3rd Generation Tidal Turbines:
too efficient to ignore?

Stuart Ballard
stuart@saveoursevern.org

01285 657188
07768 733005

www.saveoursevern.org

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Introduction

Tidal energy is potentially one of the UK's major sources of renewable energy. As yet, the resource is untapped and the technology still in its infancy. Two major challenges still need to be overcome.

First, there is the purely technical challenge of extracting worthwhile amounts of energy from estuaries in a cost-effective, renewable way. Second, there is the environmental challenge. Can tidal energy be harvested without paying an unacceptably high environmental price?

Emerging tidal turbine technology suggests that it will be feasible to harvest significant amounts of tidal energy – cost-effectively – from the UK's major river estuaries, without the need for hugely expensive and environmentally catastrophic barrage schemes.

In the following report, SOS considers the potential advantages associated with the third generation tidal turbines. To highlight this potential, we look closely at one example – the MREV turbine currently being developed at Exeter University with funding support from BERR (Department for Business Enterprise and Regulatory Reform).

Neptune Renewables' Proteus device is another example of this state-of-the-art tidal power technology.

The reports look at the suitability of third generation turbines for deployment in the Severn Estuary/Bristol Channel (and beyond). And it looks at whether this new generation of tidal turbine should feature in the ongoing feasibility study on tidal energy extraction in the Severn Estuary, being conducted by DECC (Department of Energy and Climate Change).

What is 3rd generation tidal turbine technology?

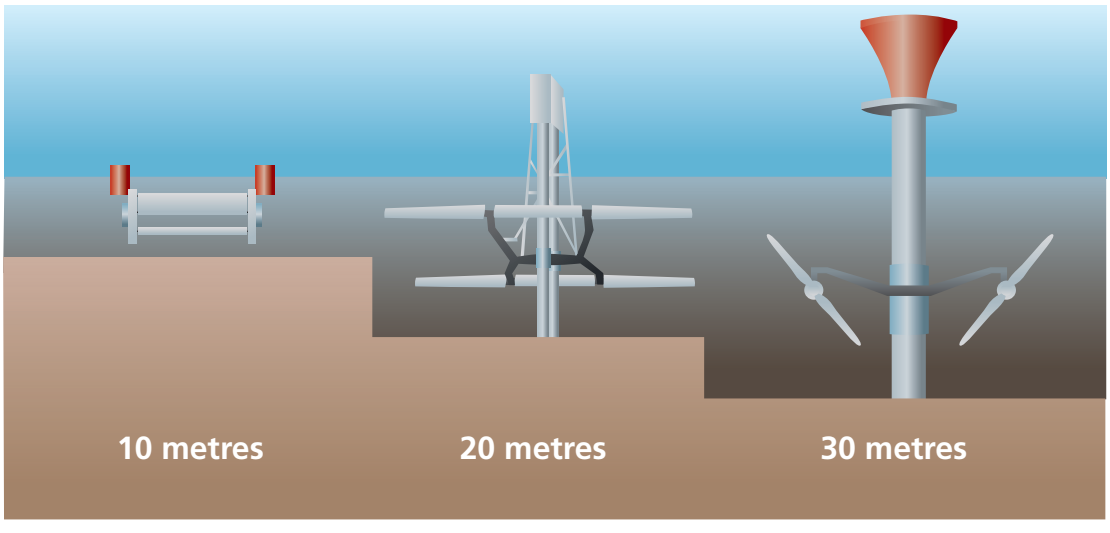
'Conventional' tidal turbines are of a propeller-based design – similar to a wind turbine – where energy is derived from lift alone. They require a minimum water depth of around 20 to 30m and a relatively high tidal current velocity. Typical efficiency levels are in the 25-35% range – low because of lack of drag utilisation in the turbine. Even so, they offer real potential to tap tidal energy in larger river estuaries without the need for barrage construction.

As an example of 3rd generation technology – the MRev Estuarine Turbine – developed by engineers at Exeter University in the UK, is a 3-dimensional device. Providing a much greater surface area for tidal energy extraction, the turbine taps energy from both lift and drag forces. This makes it far more efficient than the propeller-based design. Typically, it has achieved *minimum* efficiencies of around 55% in lab tests. Its small physical footprint, relative to its power output, makes it ideally suited for tidal energy extraction on a large scale.

