Geophysical Research Abstracts
Vol. 20, EGU2018-1925, 2018
EGU General Assembly 2018

Intra- and inter-annual changes in tides cause significant variation in tidal energy resource

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Renewable energy is a favourable alternative to conventional energy sources, especially those that are heavily dependent on fossil fuels. Tidal energy in particular, is an extremely attractive resource that has the potential to play a valuable part in a sustainable future, because of the predictability and reliability. There are two main forms of tidal energy: tidal-range, which harvests the potential energy available in the vertical tide by using an impoundment to create an artificial 'head' between the water inside a lagoon and the natural tides outside of the lagoon; and 'free stream' tidal-stream, which utilises the kinetic energy in tidal currents, typically with the use of a horizontal-axis turbine.

To date, all studies that have assessed tidal energy resource have only considered variations in tidal levels or tidal currents over relatively short periods (e.g. fortnightly spring/neap cycles). However, tidal levels and tidal currents vary over monthly, annual and inter-annual time-scales due to changes in the position and alignment of the Moon and Sun relative to Earth. Over a month, tidal range changes as the Moon moves from its closest (perigee) approach to Earth, to its furthest approach (apogee) and back. Over annual time scales, changes in tidal range occur as the Sun's position varies north or south of the equator, and as it moves from its closest (perihelion) to furthest approach (aphelion) to Earth and back. Over inter-annual time scales, two precessions (a precession is defined as the rotation of a plane with respect to a reference plane) associated with the orbit of the Moon cause systematic variation of tides; the 8.85-year cycle of lunar perigee, which influences tides as a quasi 4.4-year cycle; and the 18.61-year lunar nodal cycle.

Tidal energy devices and associated infrastructure are likely to have a life cycle of decades or longer; therefore, understanding longer term variability of the tidal resource is crucial. Here we assess, for the first time, how the available tidal energy resource varies over intra- and inter-annual time-scales. We use tidal constituents, from a range of regional tidal models based on Oregon State University's Tidal Inversion Software (OTIS), to predict multi-decadal time series of tidal levels and tidal currents, globally. Using the predicted time-series, we calculate the mean and maximum monthly tidal range and tidal current speeds, for each month over a 56-year period (2015-2070, which is equivalent to three 18.6-year nodal cycles). We compute the monthly mean and net theoretical undisturbed tidal range and tidal stream power density.

We show that intra- and inter-annual changes in tides results in significant variability in the available monthly net and mean potential and kinetic energy over these time-scales. Past tidal energy resource assessments could therefore have under or over predicted the average available energy resource for different regions by up to 30%.