EMS717U/EMS717P

Renewable Energy Sources

Tidal energies

Content

- **Origin of tides**.

- **Conversion of tidal range to power:** Potential, principle of conversion, sample cases, design and calculation; environmental, economic and social impacts

- **Conversion of tidal current to power:** Potential, characteristics of tidal current, principle of conversion, turbines, design and calculation; environmental, economic and social impacts

Tidal power

Origin of tides

Two Types : Tidal range and tidal current

Possible resource
Principles and magnitudes
State of development
Environmental consequences

Tidal flows

Generation of tidal flows: gravitational pull of moon and sun

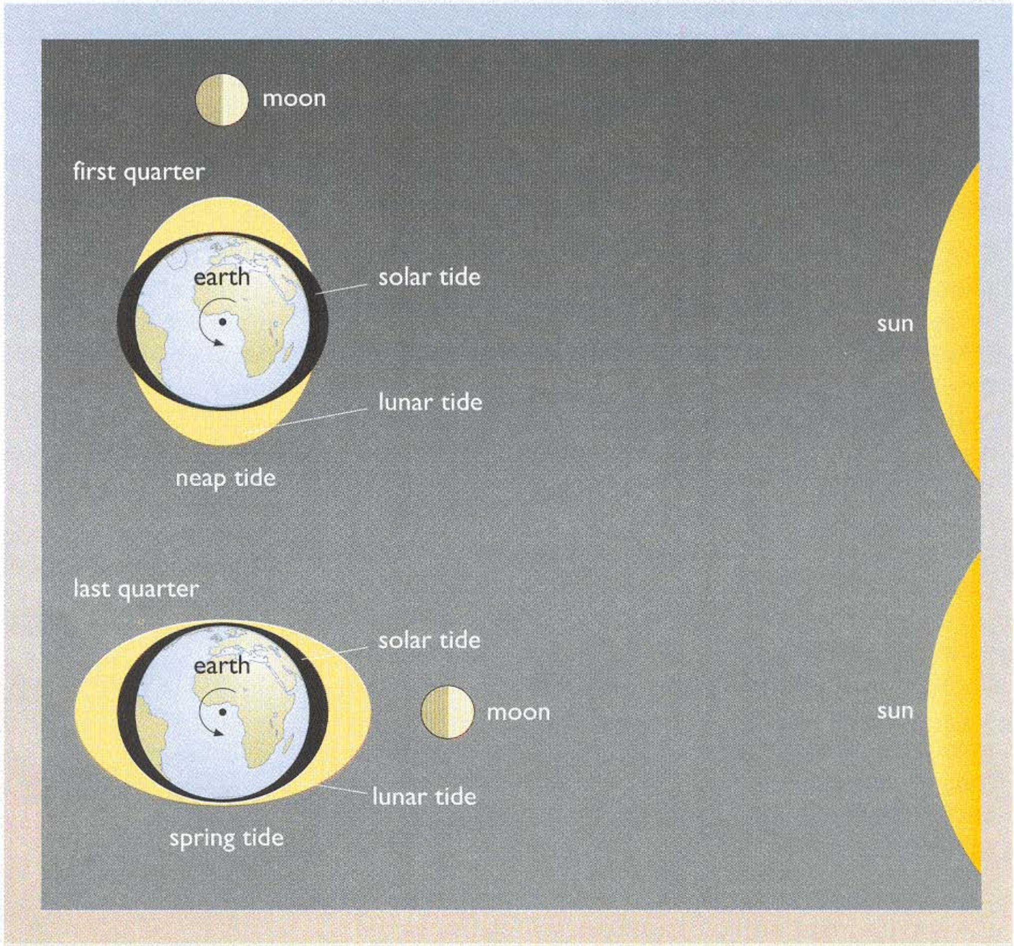


Figure 6.4 Influence of the sun and the moon on tidal range (not to scale)

Tidal: Arrangement of power extraction

- **ebb**
- **flood**
- **both ebb and flood**
- **capacity [m^3] versus height [m]**

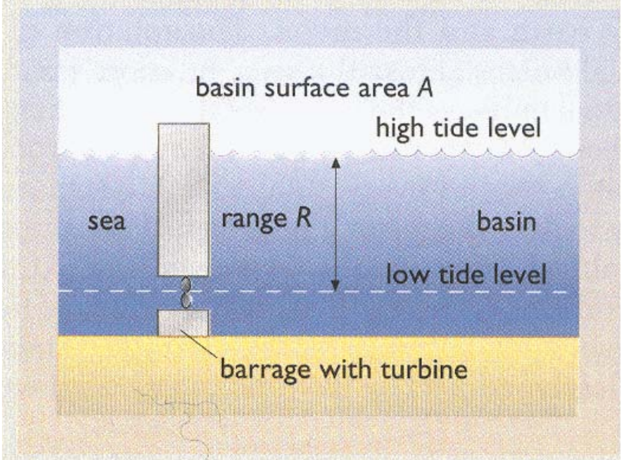


Figure 6.6 Power generation from tides

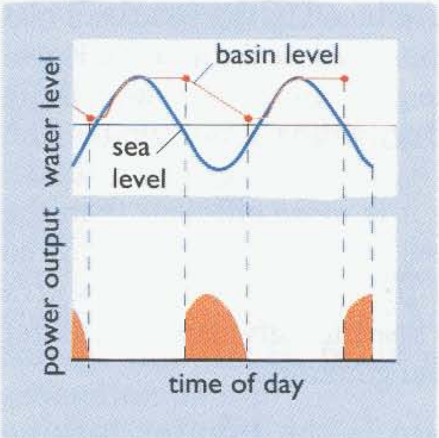


Figure 6.7 Schematic diagram of water levels and power outputs for an ebb generation scheme

