Tidal Lagoon Swansea Bay

Project introduction
Contents

- Why tidal energy? Why Swansea Bay?
- Developing Swansea Bay Tidal Lagoon
- Investigations
- Design
- Construction aspects
- The future
Energy & emissions context

UK energy sources (2011) – 88% fossil fuels, 8% nuclear, 4% renewables. 43% imported
• Only Malta and Luxembourg produce less renewable energy in Europe
• CEO of Ofgem predicts UK ‘energy crunch’ & black-outs by 2017 as power plants expire faster than they are built, nuclear build program falters, and fossil fuel prices rise (Feb ‘13)

Climate Change Act 2008 – 80% reduction in carbon dioxide emissions by 2050
• 25% reduction in energy consumption
• Transition of energy for transport and heat from fossil fuels to low carbon sources
• 100% increase in electricity generation

EU Renewables Directive 2009 – 15% of UK energy needs from renewables by 2020
• Equates to 30% of renewable electricity
• Requires investment in 30GW of renewable energy capacity
• Also requires substantial investment in gas to provide back-up
Share of renewable energies in gross final energy consumption in EU-27 countries in 2010 (in %)

- United Kingdom
UK tidal energy resource

- Island nation with largely un-tapped marine energy resource – best in Europe
- Tidal lagoons require:
  - Shallow water
  - Large tidal range
- Difference in high tide times around the UK creates potential to produce 24-hour base-load renewable electricity from a network of lagoons
- Essential part of energy mix and a new, exportable industry
Swansea Bay – opportunity overview

• **240MW tidal lagoon** generating 420GWh net annual output. Electricity for **120,000 homes** (more than Swansea’s annual domestic use)

• An extremely **reliable electricity source** offering predictable, zero carbon, electricity for 100 years. Saving over 200,000 tonnes CO₂ p.a. based on DEFRA guidelines

• **World’s first man-made lagoon** capable of generating electricity 16 hours a day using both ebb and flood tides

• An iconic **education, sports** and **art amenity**

• An opportunity to develop a **tidal range industry** for the UK, centred around Wales

• Low risk adaptation of **proven components**. Project is comprised of UK standard sand core breakwater & bulb hydro turbines mounted inside concrete turbine housings

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**Welsh Power Comparison**

<table>
<thead>
<tr>
<th>Plant Description</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alltwalis, Carm. (wind)</td>
<td>23MW</td>
</tr>
<tr>
<td>Barry Power Station (gas)</td>
<td>235MW</td>
</tr>
<tr>
<td>Gwynt y Môr (offshore wind)</td>
<td>576MW</td>
</tr>
<tr>
<td>Wylfa, Anglesey (nuclear)</td>
<td>490MW</td>
</tr>
</tbody>
</table>
Typical 48-hr lagoon operating cycle

- 48-hour sequence shows holding, sluicing & (avg. 14-hr per day) power generation periods for single lagoon with 16 turbines and 10 sluice gates
- Second & subsequent lagoon cycles would be staggered, combining to provide 24-hour base-load power
Work-to-date: EIA, viability & design

2 years of site-specific development work suggests Swansea Bay offers great potential for lagoon construction. Key work streams:

- **Hydrodynamic modelling** – multiple lagoon shapes/sizes tested for water quality, sediment transport and sand erosion/deposition impacts

- **EIA** – scope agreed with regulators, EIA nearing completion, with collaborative input from statutory consultees (including NRW and LPAs). PEIR published 4 July.

- **Energy optimisation / value engineering** – maximise energy output; reduce cost of sea wall, turbine housing, construction methods

- **Turbine design** – leading manufacturers Voith/Alstom/GE refining specifications for low-head bulb turbines

- **Grid connection** – discussions with National Grid & Western Power Distribution to identify grid connection, network capacity and timescales

- **Leasing & consents** – engagement with landowners including The Crown Estate, ABP Swansea, Swansea University, St Modwen

- **Onshore masterplanning** – maximising onshore opportunities
Summary of lagoon options considered

Installed capacity: 250MW

Annual output: 400GWh (equivalent to Swansea's annual domestic electricity use)
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wall length</td>
<td>9.5km</td>
</tr>
<tr>
<td>Area</td>
<td>11.5km²</td>
</tr>
<tr>
<td>Rated capacity (@4.5m head)</td>
<td>240MW</td>
</tr>
<tr>
<td>Annual output (net)</td>
<td>400GWh</td>
</tr>
<tr>
<td>Design life</td>
<td>50-100yrs</td>
</tr>
<tr>
<td>Height of wall</td>
<td>5-20m</td>
</tr>
<tr>
<td>Wall above low water</td>
<td>12m</td>
</tr>
<tr>
<td>Wall above high water</td>
<td>3.5m</td>
</tr>
<tr>
<td>Tidal range Neaps</td>
<td>4.1m</td>
</tr>
<tr>
<td>Tidal range Springs</td>
<td>8.5m</td>
</tr>
</tbody>
</table>

