.g. [2–4], however in general, these reports focus on a wide geographical region and aim to assess the potential available resource rather than focus on the detailed assessment for a specific site. Mackay et al. [5,6] present a detailed overview of uncertainties in resource assessment and variability in resource levels, and the impact this may have on predictions of output power from a wave energy device. However, the study presented in this paper differs in that it aims to review the resource assessment process and results for a specific site and

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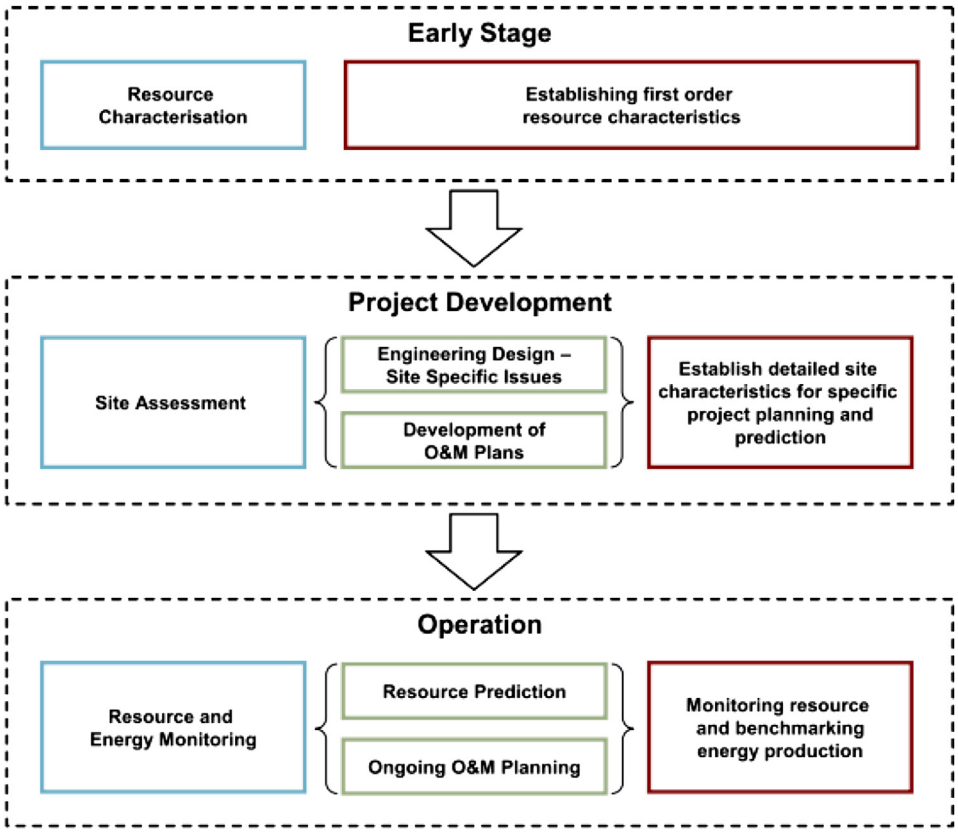

Fig. 1. Characteristics of the three resource assessment stages (from [1]).

illustrates the real challenges faced when attempting to provide detailed data for device and project developers.

Wave Hub is one of the few wave energy sites to have gone through the full development process. Located in the southwest of the UK (see Fig. 2), Wave Hub is a 20 MW test site for single devices or arrays. It comprises a grid-connected subsea cable, linked through a seabed hub to four berths for device or array deployment. The infrastructure was deployed in the summer of 2010, and the site is currently awaiting the first deployment of devices, planned for summer 2012. In common with other early developments, the Wave Hub resource assessment used data from a range of sources, including local measurements and global model output. However, the datasets were disparate, of varying length, and recorded or hindcast at different locations. As such, the published resource data for the site (see Section 2.3) provide a range of estimates of available power, dependent on the dataset used, which are insufficient for detailed project planning.

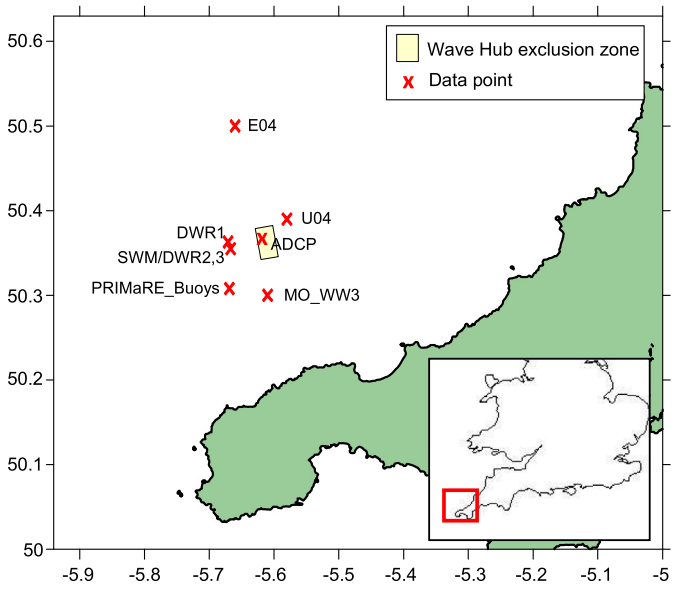

Fig. 2. Positions of measurement and model locations relative to the planned Wave Hub exclusion zone.

This paper reviews the resource assessment process at Wave Hub and the datasets used, and describes attempts to assimilate the wide range of data to provide a more detailed overview of the available resource and estimation of the associated uncertainties than were published in the original Environmental Statement [7]. It aims to highlight the challenges faced by site developers and the uncertainties that can be introduced into power predictions for a site. It concludes with a discussion on wave energy resource assessment in general, focussing on the lessons that can be learnt from the Wave Hub data and how these can be applied to future studies.

2. Data review

2.1. Summary of data

The Wave Hub resource assessment studies utilised two types of data for analysis: recorded data from instruments deployed at sea, and hindcast data from numerical models. Table 1 presents a summary of the datasets used. The dataset locations are illustrated in Fig. 2, and a timeline of data availability is provided in Fig. 3.