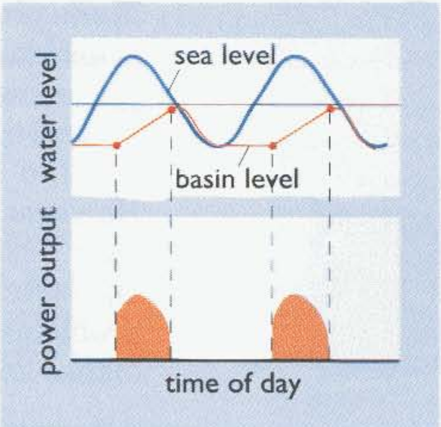


Figure 6.8 Schematic diagram of water levels and power outputs for a flood generation scheme

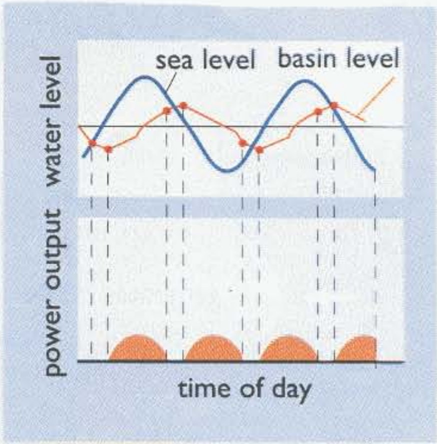
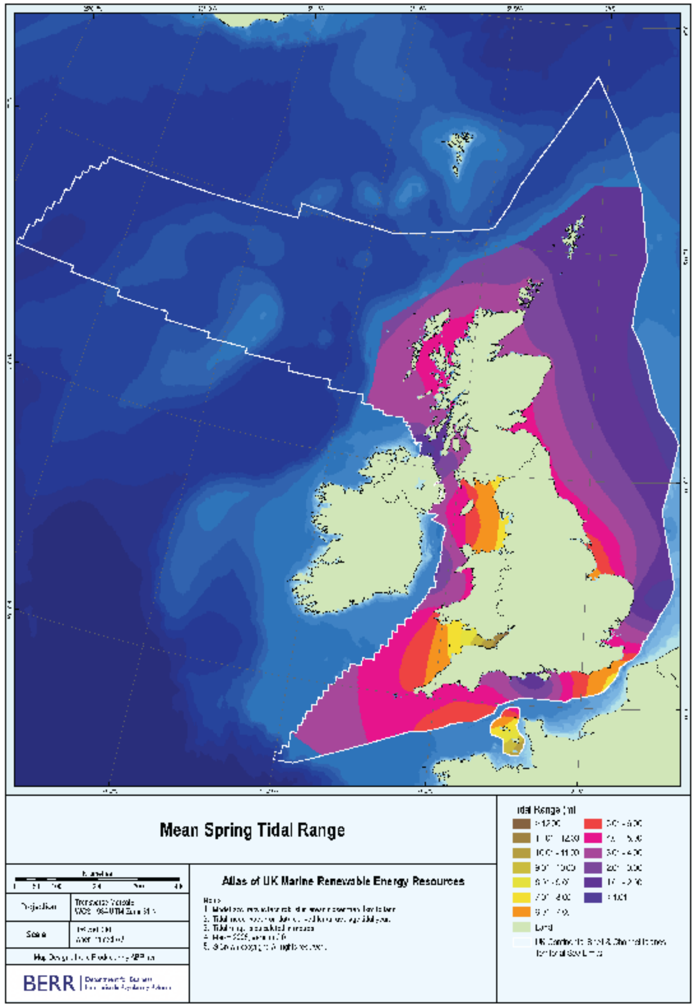


Figure 6.9 Schematic diagram of water levels and power outputs for a two-way generation scheme