Statutory consultation (PEIR): Jul-Aug ‘13
Assessed for: energy output, costs, EIA
Investigations

- Bathymetry
- Geophysical survey
- Geotechnical investigations
Geophysical investigation
Geotechnical - Scope Phase 1 - SI

- 3 foreshore window samples/CPT
- 10 vibrocores
- 9 seabed CPT's
- 7 jack-up boreholes
Foreshore investigation

3 onshore boreholes
• Maximum penetration of 4.5m
• SPT N-value 20 – 50
• Composition – SANDS, Shells, Organic matter, Coal (port)

3 onshore CPTs
• Penetration of 10m
• Medium dense to very dense SAND
Jack-up boreholes

7 jack-up boreholes drilled from platform visible in the Bay during July
Main geological units

Key

- Yellow: Seabed Shelly Sand
- Green: Marine Clay
- Gray: Marine Silt and Sand
- Red: Peat
- Blue: Clay/Silt
- Orange: Glacial Sand and Gravel
- Blue: Glacial Clay
- Purple: Bedrock
Design

• Overview
• Bund wall
• Turbines
• Sluices
Bund construction

Lagoon wall is built using sandy materials gained from the sea bed inside the lagoon, hydraulically filled into geotextile casings known as Geotubes®. On top of these Geotubes and compact sand fill we place small rocks, and on top of this the larger rock armour.

The construction has been modelled to withstand local sea/climate conditions, and to account for sea-level change.

Geotube® systems are a product of TenCate
Construction techniques

Foundations for Incheon Bridge, Korea. The same construction technique, in conditions comparable with Swansea Bay: 9m tides on soft sea bed

1. Laying tubes on scour apron
2. Divers assisting with positioning
3. Levelling out gaps with dredge/sand
4. Laying top layer on even surface
5. Infill sand between two Geotube® structures
6. Bridge concrete foundations built on geotextile structure
Incheon Bridge, South Korea
Bund wall construction – filling Geotubes

Cutter suction dredger

The bund base will comprise Geotubes® (geotextile casings)

The Geotubes® will be laid and hydraulically filled directly from this purpose modified vessel
Swansea double-regulated bulb turbine
Latest turbine dimensioning: modifying draft tube & inlet geometry to optimise dual flow
Sluice
Sluice gate at the Rance Barrage, France
Construction aspects

- Construction sequence
- Site set-up
- Temporary structures
Construction sequence – 1st season 2015

- Construct temporary bund – team 1
- Construct western bund starting from shore and working out – team 2.
- Construct Phase 1 eastern bund starting from shore – team 2.

Installed capacity: 250MW
Annual output: 400GWh (equivalent to Swansea’s annual domestic electricity use)
Construction sequence – 2\textsuperscript{nd} season 2016

Apr to Aug 2016 construction sequence:

- Construct phase 2 of the Eastern Bund

Phase 2 of Eastern Bund
3.1 km total
Construction sequence – 3rd season 2017

Apr to Jun 2017 construction sequence:

• Remove temporary bund – team 1

• Construct final section of Eastern Bund – team 2

NB: materials from temporary bund will be used in closing the Eastern bund where possible

Installed capacity: 250MW
Annual output: 400GWh (equivalent to Swansea's annual dom. electricity use)
Construction access routes

- Sand & rock for lagoon wall construction will be transported by sea
- Rock will be stockpiled in the areas shown prior to installation on the wall.
- All materials for turbine house will be accessed via Swansea bund from the Docks
- Neath bund access used for construction plant & finishing materials.

Installed capacity: 250MW
Annual output: 400GWh (equivalent to Swansea's annual domestic electricity use)
Construction compound location
Grid connection

- Along western breakwater
- Around ABP Queens Dock, and across to Fabian Way
- Along Fabian Way in westbound verge
- Across Crumlyn Burrows SSSI in open trench
- River Neath Crossing two options:
  - In existing ducts
  - Directional drill under river
- Open trench to substation
Construction of turbine housing
Temporary bund: twin wall sheet piles
Temporary bund: twin wall sheet piles
Crane coverage for structures
A future programme of lagoons in the UK

Blackpool: 1,000MW
Colwyn Bay: 1,500MW
Swansea: 240MW
Newport: 750MW
Bridgwater: 2,000MW
Key partners

ATKINS
Design, engineering & project management

Van Oord
Marine ingenuity
Dredging, marine engineering & offshore projects

Costain
Tier one, engineering solutions providers

Tencate
Textiles technology, Geotubes®

Alstom
Turbine design & testing

Voith
Specialist in control & design of water gates

LDA Design
Masterplanning & landscape design

TI
Turbo Institut
Turbine testing and design
Thank you…