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ScienceDirect

Energy Procedia 142 (2017) 328–336

Energy Procedia

www.elsevier.com/locate/procedia

9th International Conference on Applied Energy, ICAE2017, 21-24 August 2017, Cardiff, UK

A multi-parametric criteria for Tidal Energy Converters siting in marine and fluvial environments

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Abstract

Marine renewable energy deployment involves site resource assessment as strategic support for installation and optimization. This part of the design needs to be based on best available measurement technologies and deployment methods, minimizing the investments. The siting and design of a kinetic energy converter (like a Tidal Energy Converter ones) require characterization of the variability of the flow velocity acting on the energy capture area in space and time, in order to assess the hydrodynamic forces, to design the structural loading and power capacity of the TEC, helping investment decisions and project financing. In this work, a site assessment procedures for emplacement of TEC machines are shown, comparing sites with different hydrogeological characteristics using the same design approach. In order to define the best conditions for siting, three case studies have been carried out, two for sea and last for river installation. The strait of Messina (Italy), a marine channel with an amphidromic point for the tides, has its minimum depth at 72 m, between Ganzirri and Punta Pezzo, deepening to 1000 m to the North East and down to 2000 m to the South. The Cook Inlet (Alaska), a large subarctic estuary in South-central Alaska which extends about 250 km from Anchorage bay to the Pacific Ocean. Tidally dominated currents control the hydrographic regime, meanwhile water levels and currents are influenced by tides coming from the Gulf of Alaska, which are significantly amplified as approaching Anchorage bay. The Pearl River Estuary and its adjacent coastal waters (China) have a length of about 70 km, a width of about 15 km and an average depth of about 4.8 m, but it has a depth of more than 20 m in its eastern part.

Keywords: *TEC machines, siting, marine and fluvial environment,tidal*

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10.1016/j.egypro.2017.12.052

1. Introduction

Turbines placed directly in river, ocean, or tidal current generate power from the kinetic energy of moving waters, so, in order to install, at the better conditions, such machine, a correct approach is to focus, from one side the site and its characteristics and from the other side, the machine optimization.

Hydrokinetic devices are ideally installed at locations having relatively steady flow throughout the year and are not prone to serious flood events, turbulence, or extended periods of low water level [1].

The siting procedure requires characterization of the spatio-temporal variation of the current velocity (an optimum range is the 1.5÷3.5 m/s [1]) and turbulence acting on the on the machine so as to provide the hydrodynamic forces and available power estimates over a representative period of record, to design the structural loading and power capacity of the machine itself.

Although each tidal energy site is unique, there are a number of common features affecting the deployment. New approaches to device anchoring may expand the range of operationally feasible sites.

Environmental effects of tidal power generation are almost similar to those of wave power and offshore wind power generation. In order to appropriately site and operate tidal power installations, the environmental risks of the technology must be well understood [2]. In doing so, it is important to distinguish between environmental effects and environmental impacts. Environmental effects are the broad range of potential measurable interactions between tidal energy devices and the marine environment. Environmental impacts are effects that, with high certainty, rise to the level of deleterious ecological significance.

The aim of this work is to establish some key parameters allowing a first raw performance comparison between sites, using a new machine concept and taking care about imposed site limitations. A first guidelines, can be based on a combined multi-parametric criteria:

1. water depth and turbine spacing requirements, to best fit the turbine design and rating power that can be devices accommodated within a tidal inlet or channel;
2. tidal current energy resource attributes, i.e. annual average energy flux per swept area of device;
3. seafloor geology and coastal morphology suitable for device installation and anchoring system;
4. turbine interaction with marine life for an safe environment installation and operation;
5. water salinity, mostly for material lifelong operation.

Seafloor geology significantly influences the device installation. Research on sediment dynamics postulates a threshold value for the initial movement of particles [3], essential to know if hydrodynamic conditions, in the study area, induce critical shear stress velocities enough high to erode sediment surfaces which could be involved in turbines.

1.1. Site parameters

Several parameters have to be considered in order to match the best turbine performances and the site characteristics. The main energetic ones are explained below [4].

- *Power Density*

The instantaneous Power Density (W/m^2) of a flow incident on a tidal current turbine is given by the equation:

$$\left(\frac{P}{A}\right)_{Water} = \frac{1}{2}\rho V^3 \tag{1}$$

where A is the cross-sectional swept area of the device (m^2), ρ is the water density and V is current speed (m/s). For tidal currents V changes with time in a predictable manner.