Renewable Energy 119 (2018) 309–319

Contents lists available at ScienceDirect

Renewable Energy

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

Environmental interactions of tidal lagoons: A comparison of industry perspectives

Kathryn Mackinnon [a, *], Helen C.M. Smith [b], Francesca Moore [c], Adriaan H. van der Weijde [d], Iraklis Lazakis [e]

[a] IDCORE Black & Veatch, UK
[b] University of Exeter, UK
[c] Black & Veatch, University of Hull, UK
[d] University of Edinburgh, UK
[e] University of Strathclyde, UK

ARTICLE INFO

Article history:
Received 15 February 2017
Received in revised form
31 October 2017
Accepted 22 November 2017
Available online 5 December 2017

Keywords:
Tidal lagoon
Environmental impact
Mitigation hierarchy
Tidal range energy

ABSTRACT

Tidal lagoons are an attractive renewable energy option that could aid the UK in meeting its ambitious renewable energy targets. One of the main barriers to tidal range development in the UK to date has been regulatory environmental concern. In order for the nascent lagoon industry to move forward into development, the views of the developers and other influential stakeholders such as government bodies, regulators, conservationists and practitioners (herein referred to as 'influencing stakeholders' or 'influencers') need to be aligned. This study is the first of its kind using online questionnaires and semi-structured interviews to present and compare the views of both developers and influencing stakeholders on the environmental interactions of tidal lagoons. We find that, whilst both influencers and developers are working towards the common goal of a good environmental outcome for tidal lagoons, there are mismatches in their views in terms of the priorities given to the key environmental impacts, benefits and potential solution options. The work provides insight into what is at the forefront of developers' and influencers' minds, highlighting the key themes within their views and transforming this information into policy recommendations that will help the industry's development move forward.

1. Introduction

The deployment of renewable energy is regarded as a strategy to combat climate change through the displacement of fossil fuel energy sources and therefore the reduction of carbon emissions. There have been a number of global agreements aiming to mitigate the impact of climate change, the most recent being the 2015 Paris Agreement. To date, 114 of 174 parties have signed this historic agreement and begun to adopt climate change strategies into their own national agendas [1]. Nationally, the UK has a target to provide 15% of its energy needs from renewable sources by 2020 [2]. There needs to be an increase in the rate of deployment of renewable energy in the UK if it is to achieve this target within the next 3 years. Under 'business as usual' conditions it will fail to achieve this target [3].

There are a variety of renewable energy options that the UK could deploy to meet these ambitious targets. Often overlooked is the vast amount of marine energy available around the UK coastlines, the majority of which is currently untapped. This article focuses on tidal lagoon energy as part of the marine energy sector; Fig. 1 shows a breakdown classification of marine energy and how tidal lagoons are placed within this.

Tidal range technologies harness the energy available in the rise and fall of the tides. Traditionally tidal range energy consists of tidal barrages and tidal lagoons. A tidal barrage typically extends the banks of a river or estuary, whilst a tidal lagoon forms a loop attached to one side of an estuary or is completely offshore [5]. Fig. 2 shows a basic sketch describing this difference.

Tidal range schemes, including both barrages and lagoons have a theoretical resource potential of 121 TWh/year in the UK [6]. To put this into perspective, in 2015 the UK produced 339 TWh of electricity [7]. In theory, although not necessarily in practice, tidal range

* Corresponding author.
E-mail addresses: mackinnonk@bv.com (K. Mackinnon), H.C.M.Smith@exeter.ac.uk (H.C.M. Smith), mooreF@bv.com (F. Moore), h.vanderweijde@ed.ac.uk (A.H. van der Weijde), iraklis.lazakis@strath.ac.uk (I. Lazakis).

https://doi.org/10.1016/j.renene.2017.11.066

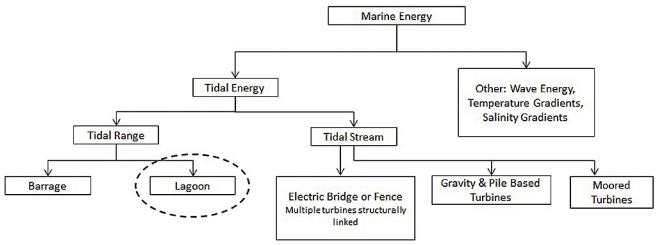

Fig. 1. Marine energy classification. Source [4].

schemes could contribute up to 36% of the UK's electricity production, with lagoons contributing 7.4pp, of that figure. Tidal Lagoon Power Ltd, one of a number of companies investigating options for tidal lagoon development, has a framework plan for the UK to develop a fleet of 6 tidal lagoons. It is estimated these could contribute 8% to the UK's total electricity supply [8].

