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A World First: Swansea Bay Tidal lagoon in review

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ABSTRACT

Global energy focus is turning more and more towards renewable energy. With legally binding agreements requiring a drastic increase in the percentage of national energy demand created with renewable sources, tidal energy holds an important advantage – predictability. The UK is fortunate, having the greatest potential for this energy in the world, which if exploited, would be able to provide approximately 20% of the national energy demand. The most discussed tidal energy site has been the Severn estuary barrage, with repeated proposals outlined and rejected throughout the last 100 years. The reasons for this refusal were due to both high costs and environmental concerns. However, a new proposal for a tidal lagoon in Swansea Bay has been able to circumnavigate both of these downfalls by reducing both the investment needed and effects to the surrounding environment. Subject to a tidal range of 10.5 m and situated next to a largely populated city with excellent grid connections, Swansea bay is a perfect location. If the lagoon project goes ahead, it would be able to produce a rated output of 320 MW using bulb turbines, powering 155,000 homes. Being the first tidal lagoon project, what is certain is: the UK and Wales in particular are sending out a strong message regarding renewable energy and it has the whole worlds attention. This paper sets out to bring together current literature regarding the planned Swansea Bay tidal lagoon into one concise document.

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1. Introduction

By 2020, the UK is legally obliged to meet 20% of its electrical demands with renewable sources [1]. Currently, renewable sources account for as little as 5%, meaning drastic action is required to meet this target [2]. The UK is also committed to reduce CO_2 emissions by 60% by 2050 [3].

Using clean energy is not just important to help combat climate change, but also to allow the UK to have more control on its energy. With the decline of the North Sea oil and gas industry, there is more and more reliance on importing these fuels through costly negotiations. Furthermore, being in control of our energy

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sources and especially with renewable energy, the cost for electricity can be stable and independent of any price fluctuations or politics.

The UK is fortunate with an abundance of renewable energy options, including the greatest potential for tidal energy in the world. This type of energy holds an important advantage over other forms of renewable energy – predictability. With comprehensive tide data for years in advance, any tidal energy project can have a known output the national grid is able to plan for. The successful utilisation of tidal energy alone could provide in excess of 20% of the nations energy demand [4].

The repeated proposals for the Severn barrage since the 1920's have proved the necessity to evolve techniques used for tidal range generation, with each proposal turned down due to high costs and environmental concerns [5–7]. Other UK sites that have been investigated for a barrage scheme also include the Solway [8,9], Mersey [10], Loughor, Duddon, Wyre and Thames Estuaries [11]. However, unlike Swansea Bay lagoon, these projects are not currently progressing.

Currently the most advanced project in the UK is the Swansea Bay Tidal lagoon, which is making rapid progress and will hopefully be generating electricity in 2019. The power generated would be able to provide energy for approximately 155,000 homes [12]. As the project is the first of its kind in the world, its construction would send a clear statement of the UK's commitment to clean, renewable energy.

The aim of this paper is to bring together the current and existing information regarding tidal lagoon developments while focusing specifically on the planned Swansea Bay Lagoon.

2. Background/Tidal Lagoons

Tidal lagoons are a new concept based on the adaptation of an existing, proven technology – tidal barrages. Like any tidal range project the success is heavily dependant on the chosen location and with Swansea Bay being part of the Severn Estuary with the largest tidal range (10.5 m) available within the EU [13]. With easy connection to the national grid available and a largely populated city nearby, the electricity generated will be able to be utilised easily.

In the same way as a barrage, a tidal lagoon uses a man made structure to create a head difference between the flood and ebb tides. Using this head difference, water is allowed to pass through the turbines when the sluice gates are open, generating electricity. The unique aspect revolves around the size and shape of the dam – a barrage spans the entire width of a river, whereas a lagoon uses a circular shape to encompass part of it, not fully spanning the Estuary [13].

There are currently two different types of lagoon structures: offshore and onshore. An offshore lagoon is comprised of a circular dam, with the electricity transported to shore through cables below the seabed [16]. For the onshore lagoons, the dam forms a horseshoe shape, with the remainder of the circle is formed of the coastline it is attached to [17]. This will be the case for the Swansea Bay lagoon (Fig. 1).

3. Swansea Bay Lagoon

3.1. Cost

The estimated initial costs to construct the lagoon are substantial at £1bn. However, when this is compared with the £34bn required to construct a Severn barrage, this figure is much lower [19].

Fig. 1. What the Swansea Bay Lagoon will look like [15].

The project has already been backed by several large investment schemes to generate the required initial equity. Financial firms Prudential and InfraRed have each backed £100million towards the project [20,21]. This combined with several other smaller scale investor and shareholders has easily surpassed the required equity to begin the project, with the remainder provided as debt.

To make not only this project, but also other renewable energy projects profitable the government has created a variety of incentives to encourage green energy. One of these incentives is a "Feed-in Tariff Contract for Difference". This contract means that the revenue gained through selling each megawatt of electricity is topped up to an arranged 'strike price' (the amount required for the project profitable). The amount required for Swansea Bay lagoon is £168/MWh for 35 years, which is more than the amount required for wind or solar and the strike price is needed for a longer amount of time [22]. However, when the lifetime of the project is taken into account (120 years) this is approximately 5 times that of an offshore wind farm (20-25 years) and twice that of nuclear (60 years) [22]. The long lifetime of the project means it will produce very low cost electricity for years after the contract of difference has been completed.

Aside from the still large initial costs, the project is guaranteed to help not only the local economy but also the UK economy as a whole. Besides creating almost 2,000 short term and over 80 permanent jobs [15,12], there will be a substantial increase in tourism to the area, as seen in France. Over 70,000 tourists flock to visit the La Rance tidal barrage in Brittany each year [23].

Furthermore, to boost the UK economy, over 65% of capital spent on parts and construction will be contracted to UK firms, with all the generators and the majority of turbine parts all created in UK [24]. Furthermore, due to the presence of the lagoon, the effect on the Welsh Gross Value Added is estimated to be an added £76 million each year [25].

3.2. Planning and Construction

As set out in Table 1, if all goes to plan and government consent and licences are issued on time, construction will begin in the late stages of 2015 and be fully operational at the beginning of 2019 (36 months) [24]. The lagoon structure will last for at least the operational life of 120 years, be able to withstand even 500 year storms and has taken into account climate change [27]. The structure will also provide coastline protection against these storms and act as a flood defence [28].

The lagoon wall will be created out of three main materials: sand, concrete and rock [27]. Sand will be dredged from the lagoon basin area and used to fill complex geotubes. These are a low cost, durable plastic textile that is a proven technology having been used in large-scale operations in South Korea and others [29]. The