Another tidal power pioneer, Neptune Renewables, are developing a 3rd generation tidal power device called the Proteus. This looks to have similar advantages.

There's no doubt: tidal turbine technology in the UK is entering an exciting phase. It has the potential to provide large amounts of green power and green jobs – without the environmental damage associated with barrage construction.

Fig 1: minimum operating depths of the different tidal power technologies



What is the potential for power generation?

Based on extensive wind tunnel and water flow trials, the power output potential of the 3rd generation MRev Turbine is very impressive.

Given that this technology now opens up much of the Severn Estuary's shallower (i.e. sub-20 metre) sites, the potential in enormous. It is estimated that this design will allow energy extraction of at least 80MW per sq km with an installed cost in the region of £2 million per megawatt.

This represents a massive leap forward in tidal energy extraction and simply cannot be ignored – especially when the environmental impact of the MRev Turbine is so small.

This exceptionally high output figure also underlines just how out-of-date the parameters of the tidal power debate have become. A 2007 report by AEA (commissioned by the Sustainable Development Commission) stated that "most tidal energy concepts currently under development require a minimum water depth of 30m and a mean spring peak velocity of more than 2.5 m/sec". The MRev turbine can work at much lower depths and lower velocities than this, making these parameters obsolete. It also means large, previously non-viable areas of the Severn Estuary/Bristol Channel can now be considered for tidal energy 'farming'.

The technology could be easily deployed around the rest of the UK and the world. Because of the wider range of conditions in which the turbine can generate power successfully, the potential contribution to reducing carbon emissions – nationally and globally – is very big indeed.

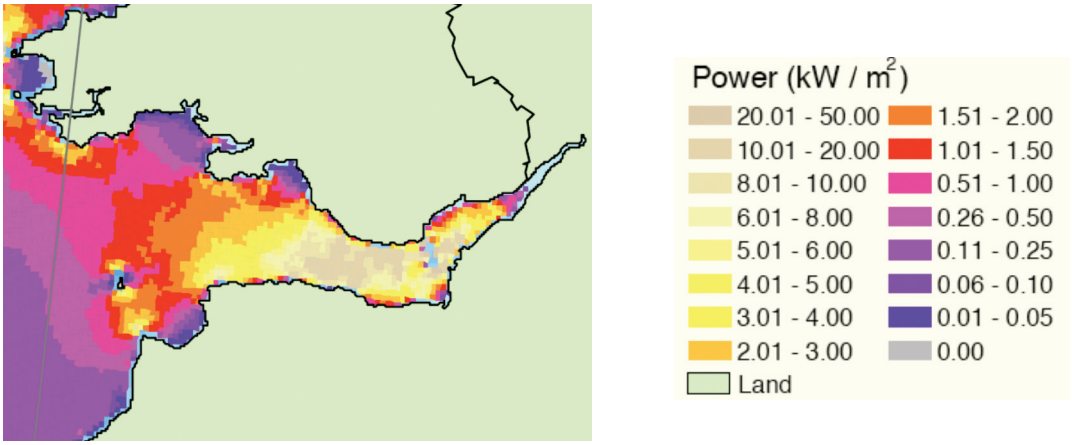


Fig 2: Energy available in the Severn Estuary

What are the advantages of 3rd generation tidal turbines?

It can work at a shallow depth
Unlike the propeller-based design, the 3rd Generation MRev turbine can work at shallow depths (minimum 10m), making it feasible in areas of the Severn Estuary/ Bristol Channel where the tall propeller turbine could not be deployed.

It can work at lower tidal current velocities
The turbine's efficiency is maintained even at lower tidal current velocities. Again, this increases the number of possible sites were the turbines could be deployed – not only in the Severn Estuary/Bristol Channel, but in other UK estuaries and offshore locations.

It will work on the flow and the ebb
The MRev turbines can generate power on the incoming and outgoing tide without active control, making it better able to supply electricity during peak demand periods. Barrages only work on the ebb.

It's a flexible, modular design
The MRev turbine can be deployed in any shape or size to suit the location. It can be tall and thin or short and wide as required, without affecting the efficiency of energy extraction. This means turbine arrays can be easily tailored to a particular location, taking account of variables such as depth profiles, differences in tidal flow speeds and the need to keep shipping lanes clear.