Tidal range: Resource around UK

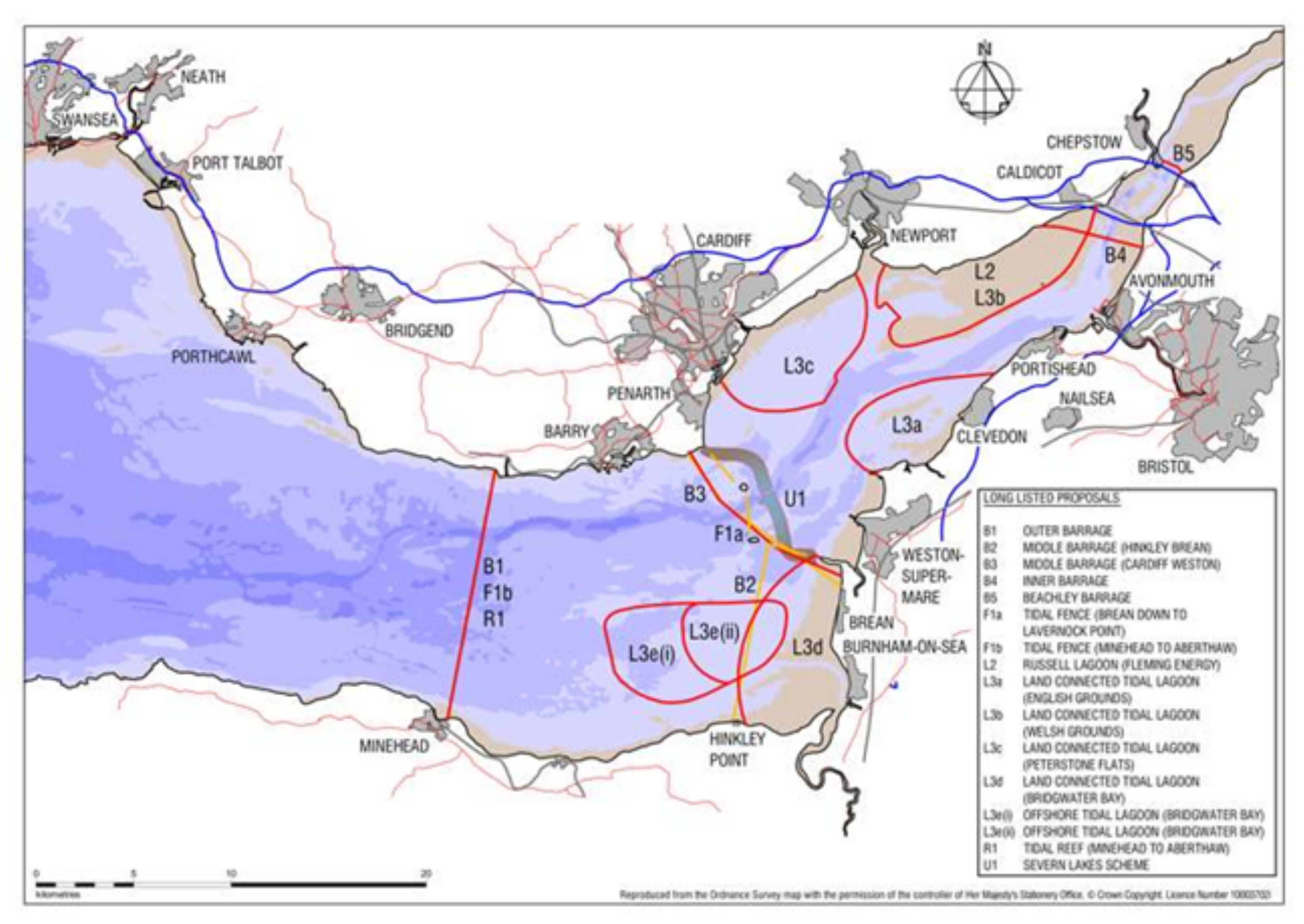
Yellow : 7-8 m
Red : 6-7m



Total UK Resource: <50 TWh/year

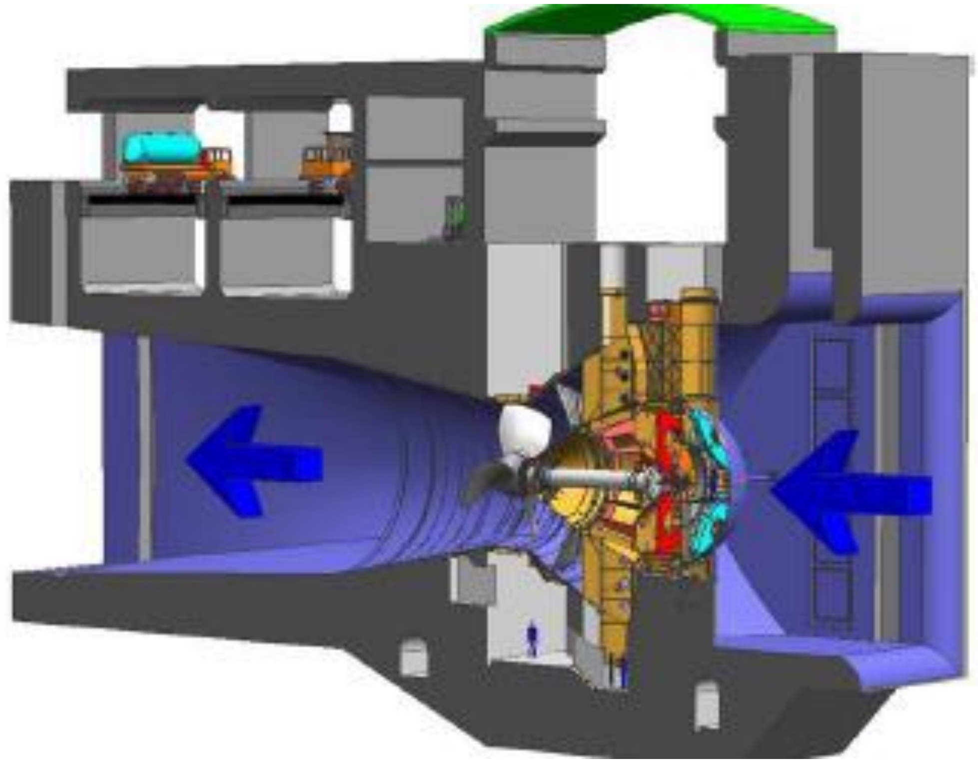
Severn 17 TWh/year
Mersey 1.4 TWh/year

Tidal range: Schemes for the Severn Estuary



Practical tidal range power

Barrage at La Rance, France (60 MW)



Low head turbine

From Aggidis, 2011

Costs and timescales for Severn Barrage scheme

Length (Cardiff to Weston) : 16 km

Power: 8 GW
Energy: 15.6 TWh / year
Construction time: 15 years
Carbon pay-back time: 2.6 years
Cost: £30 bn
Net Present Value: - £ 4.6 bn ⇩ 10%
Cost of electricity: 312 £/MWh

http://www.decc.gov.uk/assets/decc/what%20we%20do/uk%20energy%20supply/energy%20mix/renewable%20energy/severn-tp/621-severn-tidal-power-feasibility-study-conclusions-a.pdf

