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A3_11 Energy from rip currents

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Abstract
The power contained within a typical rip current is estimated, and a simple calculation is made of the amount that could be extracted and used. Technical difficulties with scaling up the process to provide a significant contribution to energy needs are discussed, and conclude that natural rip current power is not suited to large scale electricity generation.

Introduction

A common danger on beaches the world over is that of rip currents, channels of water flowing seaward at up to 8 ft/s [1]. They are usually created by a raised area of seabed running parallel to the shoreline, with one or more breaks in it through which the currents pass. Sandbanks and reefs are two examples of subsurface structures that might lead to the formation of rip currents.

On sandy beaches, the currents are formed when waves break over the sandbank and overfill the deeper section of beach behind (shoreward side), then flood out through channels in the sandbanks towards the sea, pushed by the weight of additional water from behind (figure 1). Thus the flow rate in the channel is proportional to the flow rate over the top of the sandbank in the opposite direction.

The strength of these currents is well known to swimmers and surfers, with as many as 100 people a year in the US being killed by them [2]. A typical rip current flow rate is around 2 ft/s (0.6 m/s) [1] and is likely to be 20-100 ft (6-30 m) wide, and extend hundreds of feet out to sea. This flow rate and volume is compatible with the submersion of hydro-electric water turbines into the current, similar to those in dams and tidal power systems. It should be noted however that while tidal technology may be applicable

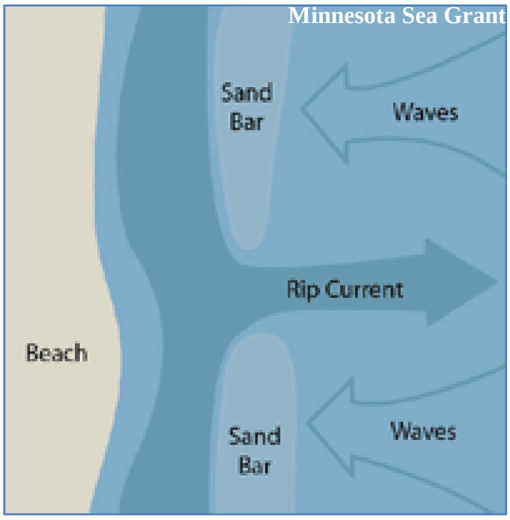

Figure 1 - Schematic of a rip current on a sandy beach

to rip currents, they are not wholly dependent on the tides and often operate to some extent regardless of the tides [3]. The channels themselves are not likely to be deep enough to fit a turbine, but the depth increases quickly on the seaward side without significant current dispersion. Therefore the turbine can be placed in the deeper region without sacrificing power. For the sake of this paper the usable current will be assumed to be 6 m square at this point.

Hydroelectric dams use a height differential, or head, to boost flow rate, converting gravitational potential to kinetic energy. In the case of river generators there is no change in height so turbines are designed differently to work in the lower areal flow rate. While in some rip currents there may be sufficient head to use micro-hydro generators, most sandy beaches are too shallow and would require zero-head generators, so only those are considered here.

Power generation

The amount of power contained in a rip current can be calculated from the momentum of the water, using the following equation:

$$P = \frac{1}{2}\rho Q, \quad (1)$$

where ρ is the water density and Q is the flow rate. Assuming ρ = 1000 kgm^{-3} and with

$$Q = Av, \quad (2)$$

where A is the cross-sectional area of the channel and v is the flow velocity in the channel, the power is estimated at ~10.8 kW.

The *Betz Criterion* [4] gives the fraction of power that can be extracted from the flow: *Cp* = 16/27 = 0.59. The amount converted to electricity is further reduced by the efficiency factor of the turbine and of the generator, estimated at around 0.5 [5]. This gives a final output power of 3.2 kW for a typical rip current with cross sectional area 6 m^2 and flow velocity 0.6 m/s. Assuming that the system could cope with excesses and shortfalls in the flow rate around the average scenario considered here, and that it was able to run all year round, this equates to 28 MWh, approximately equal to the power consumption of 6 average UK homes [6].

Discussion

Multiple rip currents often exist on the same stretch of beach and so the calculated power could potentially be extracted at many points along a coastline. The number of suitable locations is unknown, and rip currents have a tendency to migrate along beaches, so it might be necessary to modify the beach to fix their position, or perhaps even use mobile turbines. These considerations could severely limit the cost effectiveness of such a system. Turbines and generators are not necessarily expensive to construct to reasonable efficiency, but landscaping beaches can be very costly. It has however been observed that some rip currents remain in place for several weeks or months [7] and so targeting these may reduce the migration problem.

Some other places where rip currents can be found are around man-made structures like harbours, jetties and groins. In the most part these are necessary structures and as such can be considered as outside the cost of a rip current power generation system. Therefore these are potentially more suitable locations for rip current turbines.

To conclude, rip currents certainly contain a useful amount of power, of which a significant fraction can be extracted, but this requires very specific circumstances which would likely pose difficult engineering problems. Ultimately only a small number of sites would be suitable and thus rip currents are not likely to make a major contribution to our energy needs.

References

[1] http://www.ceoe.udel.edu/ripcurrents/characteristics/index.html retrieved 23/11/11

[2] http://www.ceoe.udel.edu/ripcurrents/Safety/index.html retrieved 23/11/11

[3] http://www.ripcurrents.com.au/About-Rip-Currents/Rip-Science.aspx retrieved 23/11/11

[4] J. Twidell and A. Weir *Renewable Energy Resources* 2nd Edition

[5] http://www.nooutage.com/hydroele.htm retrieved 23/11/11

[6] http://www.carbonindependent.org/sources_home_energy.htm retrieved 23/11/11

[7] http://www.ripcurrents.com.au/About-Rip-Currents/Rip-Science.aspx retrieved 23/11/11