It's a low footprint, high output technology
The MRev design produces higher output from a smaller device – compared to conventional tidal turbines. Its smaller footprint, combined with greater efficiency, creates the potential for very high energy yields for any given area of the Severn Estuary/Bristol Channel.

It's a low cost technology
The ingenuity of the MRev tidal turbine lies in its design, not the materials – mainly steel – required to produce it. This means relatively low infrastructure costs for every unit of energy produced. It also has a spin-off benefit – a boost for UK steel makers.

It can be deployed incrementally
One of the biggest advantages of the MRev turbine is its ability to be deployed incrementally. Turbine arrays could be piloted on a small scale, with activity scaled up over time. Ongoing research could be used to optimise long-term energy yields while minimising environmental effects. No barrage proposal can offer this – if a barrage fails, it will be a catastrophic failure and a truly spectacular waste of taxpayer's money.

Fast payback
The flexibility of the technology and ease of installation means turbines will start paying back from the very first module deployment. Costed over the 10-15 years it would take to build a barrage, this represents an enormous saving and much faster payback for taxpayers and/or investors.

No barrage solution can be deployed incrementally. There's no scope for a toe in the water approach. If a barrage fails, it will be a catastrophic failure and a truly spectacular waste of taxpayer's money.

Environmental impact

Compared to the unacceptably high environmental cost of barrage proposals for the Severn Estuary, the environmental impact of the 3rd generation tidal turbine is likely to be very small.

The risk to fish and other marine life
Because the 3G turbine operates at a relatively low speed and has large gaps between its blades, the impact on fish is predicted to be less than the propeller-based turbines and the proposed barrage turbines – both of which have dangerously high tip speeds. This is an area requiring further research. We applaud the willingness of the turbine's developers to work closely with the Environment Agency on detailed fish impact studies.

The risk to birds
This is likely to be minimal. The main effect is likely to be associated with any reduction in the tidal reach of the Severn and its effect on habitats – see below. Blocking the river with any barrage would remove precious habitats for thousands of migrating birds. It would also flout European environmental protection laws. The Severn Estuary is one of Europe's most environmentally sensitive areas, protected by SAC, SPA, Ramsar and SSSI designations.*

Tidal reach
Any tapping of tidal energy in an estuary is likely to lead to some reduction in the tidal reach. However, as the third generation turbines do not block the river (in the way a barrage would), it is believed that this technology would leave a very large part of the river system in tact. The turbine's developers have expressed a willingness to work closely with the Environment Agency on producing estimates for the effect on tidal reach.

The Severn Estuary, a unique and fertile habitat that does not need to be sacrificed.

*SAC = Special Area of Conservation, SPA = Special Protection Area, Ramsar = wetlands of international importance, SSSI = Site of Special Scientific Interest

Silt

One of the biggest technical hurdles that barrage proponents have yet to overcome is that of silting. No barrage proposal has satisfactorily addressed the likelihood that, if dammed by a barrage, the Severn would silt up very quickly.

Unlike the non-silty La Rance Estuary in Brittany, the Severn Estuary carries huge volumes of silt. Being slowed down – or stopped – will reduce its ability to hold it in suspension. Severe silting will seriously compromise the operational efficiency of barrage turbines in a relatively short space of time. Most barrage modelling has not factored in silting effects – making the claimed power output figures and the 100-year lifespan very suspect. The site of the Shoots Barrage would be particularly vulnerable to silting.

The catastrophic and rapid silting of the Petitcodiac River in Canada – following causeway construction – underlines the need to take the silt issue very seriously.

As the MRev Turbine is likely to have a much smaller effect on the speed of the river, the silting effects should be correspondingly smaller. Moreover, because turbine arrays are moorable (i.e. moveable), this would allow tidal energy farming to be fully optimised to account for the natural shift of sediment and flow paths over time.

Gloucester Harbour Trustees

The problem of silt in the Severn Estuary - Sharpness Docks.