Environmental and infrastructure effects of the Severn Barrage

- Transport link
- Energy storage
- Fish migration
- Destruction of wetland, and hence bird habitats
- Silting effects unknown, but some flood defences
- Access to ports

Principles of tidal range power (ebb generation)

Electrical power generated by turbines $$W = \Delta P Q \eta_t \eta_g$$

where hydrostatic head $$\Delta P = \rho g h = \rho g (x - x_0)$$

Lagoon level falls according to $$\frac{dx}{dt} = \frac{Q}{A_{lagoon}}$$

Total maximum potential energy is $$PE = \frac{A_{lagoon} \rho g h_{\max}^2}{2}$$

Magnitudes for tidal range (Bridgwater Bay)

$$\eta_g = 0.95, \eta_t = 0.90$$

$A_{lagoon} = 95 \text{ km}^2$

$$\frac{dx}{dt} = 1 \text{ m/hr}, \; h = 2.5 \text{ m}$$

Electrical power?

Magnitudes for tidal range (Bridgwater Bay)

$$\eta_g = 0.95, \eta_t = 0.90$$

$A_{lagoon} = 95\ km^2$

$$\frac{dx}{dt} = 1\ \text{m/hr},\ h = 2.5\ \text{m}$$

Electrical power?

$$1000 \times 9.8 \times 2.5 \times \frac{1}{3600} \times 95.10^6 \times 0.95 \times 0.90$$

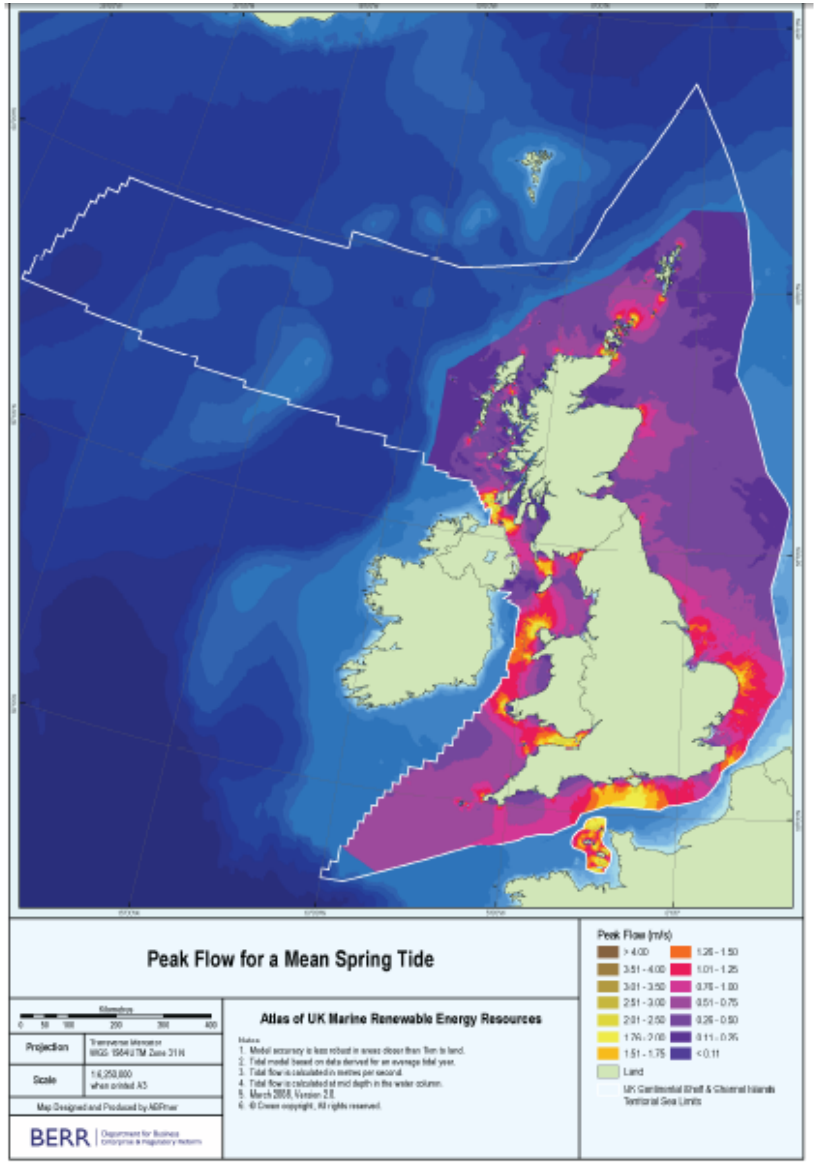
$$\approx 5.6 \times 10^8\ \text{W} = 560\,\text{MW}$$

