The Severn and other Tidal Barrages

Price 40p

Some history

There is nothing new in capturing tidal power. Tide mills pre-date windmills and many were recorded in the Domesday Book. Banks were built across tidal inlets and some form of gate installed in them. Water flooded into the enclosed area or 'pound' behind the bank at high tide. It was held until the tide dropped and then allowed out through a mill race driving a waterwheel in a similar way to watermills on rivers. Records have been found of tide mills at over 200 sites. Many operated for at least 6 centuries. The site at Woodbridge, Suffolk* (see Fig. 1) was first used in 1170 AD. Commercial milling

Fig 1 Woodbridge tide mill, now a working museum. The pound was originally 15 times the present demonstration size.

continued there until 1957, a span of nearly 800 years. Tide mills gave power for about 4 hours on each tide and, though this meant the miller often worked unsocial hours, the timing of his work was at least predictable.

The situation today

Much more recently the French built a 240 Megawatt (MW) tidal power station at La Rance on the Channel coast using modern engineering technology. This has operated successfully since 1966 with a 25% utilisation rate. There are also two smaller modern barrages, a 20 MW barrage at Annapolis in the Bay of Fundy, Canada, and a 0.5 MW one in Russia. A 254 MW barrage at Sihwa Lake, Korea, should be operating this year with 2 more planned in that country and there are other potential sites around the world with several larger even than the Severn.

** Others can be found at Eling on Southampton Water, Carew Castle in Pembrokeshire, and Thorrington, Essex*

Many estuaries around the UK have large tidal ranges. The incoming Atlantic tide is funnelled up the English Channel, Bristol Channel and elsewhere and the water level rises as it does so. The Severn for example has a 14 metre tidal range at one point and, because the available energy is proportional to the square of the range, it is not surprising the Severn Estuary has been identified as the most attractive site for many years. Indeed interest was shown as early as 1849 and the first scheme was put forward in 1923. Other sites, in order of size, are the Solway Firth, Morecambe Bay, Wash, Humber, Thames, Mersey and Dee Estuaries, followed by 34 smaller ones. Plans to use tidal power in the Mersey accelerated in 2007. A barrage there would generate 1.2 TWh (Terawatt- hours)/year, only 7% the amount from a Severn Barrage, but cheaper per unit of electricity. A study of a Solway Barrage is also currently under way.

The Severn Barrage

A barrage across the Severn would dwarf others in the UK and generate over 30 times as much power as La Rance. In the '80s the Severn Tidal Power Group, formed from leading British construction and power generation groups, spent £4m to show that the Severn,

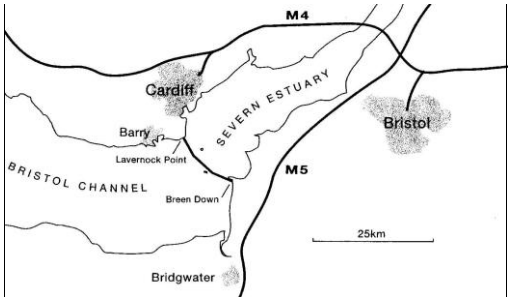

Fig 2 Location of Severn Barrage

with its large tidal range and huge estuary, could generate 8640 MW of electricity at peak and 17 TWh of electricity a year. This is equivalent to an average of 2000 MW or about 4% of total UK electricity demand now. The barrage would have been built from Lavernock Point near Cardiff to about 1 km W. of Brean Down, Weston-s-Mare (see Fig 2). Such a barrage would be 16 km long and take 7 years to build. The £10bn estimated cost in 1989 has doubled now, though the present cost includes £3.9bn compensation to re-create lost

An ALDES Briefing Note

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This note arises from a meeting at the Liberal Democrat Spring Conference in 1997 at Cardiff. The speakers were Rowland Morgan, lecturer in Civil Engineering at Bristol University and Duncan Huggett, RSPB. Subsequent notes include developments since that time. ALDES welcomes comments which should be sent to Richard Balmer, email: richardbalmer162@btinternet.com

environment including bird feeding grounds. The cost of electricity depends on the interest rate and other factors but would be at least double the cost of onshore wind. It would look more attractive if the economic benefits from recreational opportunities, such as sailing and tourism, and from a new road and or rail crossing of the estuary, are included in the figures.