Wider economic benefits: green jobs and exports

Third generation tidal turbine technology could fuel major economic growth and create thousands of new jobs in the sustainable energy sector and related industries. If developed on a large scale, the following economic benefits could accrue:

- A major UK-based manufacturing operation
- A world-leading R&D centre for third generation tidal turbines
- The creation of specialist management, servicing and maintenance teams around the UK and overseas
- Increased demand for ancillary marine services
- Increased demand for UK-produced steel
- A big boost for UK jobs directly and indirectly
- Huge export potential

The barrage does have the potential to create jobs in the short term. However, the bulk of these jobs will disappear when construction is complete. A barrage would make little or no contribution to enhancing and developing our engineering and manufacturing sector.

Conversely, the development of tidal turbines in the UK represents a real opportunity to create a long-term manufacturing base with incredible export potential. These particular turbines represent the edge the UK has over international technology.

In particular, Aquascientific's design makes containerisation of turbines a real possibility for the first time. Turbines could be manufactured in the UK and shipped by sea, road and rail to be unpacked and deployed anywhere in the world. Bristol and South Wales are both perfectly placed to provide this very workforce and knowhow, as well has providing port facilities to service its export potential.

Globally, the export potential for tidal turbines is huge. With the right support, tidal turbines developed and manufactured right here in the UK, could play a major part in generating much-needed export earnings – as well as reducing global reliance on fossil fuels.

The role of the UK Government

Aquascientific, the developers of the MRev turbine, have already won various prestigious awards including a highly competitive award from the Royal Society. More importantly, BERR (Department of Business Enterprise and Regulatory Reform) and the Technology Strategy Board have funded Aquascientific to the tune of £250,000 for an Estuarine demonstrator. SOS applauds BERR for this support.

Now beyond proof-of-concept stage – and with patent protection – the MRev turbine will shortly undergo testing in the Exe Estuary. Fasttrack plans for a pilot site on the Severn could be implemented within 3 years. Another tidal power pioneer – Yorkshire-based Neptune Renewables – is also developing a 3rd generation tidal power device called the Proteus which is nearing full scale deployment stage on the Humber.

But for this to happen, The Department of Energy and Climate Change (DECC) must embrace the third generation tidal turbine concept. And it must recognise that the turbine has a role to play in tidal energy extraction – in the Severn Estuary and beyond.

Given that this is a UK Government-sponsored research project, surely their own feasibility study should include 3rd generation tidal turbine technology? To fail to do so would not just undermine the good work and foresight of BERR. It would miss a golden opportunity to create a truly renewable energy source on the Severn that doesn't jeopardise its unique natural habitats.

Third generation tidal turbines, exploiting lift and drag forces, will play a significant part in renewable energy generation – globally – over the next decade. If the UK is to be a major player in tidal energy extraction, the UK Government must give every support to the technology now.

Conclusion/summary

- The potential power output of the third generation MRev Tidal Turbine could meet or even exceed that of a barrage proposal.
- The cost per kilowatt produced would be significantly less than any barrage proposal.
- The technology opens up vast new areas of the Severn Estuary/Bristol Channel (and elsewhere) that could produce tidal energy cost-effectively
- 3rd generation tidal turbine energy farms could be producing output (and returns for investors/taxpayers) within a few years
- The likely environmental impact is relatively small
- The use of tidal turbines is unlikely to cause large-scale silting of the kind experienced on the Petitcodiac in Canada – no Severn barrage proposal has satisfactorily addressed the silt risk
- If deployed on a commercial scale, the 3rd generation Tidal Turbine would provide a major boost for UK jobs and exports, directly and indirectly
- DECC (Department of Energy and Climate Change) should build on the good work of BERR and recognise the contribution that 3rd generation tidal turbines can make to the extraction of tidal energy in the Severn Estuary/Bristol Channel – as well as its potential to reduce carbon emissions globally
- DECC should include 3rd generation tidal turbine technology in its tidal power feasibility study

SOS verdict:
Third generation tidal turbine are too efficient to exclude from the Government's Severn tidal power feasibility study. It is the only technology which combines high power output potential with low environmental impact.

Useful links

3rd generation tidal stream turbines: www.aquascientific.com and www.neptunerenewables.com

News on tidal power technology: www.tidaltoday.com

Public consultation (first phase closes 23rd April 2009)
http://severntidalpowerconsultation.decc.gov.uk/