Tidal current : Resource in UK

Yellow : 1.75-2.00 m/s
Red : 1.00-1.25 m/s

Exploitable resource:
18 TWh in the year

Potential resource:
100 TWh in the year



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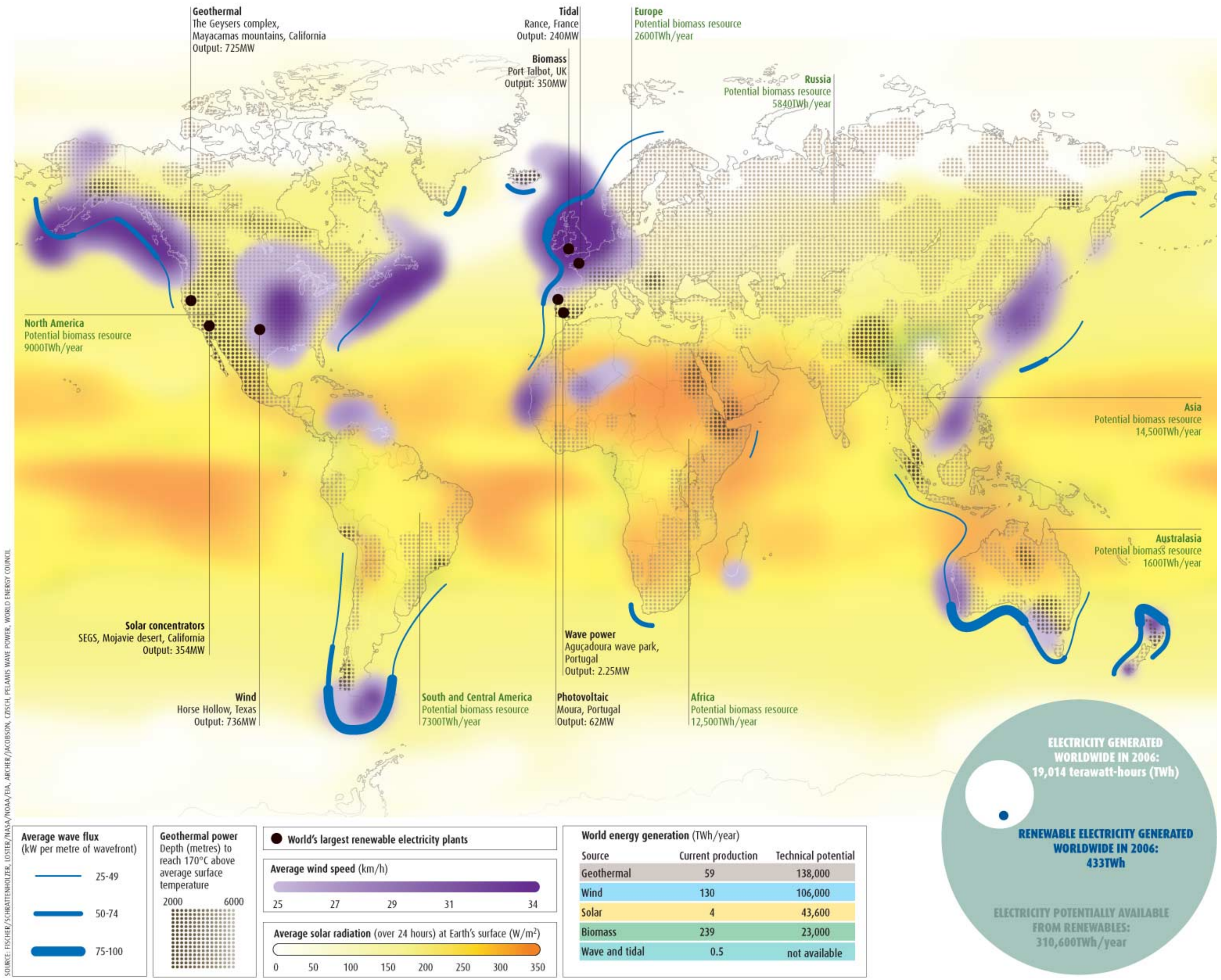
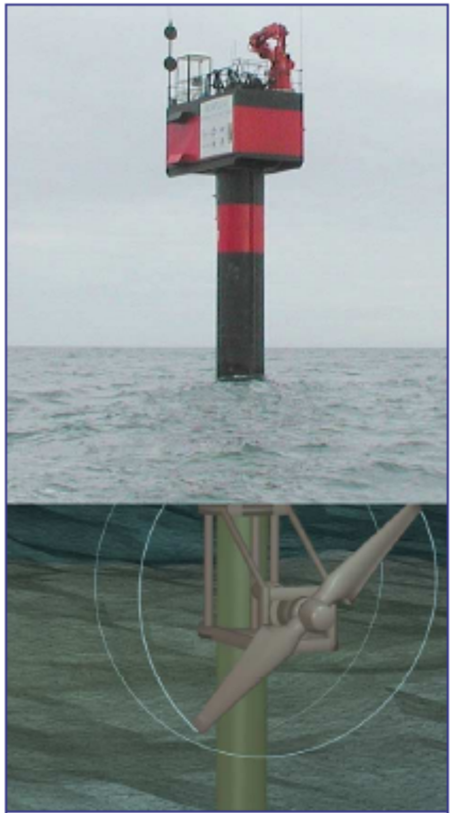
Tidal current : worldwide resource

