Mini Review

Marine environmental impact of hydrokinetic energy

Abstract

Hydrokinetic energy is considered to be the next renewable energy source to be deployed in one or more of its variants within the next few years. In order to reduce the technology deployment time cycle, arguments are presented for the simultaneous consideration of marine environmental impact, along with turbine technology development and geographical site assessment, in the technology readiness level determination.

Keywords: Hydrokinetic energy, Technology readiness level, Marine environmental impact

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Introduction

Hydrokinetic energy (HKE), a renewable energy source, may simply be defined as the conversion of water stream kinetic energy to electrical power. There are two major variants of HKE: ocean currents and river currents. Ocean current HKE possesses two principal subvariants: deep ocean currents, and shallow coastal tidal currents. Similarly, river current energy has two subvariants: natural water river currents, and regulated water currents downstream of hydroelectric power plant; for a recent overview of HKE, see.[1,2]

Of all ocean renewable energy sources (including ocean wave energy and ocean thermal energy), tidal current HKE is considered to be the nearest to full scale deployment.[3] River current HKE harnessing is growing at a great pace, albeit requiring more technoeconomimc assessment studies, this variant of HKE being of extreme importance in introducing electricity to isolated rural areas where connection to an electricity grid is not economically viable.[4]

The successful deployment of HKE rests on two major pillars: HKE conversion device (turbine) technology and geographical site HKE resource assessment. Laws & Epps[1] provide a recent review of the status of both HKE turbine technology development and HKE site assessment. There exist several reported studies of specific sites assessment for the conversion og HKE to electrical power; e.g. González-Gorbuña & Behrouzi et al.[5,6] Impacts on the marine environment in which HKE is deployed have been studied; e.g. Karmar & Pheonix.[7,8] The purpose of this paper is to argue that there is a necessity for the incorporation of marine environmental impact as a third pillar for the deployment of HKE.

Integrated marine environmental impact and Technology readiness level

Technology readiness level (TRL) may be defined as a metric for the assessment of the proximity of a technology towards its full scale deployment. It was originally conceived in NASA, and has been adapted to diverse fields in the manufacturing and service industries. TRL possesses nine levels, with each of which is associated an integer that signifies in ascending order the progress of a technology in accordance with the following order[3]

Level 1: Basic principles observed and reported;

Level 2: Technology concept and/or application formulated;

Level 3: Analytical and experimental critical function and/or proof of concept;

Level 4: Technology (system or components) validated in a laboratory experiment;

Level 5: Laboratory scale, with similar system validation in a realistic working environment;

Level 6: Engineering/pilot scale, with prototype system or model demonstrated in an actual working environment;

Level 7: Full scale or prototype technology demonstration in an actual working environment;

Level 8: Actual system completed and qualified ready for deployment through test and demonstration:

Level 9: Technology operational over full range of expected lifetime conditions.

The success of TRL in practice has been demonstrated for several decades in various areas; furthermore, it has been extended in several directions with a view to increasing its applicability through a more sophisticated quantification of its metrics; e.g.[9-11] However, to the authors´ knowledge, there does not appear to be any work reported in the literature on the incorporation of environmental considerations within the TRL framework.

The basic argument expounded in this paper is that the environmental impacts of a technology, and the focus here is on HKE, should and could be an integral part of the identification of the TRL at which the aforesaid technology is encountered. In HKE, TRL considerations have been insufficiently ambitious in concentrating on only two pillars: turbine technology and site assessment. What is proposed here is the simultaneous consideration of marine environmental impact as well. An advantage of this is almost certainly the reduction of HKE evolution time towards full deployment, as environmental impacts are taken into account *during and not after* reaching the full deployment stage. The dual stresser – receptor concept introduced by Gill[12] and enhanced by Boelhart & Gill[13] for ocean renewable energy development provide an attractive starting point to integrating the environmental pillar into HKE TRL assessment.

Conclusions

The argument presented in this paper appears to be sound and feasible to implement in practice within the TRL assessment of HKE in all its variants (ocean and river). The incorporation of marine environmental considerations right from the start of the evolution of HKE projects shouls result in a significant reduction of its deployment through a reduction in the environmental licensing of such a project.

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Conflicts of Interest

None.

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