The proposers expected power generation for about 5 hours twice a day on the ebb tide. Because tide times vary, the maximum power would not usually coincide with peak demand, but some juggling would be possible to increase peak output at the expense of total electricity produced by using the reservoir for 'pumped storage'.

An important advantage of tidal power is that it is *predictable*. Electricity from wind, wave and solar energy is unpredictable and fossil fuel stations have to be on permanent standby for when output drops.

The Objections

There are a number of problems however. First, the project would commit a large fraction of the UK heavy construction industry. Indeed, when it looked like receiving the green light in 1989, it was competing with construction of the Chunnel - and the Chunnel won. Second, huge quantities of rock, stone and sand would be required though, rather than clog the roads, it is likely they would come by ship from quarries in North Wales or even Scotland. Third, there would be loss of farmland due to flooding, though elsewhere there would be gains and more protection against exceptional floods. Fourth, there would be problems with effluent from existing sewage works which would require either more expensive treatment or re-routing downstream. Fifth, locks would be needed for shipping but, due to these and the slow speed of the turbine blades, it is thought fish movements would not be badly affected. Sixth, there would be drastic changes to the nature of the estuary, especially to the area of tidal mud flats.

The Natural Habitat

The coastline of the UK is of international wildlife importance. There are 130 important coastal areas, over half in estuaries, with the Severn especially important. Estuary mud flats provide ideal feeding grounds for a wide range of bird species. The barrage would massively reduce the feeding area. It would also reduce sediment flows and velocity so reducing the quantity and type of food especially shellfish. It is feared the estuary would support substantially fewer birds with particular species threatened, though it is very difficult to know how badly and whether or not there would be compensating gains. The experience at La Rance is interesting. The natural habitat was devastated by construction but slowly recovered over the years and is now at least as rich as before.

Other Impacts

Construction would provide an estimated 200,000 man years of work but also disturbance. Recreational opportunities would increase, but so would local traffic. Interestingly the barrage will change the Atlantic tidal regime and have effects on other coastlines. It has been calculated, for example, that a new barrage in the Bay of Fundy, Canada, half the size of the Severn, could raise high tides by 15-20 cm as far away as Boston, USA.

Recent studies

In mid 2006 the Welsh Assembly sought to revive consideration of the Barrage though their support has wavered since. In the May 2007 Energy Review, the then government said it wanted to 'look again' at the Severn and other tidal power options. In July 2008 it began studying 10 different Severn schemes: 6 barrages, 2 lagoons, a 'fence' and a 'reef'.

The 6 barrages included the 1989 one from Brean Down to Lavernock Point (now more usually known as Cardiff/Weston) and 2 variants. One would have run to Hinckley instead of Brean Down and, though longer, would provide extra flood defence and end closer to major grid connections. The other would have been enhanced with major recreational developments upstream and a wave farm downstream. The 4th barrage was further downstream running from Minehead to Aberthaw. The tidal head would have been less but the volume of stored water much greater. Turbine capacity would have increased to 14,800 MW and output to 25 TWh/y. The 5th and 6th barrages were above and below the Wye confluence: the Shoots barrage would generate 2.77 TWh/y, Beachley 1.67 TWh/y. The 'fence' would have sat within a Cardiff/Weston barrage and generate electricity by accelerating the river flow through piers. The environmental impact would have been less but also the electricity generated, about 3.5 TWh/y. This was true of the 'reef' which would be a kind of 2 way weir with turbines mounted on the top.

Lagoons?

Conscious of the environmental disadvantages of a barrage a company called Tidal Electric Limited (TEL) proposed a 60 MW 'tidal lagoon' in Swansea Bay. The lagoon would have been 5 km^2 in area formed by an enclosed wall of rock out in the estuary. It would be filled and emptied in the same way as the barrage through turbines in the walls. FoE unwisely leapt on this idea and advocated an estuary *full* of lagoons away from the food supplying tidal flats, with a total length of walls almost 10 times greater (95 miles compared to 9.8 for the Barrage) and a total area of 115 sq miles (compared to 185 for the Barrage). They overlooked the fact that as the estuary became blocked, currents would accelerate causing serious scour and creating mayhem for

navigation. TEL had advanced very low cost figures and FoE claimed their lagoons could produce one third more electricity than a Barrage at less than half the cost. A review of the Swansea scheme by international engineers WS Atkins found TEL had under estimated their costs by a factor of 3 and over-estimated output by at least 50%, increasing the unit cost of electricity by almost 5 times! The July 2008 study considered D-shaped lagoons extending from the river banks covering the Welsh Grounds (also known as the Fleming Lagoon) and/or one enclosing Bridgewater Bay. The lagoon walls would avoid the deepest water and so be cheaper but a tidal flat area would be lost.

