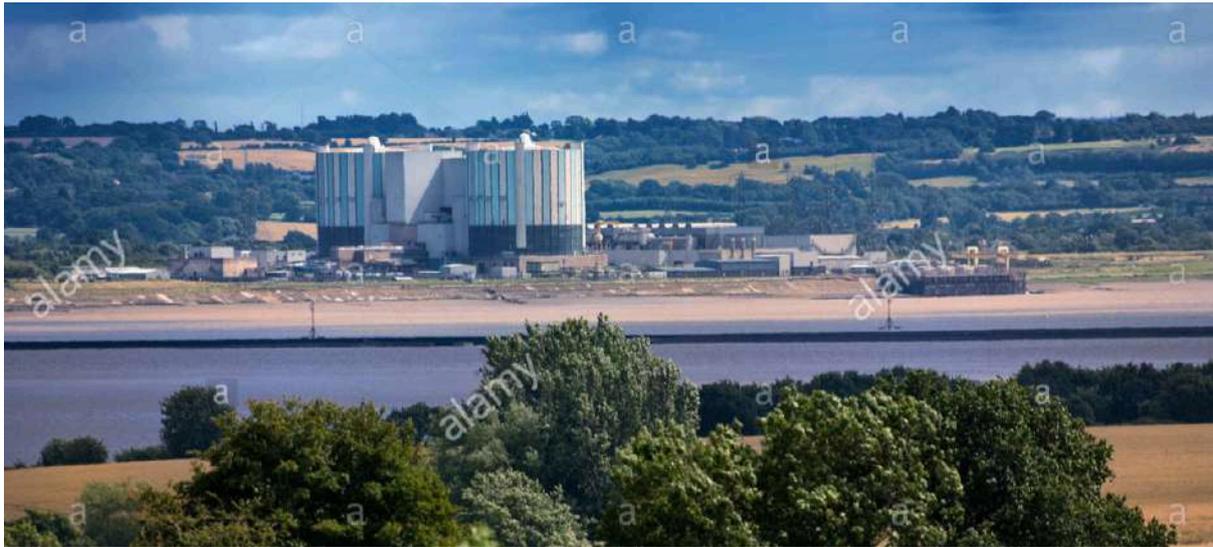


Thinkpiece

Alternatives to Swansea Bay Lagoon¹

This is not an argument against tidal power, but based on my experience, the Swansea Bay Lagoon is a tidal power project in the wrong place. I'll explain.

Firstly, a reminder that I worked for 11 years in electricity generation. In 1969, I was one of a small group of engineers working on river water cooling problems at Oldbury Nuclear Power Station which prevented us reaching full load. Oldbury NPS had a tidal lagoon² to hold up cooling water levels at low tide as it was located on the inside of a bend, away from the deep-water channel.



Oldbury NPS (now closed) The barrage wall (the dark line) is visible only for a short time at very low tide

We proved from first principles that we had a coolant flow restriction, and then carried out a depth sounder survey across the lagoon to discover the extent of the problem, and that its cause was a build-up of silt at the entrance to the cooling water pumps. We were genuinely surprised at the size of the silt build-up after only one year's operation. The station hired a dredger on a weekly, then monthly then annual contract, and eventually bought it. Although not part of the original plan, land to the west of the site was then brought into use as a dumping ground for the huge volume of silt and this is now a home to a variety of wild bird species³.

Silt can be a massive problem and is probably the strongest argument against the original proposal of a Severn Barrage from Brean Down to Penarth. The Severn carries a high silt burden acquired as it meanders down the Welsh Marches, so much so that the river authority stopped charging Oldbury NPS for river water extraction in 1967 as the quality was so poor. The silt burden decreases as one moves west down the estuary, and at Swansea

¹ <http://www.tidallagoonpower.com/projects/swansea-bay/>

² It is hard to find photos as it is only revealed at low tide. The exposed wall can be seen here <https://www.alamy.com/stock-photo-oldbury-on-severn-nuclear-power-station-gloucestershire-england-uk-24397765.html> and here <https://www.bbc.co.uk/news/av/business-17557940/rwe-and-eon-halt-uk-nuclear-plans-at-wylfa-and-oldbury>

³ https://en.wikipedia.org/wiki/Oldbury_Nuclear_Power_Station

the river silt should be sufficiently diluted to make a tidal scheme viable if properly designed.

The Swansea Bay Lagoon is often compared with the barrage across the Rance⁴ in northern Brittany, but it is very different.

Firstly – cost



The Rance Barrage. The access lock is to the left, the generators to the right

The Rance⁵ barrage has an installed capacity of 250 MW and a *proven* load factor of 28%. However, the barrage is only 700metres long and holds in an area of 22.5km² of estuary.

