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Moon Power

An outlook on the ebb and flood of the tidal energy sector

Authored by:
Dr. Steve Freeman
Daniel Pearson
Gareth Lewis

Introduction

The renewable energy sector has become a critical element in the global transition to a low-carbon economy, and continues to outperform year on year[1]. Moreover, according to the McKinsey Global Institute (2013), renewable power is a 'disruptive technology' that will transform life, business, and the global economy because "it holds a simple but tantalizing promise: an endless source of power to drive the machinery of modern life without stripping resources from the earth; contributing to pollution and climate change"[2]. Yet, such advances in technology can only come about through significant financial investment in research and development, which typically remain in a nascent form until they reach a certain critical mass and momentum (often over decades).

The commercial exploitation of 'moon power' or electricity generated power from the tides, albeit nascent, is now becoming a reality[3]. Over the past decade private and public sector investment for this new energy asset class has resulted in the successful deployment of multiple, megawatt devices and more recently, a consolidation of both technology philosophy and businesses. Both of these aspects demonstrate that the tidal sector is maturing and could be on the cusp of commerciality. Making commercial-grade renewable low-carbon electricity from this predictable commodity has to be a positive signal to investors.

Evidence of this growing confidence in the sector was the financial close of the MeyGen demonstration array (£51million, 6MW) in August 2014. First electricity generation for this project is scheduled for summer 2016 and although it may be harsh to suggest that the sector is in stasis until this is achieved, we think it is fair to say that investments of a similar size from similar sources are not expected to be made until this time.

Currently the UK has been the global pioneer in providing the leadership and belief that the sector can deliver on its promises, but a great deal of political and financial capital has been utilised to get to this stage[4]. Whilst devolved administrations within the UK are not wavering in their support, Westminster is clearly pushing the sector to attract European Union and private sector investment before it makes any further direct capital assistance.

Other countries who currently have tidal resources and who have made positive strides to encouraging the sector to develop are France, Canada and to a limited extent, China; all of whom have a similar driver to see the sector flourish. Ultimately, the establishment of exportable products (be them services or technology) and the creation of organic, home-grown employment would signal ascendance to a fully commercialised sector.

The allure of tidal range technology and its wider deployment after La Rance tidal power plant has been elusive. Primarily because of the significant upfront capital costs and

1. *See future energy scenarios by The International Energy Agency (2014). World Energy Outlook. OECD/IEA publication.*
2. *Manyika, J., Chui, M., Bughin, J., Dobbs, R., Bisson, P., and Marrs, A. (2013). Disruptive technologies: Advances that will transform life, business, and the global economy. McKinsey Global Institute.*
3. *See a review by Bahaj (2015). Marine current energy conversion: the dawn of a new era in electricity production. Phil Trans R Soc A 371: 20120500.*
4. *Bradley, S. (2015). Tidal Energy: Insights into Tidal Stream energy. Report by the Energy Technologies Institute.*

difficulty in assessing how the technology will affect the local, and in some cases, wider environment (e.g., development of dykes and embankments). These can have ecological implications that are associated with enclosures or impoundment, and can introduce widespread and substantial changes to the local habitats particularly within the inter-tidal zone. Unlike tidal stream, it is clear that the technical challenges do not require the level of proving. Moreover, the positive progression of the Swansea Bay tidal lagoon initiative has demonstrated that private finance is more than willing to invest in this class of technology.

Despite the engineering challenges associated with the efficiency of capturing energy from tidal power and the need to survive difficult environmental conditions, future design needs to consider impacts on marine life and other marine users (e.g., shipping, fishing industry). However, the evidence-base to date for understanding the potential environmental impacts of commercial scale deployments can only be extrapolated from existing knowledge (i.e. predominately from demonstration scale projects). A lack of certainty in future environmental impacts can place potentially disproportionate risks on a project from a consenting and monitoring perspective[5]. Scotland lead the way in this regard by advocating a deploy-and-monitor ethos that ensures projects can progress.

5. *Freeman, S. M. (2014) Building consensus: understanding the impacts of wave and tidal energy on wildlife. Realpower. 35:p36-39., and Freeman, S. M., Hawkins, K. R., Kirby, A. D., McCall, R. A., Blyth-Skyrme, R., and Edhouse, E. (2013) Wave & Tidal Consenting Position Paper Series: Paper Two: Fish and Shellfish Ecology Impacts. RenewableUK, Scottish Renewables and Natural Environment Research Council.*

Convergence

During the early years of the tidal energy industry, small entrepreneurial companies dominated, but in the last five years the industry has matured significantly. In part, having transitioned through a period of rapid expansion from small-scale prototype devices to full-scale early commercial arrays. Each device providing innovative designs with a bias towards vertical or horizontal axis turbine technologies. Nowadays, developers are installing full scale devices that are converging on horizontal axis turbines. This convergence in design signifies a common platform and allows for mass scale deployment which in turn will result in a lower cost of energy. This said, implications on marine wildlife and socio-economics in the area(s) of this mass deployment will need to be greatly monitored and understood such that governments and the private sector alike can continue to maintain their support during the ramp up to commerciality.