Estimated at 200 TWh in the year

Chiefly around
Canada
Japan
Korea
China
UK



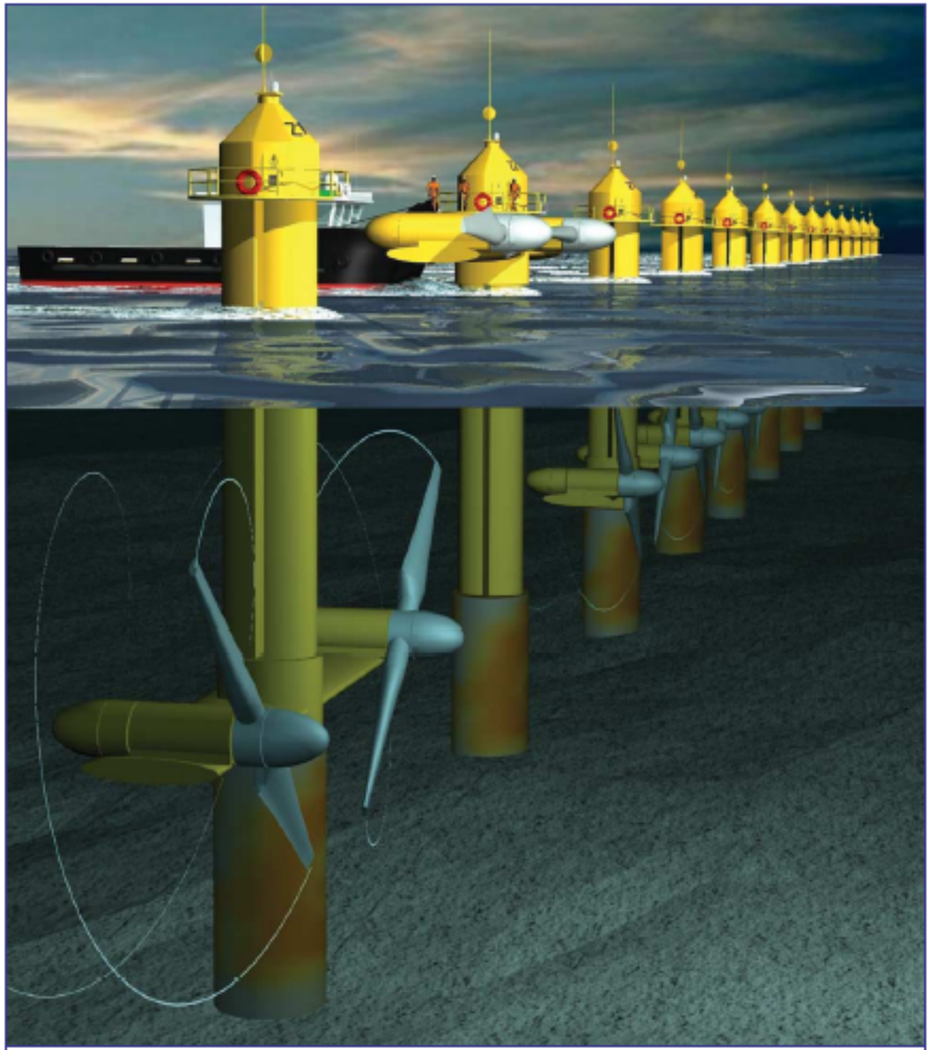
Tidal current



The rotor and powertrain combination is mounted on a steel pile driven into the sea bed.

Marine Current Turbines has had a 300 kW trial installation known as Seaflow operating off Lynmouth, UK, since last May. (Picture courtesy of Marine Current Turbines Ltd.)

Tidal current



Scaling up is a primary aim of Marine Current Turbines. This picture shows an artist's impression of a twin-rotor solution that could harness twice as much energy as a single rotor of the same size, for some 60% more cost. (Picture courtesy of Marine Current Turbines Ltd.)

Greater energy intensity in tidal currents allows a smaller device to generate the same power. This image compares 1 MW wind and tidal turbines.

Tidal current parameters

$$Power = C_p \frac{1}{2} \rho U^3 A$$

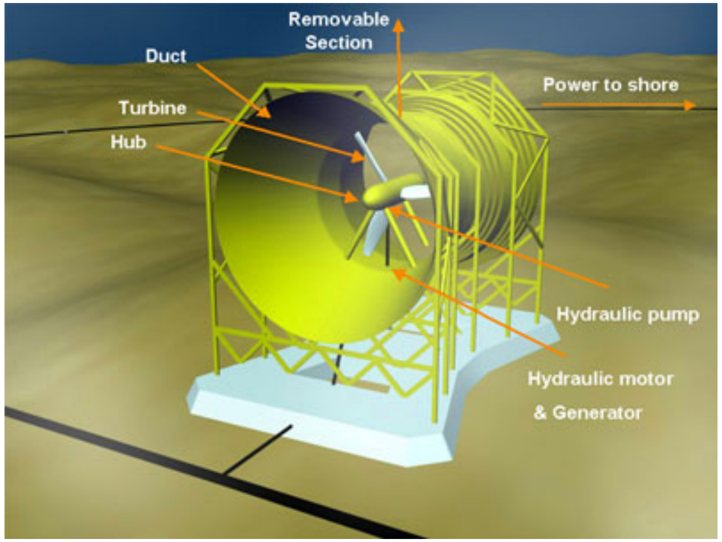
Betz limit

C_p=0.59

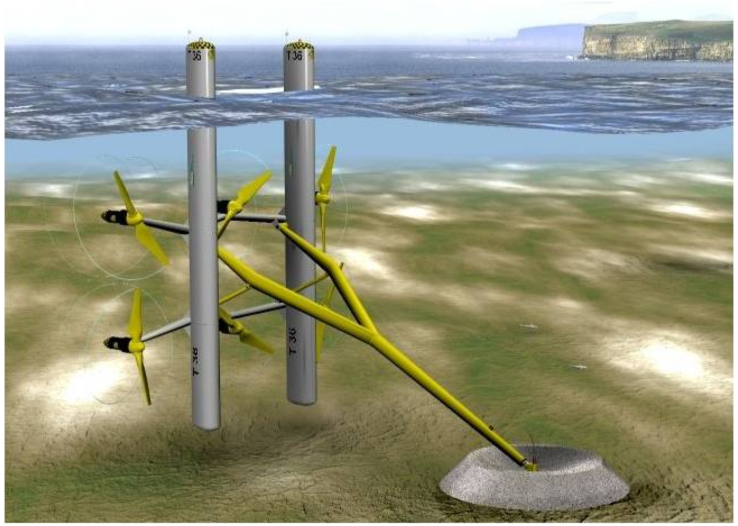
	Wind	Tide
Density / kg/m^3	1.2	1000
Rated velocity / m/s	14	2
Diameter for 1 MW/m	49	31