The Swansea Bay Lagoon is planned to have an installed capacity of 320MW, a retaining wall of 9.5km and will impound an area of 11.5km² of water. So, the ratio of barrage length to enclosed water area is 26 times greater than the Rance, hence the high capital cost of Swansea. Allowing for French price inflation, at today's prices the Rance barrage would *actually* cost £700million⁶ as compared to the *estimated* cost of Swansea Lagoon at £1.3billion.

The Swansea Bay Lagoon is anticipating a load factor of close to 60% as the proposed bulb turbines are truly reversible, being a horizontal variant of the variable pitch Kaplan design, unlike the 55 year old bulb turbines installed on the Rance, which produce very little on the flood tide⁷. Of course, if it was built today, it would use variable pitch bulb turbines and thus obtain a similar load factor to Swansea.

There is considerable confusion over some of these key issues.

For instance, the FoE report in 2004⁸ which compares the proposed Swansea Tidal Lagoon with the Severn Barrage, compares non-reversible turbines in the barrage with reversible turbines in the lagoon. There is no technical reason not to fit fully reversible turbines in a

⁴ https://en.wikipedia.org/wiki/Rance_Tidal_Power_Station

⁵ https://publications.parliament.uk/pa/cm201314/cmselect/cmenergy/194/194vw49.htm#footnote_18

⁶ *Actual* construction cost of €95million in 1965 would be €800million at 2019 prices = £700million

⁷ https://tethys.pnnl.gov/sites/default/files/publications/La_Rance_Tidal_Power_Plant_40_year_operation_feedback.pdf

⁸ https://friendsoftheearth.uk/sites/default/files/downloads/severn_barrage_lagoons.pdf

proposed Severn Barrage, which would then make the barrage competitive on price. It also uses a pessimistic 26% (rather than the 28% actually achieved at Rance) figure for the Severn barrage's load factor and an optimistic (and unproven) 62% load factor for the Swansea lagoon.

Secondly – silt

The Rance⁹ barrage has a river running through it. Furthermore, that river drains from granite hills, so the silt burden should be relatively low, and, although I can't find any stats, the silt burden in the sea off northern Brittany is visibly a little lower than in the Severn estuary at Swansea, but not dramatically so. Despite this, it has been estimated that currently 30,000 m³ of silt are being added to the Rance's marine basin each year and the water capacity has thus reduced by at least 20% since impoundment. The Rance barrage has been able to maintain its load factor despite this, largely because the enclosed area of water per installed MW is 2.5 times greater than proposed at Swansea., so there's plenty of spare capacity



The Rance Barrage – A relatively short barrage (0.7km) encloses a large estuary

In other words, based on the Rance designers' assumptions, to maintain water capacity over its proposed 120-year life, the Swansea Lagoon should really be 2.5 times bigger, and have a clean river draining into it (which it doesn't). This could result in possible load factor reduction due to silting over time, or they would have to plan for extensive dredging, which will disturb the natural ecosystem.

The potential problem of silting is a difficult area to assess, as silting is very hard to design and plan for even with the latest computer modelling, and small factors can cause big changes. To the east of the first Severn Crossing, no-one relies on underwater charts, as the sandbanks move continuously. Local knowledge and/or a depth-sounder are essential. At Oldbury the lagoon was designed in a hydraulics lab at Gloucester Polytechnic, and based on the model results, it was predicted not to silt up – but it did!

⁹ <https://tethys.pnnl.gov/annex-iv-sites/la-rance-tidal-barrage>

Thirdly - other possible barrage sites in Wales to consider

The secret of a successful, economic design is:-

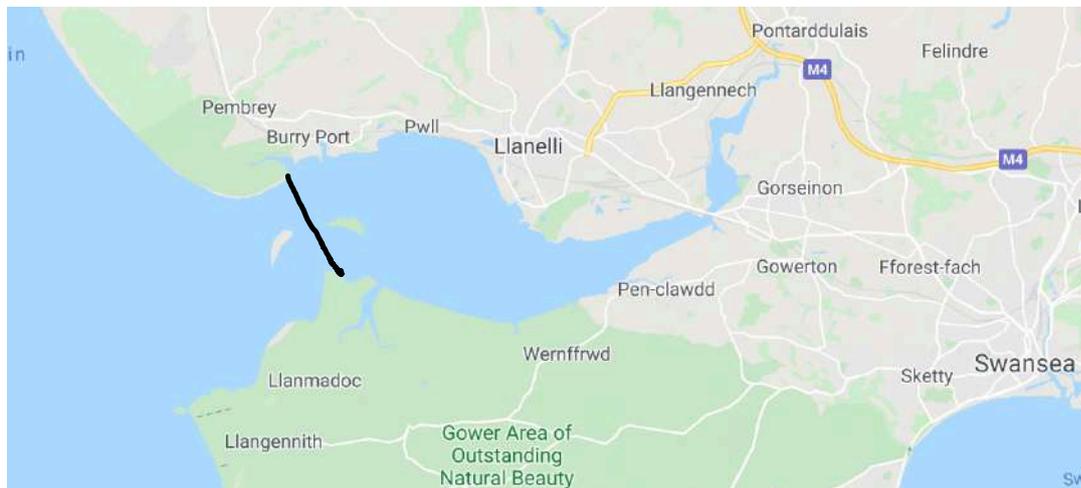
- A short barrage enclosing a large area of water
- An area free of larger shipping who could not pass easily through an access lock
- Suitable access lock for small vessels to pass through
- Low silt burden and, ideally, a river to aid flushing
- Nearby High Voltage grid connection