The outer barrage, fence, reef and the 2 Cardiff-Weston variants were dropped at the interim review in January 2009 leaving the 5 variants below. The outer barrage was too large and the untested fence and reef technology too risky for such a large project. The consultation stage ended on 23rd April 2009 but the waters were muddied again by an invitation for proposals of 'embryonic' technologies of 2 designs of fence and a low head barrage or reef. It seemed the then government thought that if none of the 5 'realistic' options gained enough support, a reef or fence might be reconsidered in the distant future after a smaller installation had been made to work elsewhere. Detailed work on the 5 alternatives continued until Autumn 2010 when the coalition government announced no Severn scheme would

Option	Type	MW	TWh/ year	Cost £bn	Cost £/MWh
Cardiff-Weston	Barrage	8640	16.8	20.9	127
Bridgewater Bay	Lagoon	1360	2.6	3.8	142
Fleming	Lagoon	1360	2.3	4	183
Shoots	Barrage	1050	2.7	3.2	104
Beachley	Barrage	620	1.6	2.3	137

receive government support.

Conclusion

There was a strong argument that if the Severn Estuary's environment was to be compromised one might as well get the most green energy one could from it. In this case the Cardiff-Weston barrage would have been chosen.

Two other factors almost certainly influenced the coalition's decision. The outer barrage had been rejected because it was *too big*. At peak it would have generated a *third* of UK average demand. 14,800 MW of fossil fuel stations would have had to be switched in and out for a few hours twice each day. Grid connections from the Bristol area would have needed heavy reinforcement. The consequences of this single 14,800 MW source going down without warning would have been alarming.

The same problem affected the Cardiff-Weston barrage. It is true power stations are already switched in and out all the time but a Cardiff-Weston barrage would have at least doubled the 'ramping' rates accommodated now. The study engineers were considering locating high energy using industries in the area and would have wanted to find another pumped storage site like Dinorwig. Some 14,000 MWh of storage would have been needed - not easy to find. Dinorwig has only 9000 MWh capacity and represented a huge investment when built. One alternative which gained favour was to generate on both ebb and flow tides. Total electricity would reduce by 10-15% (one loses electricity at both high and low water as the relative levels in estuary and reservoir 'turn round') but some electricity would be available for much longer, about 70% rather than 35% of the time.

The second problem was that once started the Severn Barrage could not be stopped if costs start escalating. One cannot leave half a barrage in an estuary. Tidal power is superior to offshore wind, the only sizeable green alternative, because it is predictable, but wind turbines are installed one at a time and programmes stopped overnight if problems arise. Nevertheless cancellation remains disappointing. Offshore wind is getting more expensive as the shallow, close, offshore sites are taken up. The capital cost of the Thames Array, for example has risen to £3M/installed MW (Cardiff-Weston would be £2.4M/MW). Though utilisation of the barrage would be less (c. 22% cf. 28%) one knows when the electricity will be there and, at 100 years, it would last at least 4 times as long.

In November 2006 ALDES recommended to the party's Climate Change working group that the Barrage be constructed. Since then nuclear energy, which is equally reliable and much cheaper, has returned to favour and it has to be admitted that barrages are an expensive way to increase renewable electricity and, like most renewable sources, have environmental disadvantages. The position might change if a smaller barrage, for example on the Mersey or Solway, was constructed first.

The coalition's decision does not entirely preclude a Severn Barrage: there is nothing to stop the private sector putting in a planning application either for Cardiff-Weston or one or both lagoons and/or one of the small barrages, though this is unlikely.

Lastly we might note with sadness that if a Severn Barrage had been given the go ahead in 1989 the Barrage would have been completed by 2000 and been generating green electricity ever since.