Horizontal-axis tidal turbines

Hammerfest strom

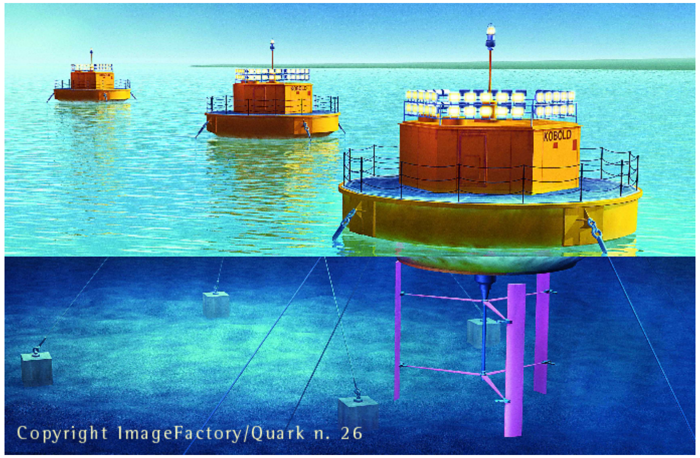


Lunar energy 'Rotech'

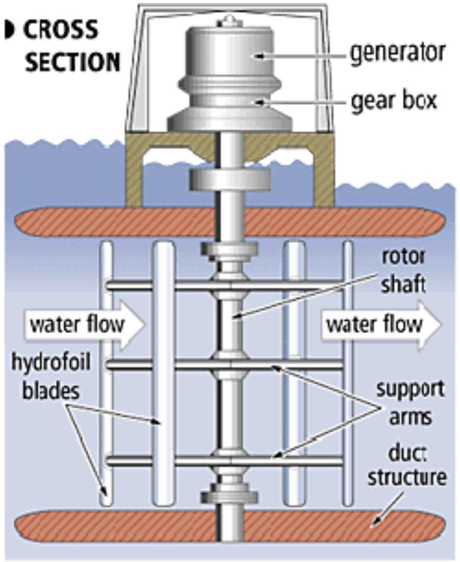


Tidal stream system

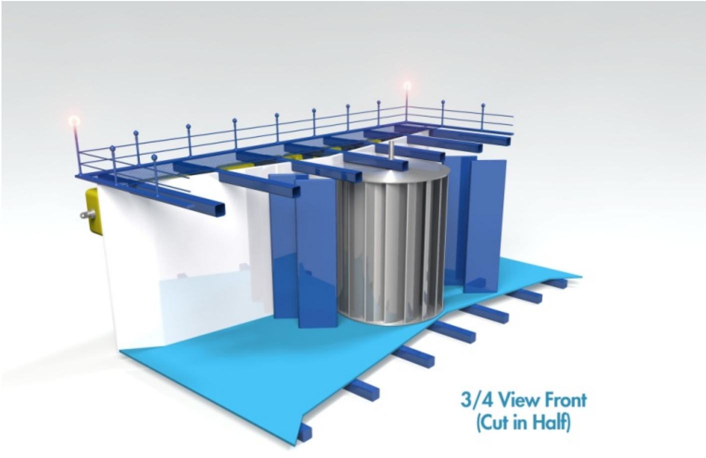
Vertical-axis tidal turbines



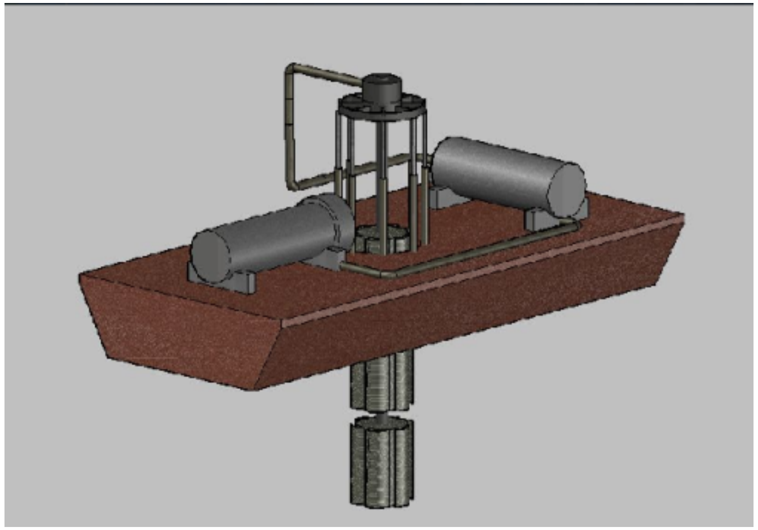
Enermar 'Kobbold' Turbine



Blue Energy International 'Davis' Turbine

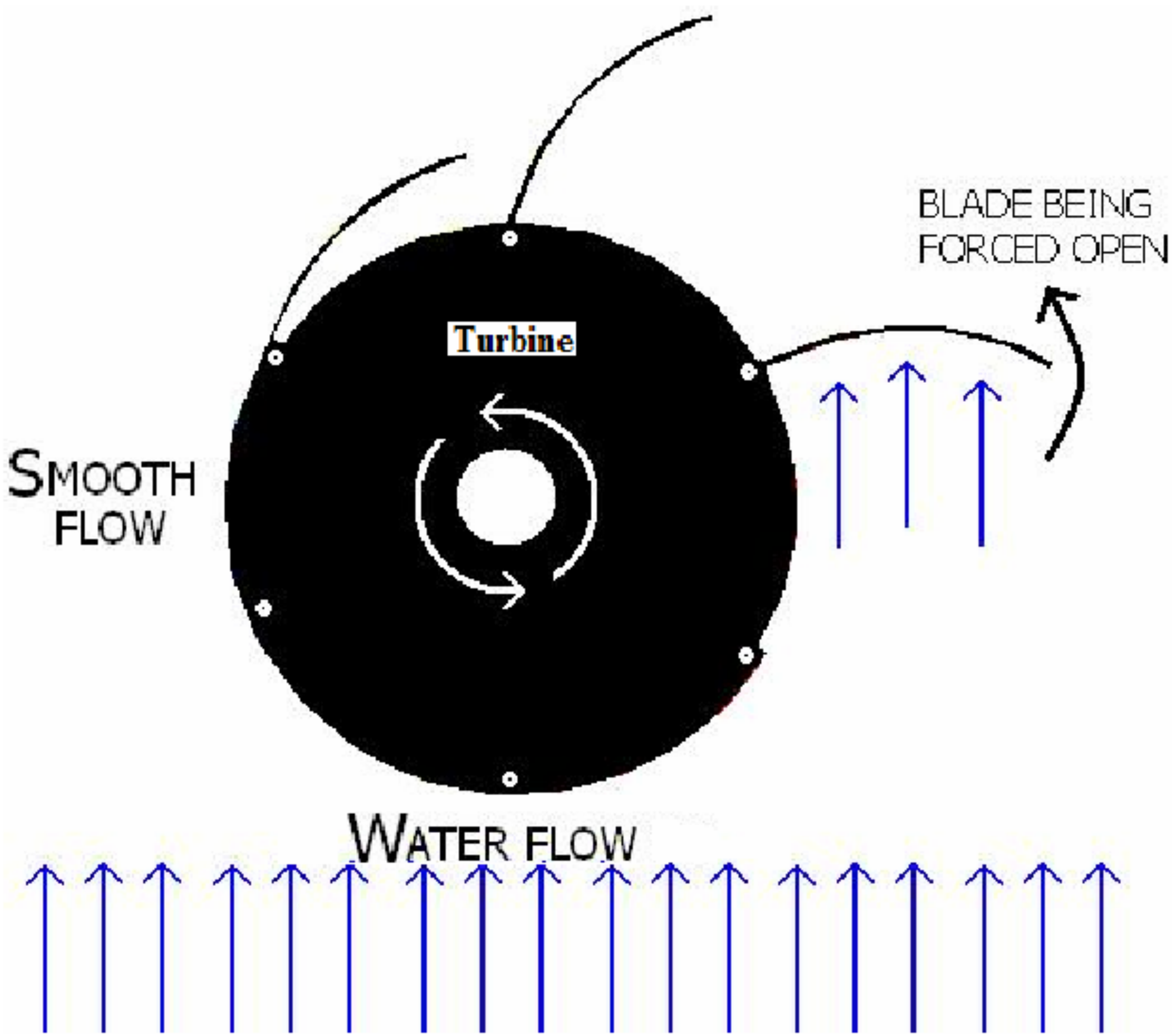


Neptune Renewable Energy 'Proteus'



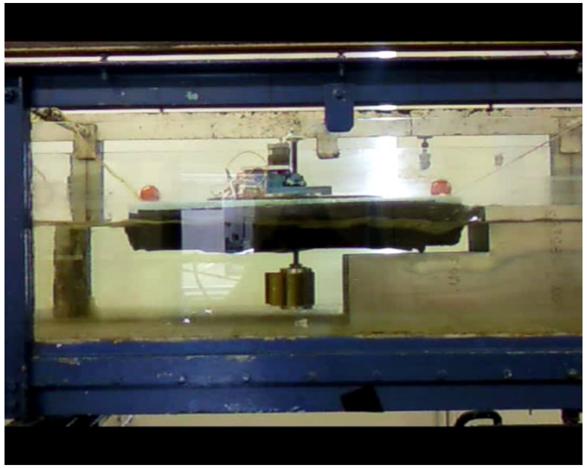
TidalFlow Power 'Hunter' Turbine