These are few possible sites to investigate, based on a quick look at Google Earth. Obviously, more detailed surveys of enclosed area, depth, ground conditions etc. are required.

The maximum tidal range also needs to be considered. This is 10.4m in Swansea Bay, compared to the world's highest at Fundy Bay in Canada, which is 11.8m.

Thus, the first three below appear to be attractive options:-

The mouth of the Loughor from Llanmadoc to Burry Port. 3km barrage to enclose circa 20 to 25km² of estuary. Max tidal range 9.7m



The mouth of the Towy from Twyn Point to Ginst Point. 3km barrage to enclose circa 8 to 9km² of estuary. Max tidal range 8m approx



The mouth of the Conwy at Deganwy (0.2km barrage) to enclose circa 4 to 4.5 km² of estuary. Max tidal range 8m



Other sites to consider are:-

These are less desirable because the Kaplan Bulb turbine doesn't operate as efficiently below 5m of head, and so the load factor would be less than 60%.

The mouth of the Mawddach at Barmouth. 0.2km barrage to enclose circa 4 to 5km² of estuary. Max tidal range 5.3m



The Menai Straits from Bangor to Llandegfan (0.2km barrage) and a second from Fort Belan (0.1km barrage) to enclose circa 6 to 7 km² of sea. Max tidal range 3.7m



N.B. The Menai Straits site would have to accommodate the users of the Garth Pier at Bangor, the Prince Madoc (Bangor University research vessel) at Menai Bridge, and the marina at Port Dinorwic with a sufficiently large access lock to ensure easy passage.

However, the barrages needed are very short, the water has a very low silt burden, and one of the barrages could provide the 3rd Menai crossing

All of these may not turn out to be satisfactory, of course. There are the technical considerations such as ground conditions to support the barrage foundations, river silt burden, detailed survey of the impounded water volume, tidal flows, etc.

It is also important to use well established designs. GE (General Electric)¹⁰ are the world leaders in bulb turbines with over 300 installations. Swansea Bay are proposing to use Andritz¹¹ bulb turbines. Andritz have more experience with Kaplan turbines, but less with the bulb layout. Both would be good choices.

N.B.

- The Towy and Mawddach sites don't have a nearby high voltage line, so grid connection would be more expensive
- Conwy has two well established marinas who would surely object.

¹⁰ <https://www.ge.com/renewableenergy/hydro-power/large-hydropower-solutions/hydro-turbines/bulb-turbine>

¹¹ <https://www.andritz.com/products-en/hydro/products/turbines-hydropower>

Fourthly – public policy

If you read “Old Sparky” in Private Eye, you’ll conclude the Swansea Bay Lagoon is promoted by the wrong people. The principals have already paid themselves £millions in consultancy fees from the early shareholders’ investment on top of the actual engineering design consultancy they have commissioned. They have also signed a deal for the company to buy stone from a quarry they’ve personally bought in north Cornwall. They need a vast quantity of stone for such a long barrage, and so would make considerable extra revenue for supplying this.

There again you might think effectively privatising a large slice of the seabed is not the right way forward, and in line with Labour Party policy, any tidal scheme should surely be developed and owned by the public sector.

Finally - Conclusions

Theoretically these alternatives should be cheaper to construct because they need a much shorter barrage to enclose a large area of water.

Using modern reversible turbines, all of the first three should be able to obtain over 50% load factors

We need to at least examine all these alternatives rather than plumping for, or rejecting, the one barrage “on offer”.

We need to ensure that the seabed and major utility installations remain in public ownership, either directly or via a similar mechanism to Glas Cymru, so whatever option we choose, the ownership should not be in the private sector.

Alex Bird, 23/01/20