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A feasibility study on producing electricity from the tidal flows at UWTSD's new SA1 campus

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Introduction

The oceans provide many forms of energy that can be harnessed to generate sustainable, zero-emission electricity, such as salinity gradient, thermal energy, tidal stream and wave energy. This project examines tidal range, defined as the potential energy of water impounded in a basin that fills and empties from the tides' regular flow.

Energy potential at UWTSD's tidal basin

- The basin's surface area is 9000m^2
- The effective tidal range is 6.58 metres (average)
- ρ=1025kg/m^3

$E = \frac{1}{2} * \rho * g * A * H^2$ (1-5)

$E = 1.96 GJ/tide$(one-way generation)

Harnessing between 33%-46% bidirectionally produces 263MWh-367MWh annually.

Tidal Power Plants	Average Tidal Range (m)	Installed Capacity	Reservoir (km^2)	Operating Scheme	Operation Dates
La Rance (France)	7.85	24x10MW	22	Bidirectional	1967-Present
Lake Sihwa (South Korea)	5.6	10x25.4MW	39	Flood production	2011-Present
Annapolis Royal (Canada)	6.4	20MW	6	Ebb Production	1985-Present
Jiangxia (China)	5.08	3.9MW	137	Bidirectional	1980-Present
Kislaya Guba (Russia)	2.5	1.7MW	2	Bidirectional	1968-Present (not continuous)

Table 1: Existing tidal range power plants. (1-5)

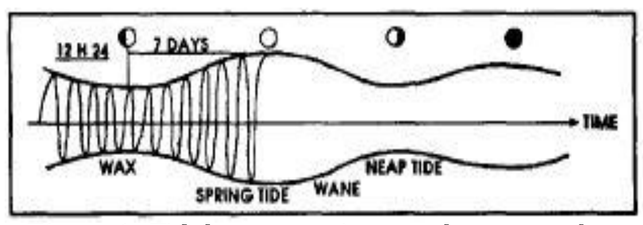


Figure 1: Tidal range varies over lunar month

A benefit of tidal energy is its predictability, even years in advance!
The generated electricity can reduce demand from fossil fuel power stations, offsetting 459kg CO2, 411g SO2 and 373 g NOx for every MWh of electricity generated.

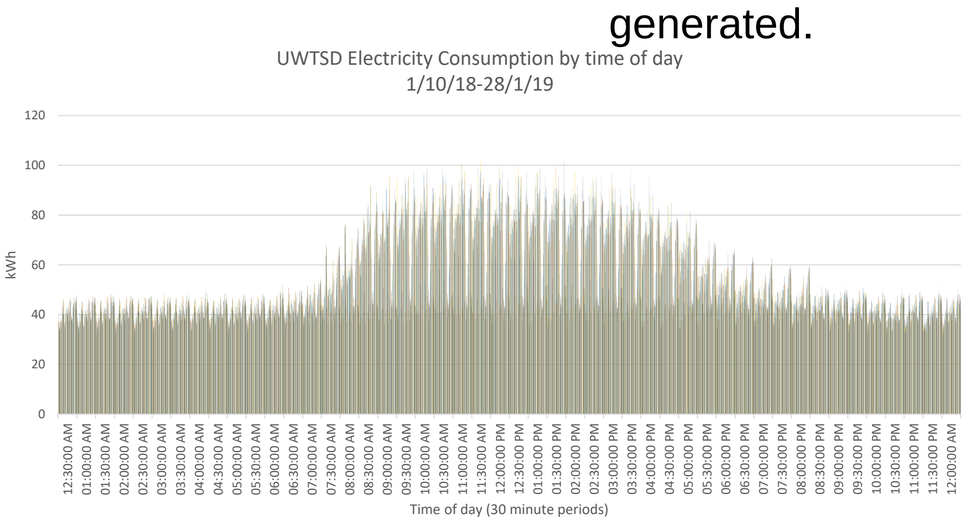


Figure 2: Tom Yearly (Head of Sustainability Delivery at UWTSD) provided data on electricity consumption at IQ building.

Incurred Savings

The University spends £0.14/kWh, and consumes on average 2467kWh each day. This project could offset 722kWh of electricity from the grid daily, incurring savings of £101 daily. Over a year this saves the university £36,820.