Future promise

Whilst the focus has been on the multi 100MW trajectory, an emerging technology class of small or microscale devices (<0.5MW) is rapidly demonstrating that a space exists in the market for its deployment. These have a potentially more diverse role to play in near-shore and estuarine tidal energy environments. Moreover, they provide lower project risks, comparatively small financial investment needs, faster deployment and easier maintenance protocols to some of their larger cousins. An exception is the Minesto Kite Delta wing (>0.5MW device), which is designed to operate in deep water with low tidal currents. Either way, technologies that are small and so potentially more 'agile', may provide the versatility that may be more in tune with local community needs and embedded generation for local industries.

A new avenue for tidal power is the use of hybrid forms of tidal range technologies to promote ecological improvement and important socio-economic benefits besides renewable energy (e.g., Sihwa barrage, Grevelingen Lake and the Bristol Channel). In these cases, flood defence, improved environmental and ecological water quality, fisheries and tourism, which could also reduce upfront costs. Furthermore, current and future hybrids are combining tidal range and tidal stream power generation, so called 'dynamic tidal power'. However, full-scale prototypes have yet to be tested or demonstrated[6].

Other future innovation is seeking to deploy tidal stream technologies that harvest ocean currents (e.g., the Agulhas current) as they provide unidirectional and generally slower but more continuous power. These conditions can allow technology to take advantage of high capacity factors. However, ocean currents tend to be located in deep water and far offshore, which have implications for the cost of installation, power export and access for on-going maintenance. By contrast, near-constant and unidirectional water flow have been exploited in rivers and non-tidal estuaries through hydropower schemes. Whilst riverine schemes are not strictly tidal energy, the resource types are complementary to tidal range and tidal stream, and so offer opportunities for knowledge transfer.

6. *See Mofor, L., Goldsmith, J., and Jones, F (2014). Ocean Energy: Technology readiness, patents, deployment status and outlook. IRENA.*

Lowering costs

In many cases, tidal power is associated with remote islands where resources are abundant but, ironically, where the barriers to success are often the greatest. These can include proximity to grid, port infrastructure, stakeholder buy-in and demands for energy. Pentland Firth and Orkney Islands, for example, have provided significant technology advances but these have been costly.

Given tidal power has yet to achieve cost parity with other established renewable energy sources, the industry is likely to follow a similar cost-reduction pathway to that of wind[7]. This will ensure projects remain commercially viable in the long run and in turn shape the nature of future technology innovation. Evidence already shows cost estimates are projected to decrease with deployment, although cost reduction is not just about energy generation[8]. Other challenges include integration (e.g., grid and interconnectors), energy storage, efficiency, deployment and operation, which all require continuous innovation[9]. Cost reduction will also require coordinated investment in supply chain innovation and greater certainty in understanding environmental and socio-economic impacts of largescale deployment.

It is estimated that costs for both tidal range and tidal stream technologies can fall by up

7. *Atlantis (2014). Atlantis Resources. Placing & Admission to AIM.*
8. *See UKERC & ETI (2014). Marine Energy Technology Roadmap 2014. UKERC UK Energy Research Centre., and Mofor, L., Goldsmith, J., and Jones, F (2014). Ocean Energy: Technology readiness, patents, deployment status and outlook. IRENA.*
9. *See technology innovations by Regen SW (2013). Future Technology Development to Meet the Cost of Energy Challenge: A summary report from the 5th Bristol Tidal Energy Forum, and Strategic Initiative for Ocean Energy (2013). Ocean Energy: Cost of Energy and Cost Reduction Opportunities.*

to 40% in cases where they are combined and integrated in the design and construction of existing or new infrastructure. Although by the same token, additional operational costs may be realised due to the control, monitoring and management of the ecological status for those environments impacted. In this regard, new infrastructure of flood defences, coastal restructuring, bridges and roads may offer opportunities to advance tidal energy technologies[10].

10. *See Mofor, L., Goldsmith, J., and Jones, F (2014). Ocean Energy: Technology readiness, patents, deployment status and outlook. IRENA.*

Conclusion

The contribution of tidal energy sector to the global energy mix now and in the next five years remains very small, as many technologies still remain in either development or demonstration phases[11]. That said, the tidal sector is fast becoming more globally competitive with other alternative renewable energies and appears to be on the cusp of commerciality. Moreover, delivering cost reduction and performance improvements will only secure its competitiveness with other forms of power generation[12], and eventually become a material part of any low-carbon future[13]. The International Energy Agency forecasts market growth for tidal energy to exceed other forms of renewables from 2020 onwards.

Given the commitment to establish favourable regulatory and incentive regimes in the UK, energy independence and the transition to a low carbon economy, tidal range and tidal stream advances offer potentially much faster development than previously achieved for offshore wind. Significant and sustained political support in research and development is still needed to encourage investment, innovation and maturity to deliver potential substantial economic benefits globally.

11. *Mofor, L., Goldsmith, J., and Jones, F (2014). Ocean Energy: Technology readiness, patents, deployment status and outlook. IRENA.*
12. *See UKERC & ETI (2014). Marine Energy Technology Roadmap 2014. UKERC UK Energy Research Centre.*
13. *Bradley, S. (2015). Tidal Energy: Insights into Tidal Stream energy. Report by the Energy Technologies Institute.*

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145 - 157 St Johns Street
London, EC1V 4PW

41 Madison Ave, 31st Floor
New York, NY 10010

renewablescg.com

Renewables Consulting Group