Lagoons therefore have the potential to contribute significantly to the UK's electricity mix. They also have a number of other advantages in terms of their energy production, including a high level of predictability, the differing times of tides around the UK allowing a phase shift for continuous energy generation and a long expected life span (120 years) [9].

Despite these advantages, there is currently no energy generating tidal lagoon in the world. The main barriers to date have been a lack of serious proposals, high capital costs and environmental concerns. There is now a serious proposal, with Tidal Lagoon Power presenting the first of their tidal lagoon developments: Tidal Lagoon Swansea Bay. Swansea Bay was awarded a Development Consent Order (DCO) in June 2015 [10]. The costs of lagoons were investigated in a government commissioned review considering the overall feasibility of lagoons for the UK energy market. This review, published in December (2016), concluded that lagoons did have a cost effective role to play in the UK and recommended that a focus should be on a small pilot scheme initially with sufficient time to allow for environmental monitoring [11]. Whilst tidal lagoons have previously been presented as a more environmentally friendly alternative to barrages [12], the environmental impacts of lagoons are still a concern for the industry, as highlighted by the recent government review [11]. As such, environmental concerns are likely to present additional hurdles in the industry's future development. Consenting and licensing issues are often seen as cross cutting barriers to marine energy [13]; an example in the lagoon industry is the current delays being seen in awarding of a Marine License to the Swansea Bay Tidal lagoon.

Whilst progress has been made in identifying and estimating the potential environmental impacts of tidal range projects, such as the hydrodynamic changes [12–17], morphodynamics [18,19] and water quality [20–23], ecological interactions with society [12] and environmental interactions with each other [4], there has been little focus on the industry's view of these environmental impacts. These key environmental changes noted in the literature will have multiple associated environmental, societal and economic implications. Whilst these are too many to document here some examples include; coastal erosion or sediment deposition, increased flood risk, extensive habitat or biodiversity loss, displacement or injury to marine mammals, damage to fish populations, damage or displacement of bird populations, impacts for local marine industry and recreation, impact on underwater marine heritage and changes to local water quality including potential impacts on the water table. Mackinnon et al. (2016) [4] describes a framework to identify and further understand the complex interactions between the environmental impacts of tidal lagoons.

The tidal lagoon industry is in its infancy; there is therefore little tidal lagoon specific research to date and hence finding information through direct industry engagement is appropriate. An additional implication of the nascent lagoon industry is the lack of tidal lagoon specific environmental regulatory guidance. This could present a further issue unless clear communication between influential stakeholders such as government bodies, regulators, conservationists and practitioners (herein referred to as 'influencing stakeholders' or 'influencers') and developers is undertaken and respective views understood.

In order for the sector to move forward in a sustainable and timely way it is therefore essential that the influencer and developer perspectives on the environmental impacts of lagoons are aligned. This will reduce any potential delays in the development process and provide the best chance for future tidal lagoons to contribute positively to the environment through an effective balance of positive and negative impacts (net gain). This study is the first of its kind, analysing the differing views of influencing stakeholders and developers within the nascent lagoon industry, providing understanding of why these views arise and how awareness of them can aid with the industry's future development.

Whilst there are tidal barrage developments elsewhere in the world [24,25], the UK is making significant progress in the lagoon sector, building on its desirable resource potential and recent industry advancements. This study therefore focuses on the UK tidal lagoon industry, and as such, on associated UK developers and influencers. The paper presents an assessment and comparison of the current influencer and developer views on the environmental impacts of tidal lagoon developments in the UK. It has three initial objectives:

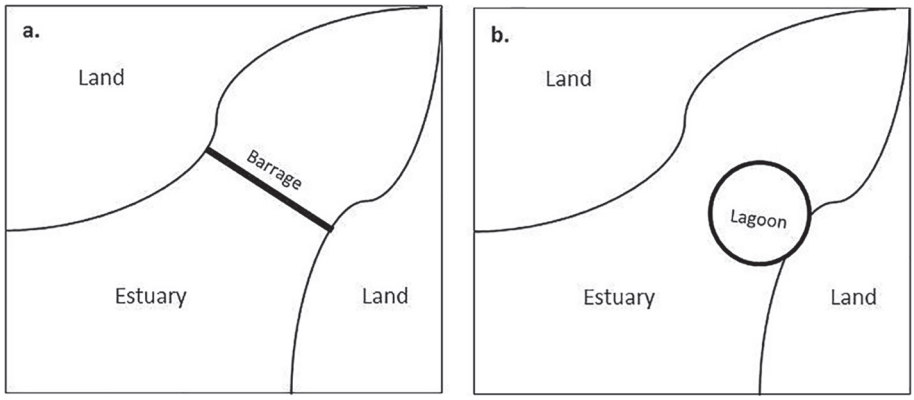

Fig. 2. Basic difference between a tidal barrage and a tidal lagoon, both of which provide tidal range energy.