Insights from past projects

All tidal range power plants (Table 1) use Kaplan bulb turbines except the Annapolis plant that uses the world's largest Straflo (rim mounted generator gear) turbine. Other potential turbines are shown in Table 2. Archimedes screw is being researched at Uni of Athens & Lancaster Uni. The bulb is most appropriate- despite the higher price. (3)

Table 2:Turbines that could be used in tidal range setting. (3)

	Environment	Efficiency	Cost	Maintenance
Kaplan Bulb	Acceptable	Good	Poor	Acceptable
Straflo	Acceptable	Acceptable	Acceptable	Poor
Modified bulb	Poor	Good	Poor	Poor
Archimedes Screw	Good	Acceptable	Good	Good
Gyro	Acceptable	Poor	Good	Good
Counter Rotating	Acceptable	Acceptable	Acceptable	Acceptable

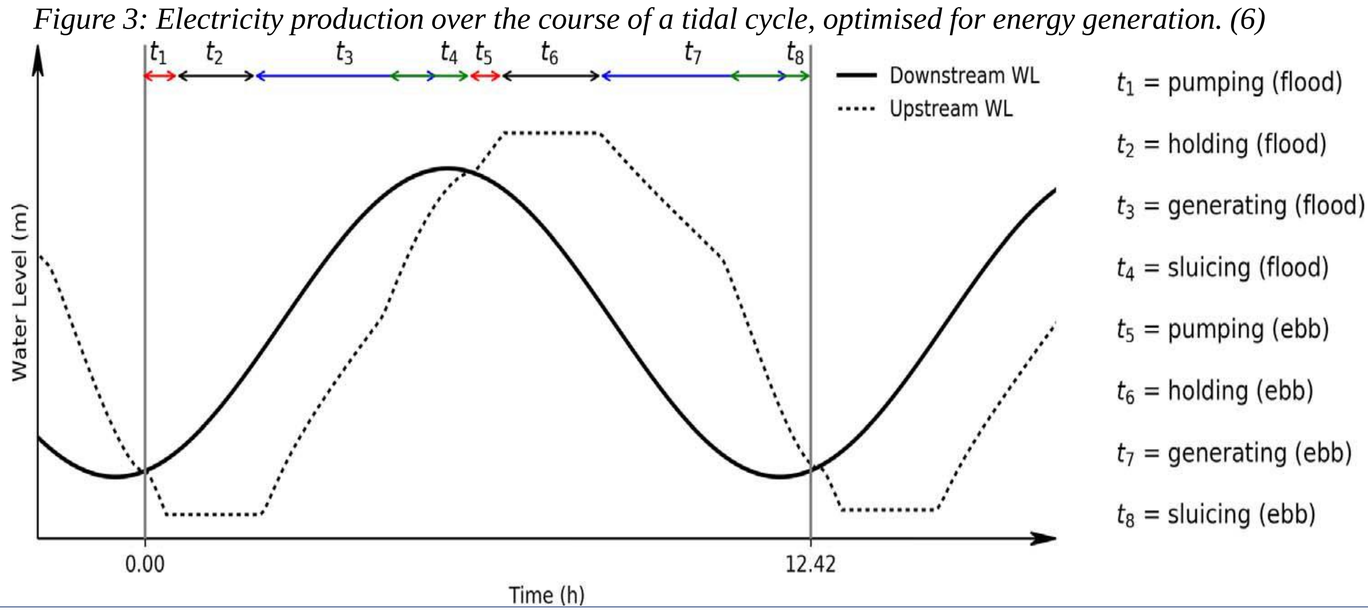
Cost, Payback & Return on Investment

The capital cost of this project is estimated to be £575,000 with annual operating & maintenance costs of £7,000. The payback period (break-even point) is after 19.3 years, after which it will provide a 5% return on investment. The levelized cost of energy (LCoE) is estimated to be £0.118/kWh. A meagre £0.023/kWh below the university's cost of electricity. Should the generated electricity be exported to the grid, the savings would be reduced.

Environmental Impacts

The environmental impacts of a project this size are negligible, with most adverse effects occurring during construction.

Figure 3: Electricity production over the course of a tidal cycle, optimised for energy generation. (6)



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