The Hunter turbine concept

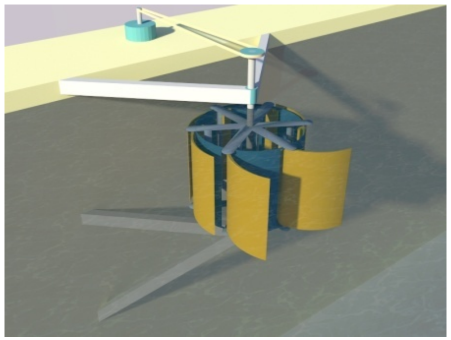


The Hunter turbine development

Tank testing at QMUL and in the Thames by Master students from a Silver Fleet Jetty



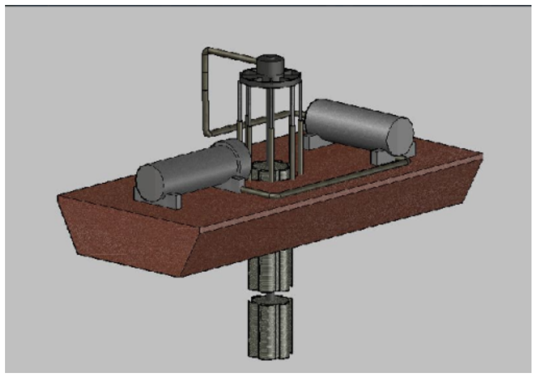
Proposed 10 kW land-based test installation



Supervisor:

Prof Chris Lawn

Possible method of deployment at large scale



Environmental issues for tidal current

- Shipping hazard
- Damage to mammals and fish
- Stirring up silt
- Restricting flow and hence flooding/draining estuaries